dixit algorizmi
the garden of knowledge

dixit algorizmi
the garden of knowledge

La Biennale di Venezia
59. Esposizione Internazionale d'Arte
Partecipazioni Nazionali

edited by Space Caviar
and Sheida Ghomashchi

Humboldt Books

Dixit Algorizmi is an ongoing series of exhibitions, conversations, and workshops reflecting on the history of technology and its relationship with contemporary artistic production. Initiated in 2019, it was presented in 2021 at CCA Tashkent and in 2022 at the Pavilion of the Republic of Uzbekistan, 59th International Art Exhibition, la Biennale di Venezia.

table of contents

preface

saida mirziyoyeva

Deputy Chairwoman of the
Council of the Art and Culture
Development Foundation of
the Republic of Uzbekistan

Uzbekistan is proud to participate in the Venice Biennale for the second time — and for the first time to present its national pavilion at the Venice Art Biennale. The Biennale has already become an important platform for us where urgent cultural issues and topics can be discussed through global conversations. We are happy to respond to the concept developed this year by curator Cecilia Alemani, "The Milk of Dreams," which appears as an ambiguous phrase implying that dreams are real, and that they help us to shape the world; as we are currently re-thinking our future and looking into our rich past for inspiration, this idea resonates with us. The story of the great Eastern scholar al-Khwārizmī is relevant on many levels today: from his original contributions to various sciences that continue to be crucial for contemporary technologies, to the very context of his work, a creative environment that made all the achievements of his time possible, questioning the modern silos of knowledge developed by Western sciences. Al-Khwārizmī managed to achieve so much as he lived and worked with other scholars at the House of Wisdom. His life and studies show how important it is for researchers to maintain a dialogue between science and culture. Similarly, it is vital for us today to support such grandiose cultural initiatives at the Venice Art Biennale.

I am glad that we got the chance to create a space for learning and exchange here, where artists and thinkers from Uzbekistan and other countries can meet, work together, and present their achievements. The concept of the exhibition reflects the ambitions of Uzbekistan today — we are a country that values experiments and creative exchanges — in the belief of shared progress for the whole world.

commissioner's perspective

gayane umerova

Executive Director of Art and Culture Development Foundation of the Republic of Uzbekistan

History demonstrates that science and culture are always a collective effort. As the work of every human being who has studied the world and shared their knowledge is valuable, our history is one of connections, exchanges, discoveries, and careful preservations, where every achievement depends on a culture that treasures wisdoms and cherishes the bright minds that animate them. Inspired by the concept of "The Milk of Dreams" put forward by this year's curator of the Venice Art Biennale Cecilia Alemani, we decided to reflect on the legacy of al-Khwārizmī, one of the greatest scholars from the past. The exhibition proposes a dream-like space that follows the tradition of gardens, where people can gather, contemplate, and work together. The national pavilion of the Republic of Uzbekistan is therefore a platform for collaboration, teaching, and learning. We are providing an opportunity for artists and audiences to think about our pasts and futures, and to respond within the festive and relaxing environment of *The Garden of Knowledge*.

The project contests the idea of linear progress and shows that history is more complex than simply the universal achievements that push civilisation forward. Though distant in time, the story and works of al-Khwārizmī are a brilliant and still relevant example today. He lived and worked in the House of Wisdom together with other important figures of his time, where he made significant contributions to various branches of mathematics, geography and astronomy. He translated and popularised many of his predecessors' works, helping to spread the innovative numeral system throughout the Middle East and Europe.

Nevertheless, it is only later that al-Khwārizmī himself became famous in the West through the translations of his treatises. Through these processes, his Latinised name eventually became the basis of the word 'algorithm,' the radical approach to problem-solving, thus immortalising him in modern languages. Contemporary global civilisation is the product of entangled and multifaceted histories. We want promote this complexity through open conversations about our shared world and future. This is what Cecilia Alemani invites us to do — to think of dreams, to imagine alternatives, and to share fantasies.

In developing the project for the National Pavilion, we wanted to revisit ancient history, go to the origin of knowledge, and show its connections with the present. We are revealing al-Khwārizmī's legacy in what has become our contemporary globalised world, interconnected by streams of data and information exchanges, all shaped by the unseen rules of algorithmic structuring.

The project is going to be constantly changing, evolving with each workshop and experience that visitors take part in. The technologies that define our global post-industrial world can be traced back to antiquity. Today we are excited to build on connections between art and science, between tradition and innovation. *The Garden of Knowledge* invites artists, musicians, and designers from all over the world to collaborate and think about our pasts and futures together. Ultimately, the pavilion becomes a space where visitors can stop and take the time to dream collectively.

curator's statement

space caviar and sheida ghomashschi

"... a cybernetic forest
filled with pines and electronics
where deer stroll peacefully
past computers
as if they were flowers..."

from Richard Brautigan, *All Watched Over by Machines of Loving Grace*, 1967

historical notes

Muḥammad ibn Mūsā al-Khwārizmī, born c. 780, was a scientist and polymath who produced vastly influential works in mathematics, astronomy, and geography. His full Arabic name is essentially a capsule biography: Abū Ja'far Muḥammad ibn Mūsā al-Khwārizmī—roughly, "Mohammed, father of Ja'far, son of Moses, the Khwarizmian." Although the name does not prove that he was born in the Khwarizm region, it is highly likely that he was raised in the city of Khiva, near the Aral Sea. Khiva and the Khwarizm region are today part of Uzbekistan.

Dixit Algorizmi (Thus spake al-Khwārizmī) is the starting phrase of a manuscript kept in the University of Cambridge library generally known by its 1857 title *Algoritmi de Numero Indorum*. This manuscript is attributed to Adelard of Bath, a 12th-century English natural philosopher who travelled widely in medieval southern Europe.

He was responsible for translating many important Arabic and Greek scientific works of astrology, astronomy, philosophy, alchemy, and mathematics into Latin from Arabic versions, which were then introduced to Western Europe. The Cambridge manuscript is perhaps the closest to its original Arabic source, al-Khwārizmī's treatise *On the Calculation with Hindu Numerals*, written around 825. The impact of this treatise in Europe is hard to overstate: as well as introducing Hindu-Arabic numbers in the Western world — an innovation that revolutionised daily life and scientific research alike — it offered simplified procedures for carrying out the four fundamental mathematical operations (addition, subtraction, multiplication, and division). It was Adelard of Bath's Latin transliteration of al-Khwārizmī's name to Algoritmi that gave us the modern word algorithm.[1]

Many of al-Khwārizmī's most significant works were carried out during his tenure as the rector of the House of Wisdom in Baghdad — a period of intensely fertile scholarly production that began around 820. The House of Wisdom was the centre for the translation of prior Greek and Latin texts into Arabic.

In the 9th century, Arab science and learning became dominant around the Mediterranean as Arab encyclopaedists made it their business to transmogrify Graeco-Roman knowledge. In the course of the Muslim conquests, the Hindu-Arabic numerals and their arithmetic were carried by the Moors through North Africa and into Spain, which is where they were intercepted and translated by Adelard of Bath, laying the foundations for centuries of previously unimaginable scientific breakthroughs across the European continent — and elsewhere. Al-Khwārizmī's ideas live on, unacknowledged, in our languages — in the modern Spanish word *guarismo* (digit) for instance, in 'algebra,' and, of course, in 'algorithm' itself.

1 Another treatise authored by al-Khwārizmī, *The Compendious Book on Calculation by Completion and Balancing*, translated into Latin by Robert of Chester in 1145, was used until the 16th century as the principal mathematical text-book in European universities.

the charisma of al-khwārizmī

What is an algorithm? Living as we are in an age steeped, both literally and philosophically, in 'machine thinking,' algorithms perfectly encapsulate the paradox of contemporary existence in the idea that they are possibly both the most familiar and most opaque presence in everyday life. Algorithms can be said to encompass a range of concepts dealing with well-defined processes of any kind, including both the structure of data that is being acted upon as well as the structure of the sequence of operations being performed. But they are perhaps most widely understood as the founding principle of modern computer science, to the point that some scholars define computer science as the study of algorithms.[2] If we consider computer science, practically applied, as the process of leveraging technology to solve problems, we can start to get some insights in some of the reasons for the disproportionate influence of al-Khwārizmī's ideas. Looking at his *Algebra* in more detail, we see that the purpose of the book was not to summarise all knowledge of the subject, but rather to give the easiest and most useful elements; the kind of mathematics most often needed in practice. Al-Khwārizmī discovered that the complicated geometric tricks previously used in Babylonian and Greek mathematics could be replaced by simpler and more systematic methods that rely on algebraic manipulations alone. De facto, he developed an application that made complex mathematical calculations accessible to 9th-century street vendors, rendering obsolete the abacus the same way the iPhone made obsolete the paper map.

These deep etymological connections between words that we assume to be quintessentially modern and the distant shores of the Aral Sea take us by surprise and challenge us to reconsider our Western-centric assumptions. Indeed, we discover, the algorithm was not invented in a garage in Mountain View, California, nor was it conceived

2 Andrei P. Ershov, Donald E. Knuth, *Algorithms in modern mathematics and computer science*, Springer Verlag, 1981.

(as the better educated might assume) by European pioneers of computer science such as Charles Babbage, Ada Lovelace, or even Leibniz or Newton. But did it even originate in Baghdad? As the French mathematician Jean-Luc Chabert has pointed out: "algorithms have been around since the beginning of time and existed well before a special word had been coined to describe them. Algorithms are simply a set of step by step instructions, to be carried out quite mechanically, so as to achieve some desired result."[3] As such, algorithms possibly represent the most consummately human practice of all time: the development of rules through which to resolve problems by breaking down the complexity of our world into simpler parts, thus making a subject accessible to a wider audience. *There's an app for that.*

As Matteo Pasquinelli puts it, the assumption that "abstract techniques of knowledge and artificial metalanguages belong uniquely to the modern industrial West is not only historically inaccurate but also an act and one of implicit *epistemic colonialism* towards cultures of other places and other times."[4] The temptation to see algorithms as a recent innovation that is integral to the technological advances of our time is a form of hubris that discounts the fact that algorithms are among the most ancient and material practices, predating many human tools, as well as the field of computer science itself.

the diffusionist model

If we take a long-term view, patterns of technological diffusion have clearly not been from Europe alone. As Joseph Needham and his associates long ago showed by substituting a Sino-centric model for a Euro-centric one, China was an important and longstanding source of new technologies — as were India, the Muslim world, maritime regions like the Indian Ocean, and many others at various stages in the creation and spread of new technologies — including agricultural ones.[5]

3 Jean-Luc Chabert, "Introduction," in *A History of Algorithms: From the Pebble to the Microchip*, Jean-Luc Chabert (ed.), Springer, 1999, pp. 1-2, quoted in Matteo Pasquinelli, "Three Thousand Years of Algorithmic Rituals: The Emergence of AI from the Computation of Space," *e-flux*, June, 2019.

4 Matteo Pasquinelli, "Three Thousand Years of Algorithmic Rituals: The Emergence of AI from the Computation of Space," *e-flux*, June, 2019.

5 Joseph Needham, *Science and Civilisation in China*, Cambridge University Press, 1956.

Historically, technologies have travelled in a number of different directions, across continents, and not simply outward from Europe or America. This stands in contrast to the accelerationist/venture-capitalist worldview that sees all innovation as descending from an inherently Western culture of innovation within which the present is steeped. This is the culture of incubators and accelerators, of investment rounds and ruthless tactics, of moving fast and breaking things; a culture which is understood to be replicable elsewhere, but which will only be successful to the measure in which it succeeds in precisely replicating (with as little deviation as possible) the political, cultural, and economic conditions found in Silicon Valley itself. Although it is rarely acknowledged, the outcome of this process tends to echo the colonial histories of the economies in which they originate, which are understood to be progressive and largely benevolent, driven by the supposedly objective rationality of a superior civilisation. Similarly, many Western historians continue to regard the history of extra-European regions, especially with respect to technology, as essentially a projection of European history. This is the 'diffusionist model' of technological innovation which relies on a generalised amnesia towards other times and places. What if, far from being fundamentally modern, there was actually very little that is historically unique or even fundamentally new in all of this?

Nowadays, as Uber-entrepreneur Marc Andreessen has said, "software is eating the world." Marshall McLuhan famously claimed that the Western way of thinking about technology is too much related to the left hemisphere of the brain which has a rational and linear focus.[6] Perhaps this explains why the model of 'radical disruption' so beloved to venture capitalism has not become anything but radical, in that it applies the same set of predictable principles — algorithms, so to speak — to the optimisation of

6 Marshall McLuhan, *Understanding Media*, Routledge Classics, 2001.

pretty much any service, from music (Spotify), to transportation (Uber), to domestic labour (TaskRabbit), and so on. Just as efficient and highly optimised construction standards — such as the reinforced concrete frame pioneered in Europe and America in the early 20th century — deleted the specificity of material variety and regional vernacular by replacing them with the generically functional and technologically homogenous solution of the steel and concrete high-rise, a fundamentally Western understanding of what technology is, and what it is there for, has taken hold of the world.

the garden of knowledge

To what extent it this inevitable? What else is possible? What are the alternatives to the hegemony of Western-centric diffusionism? Just as it is possible to imagine 'alternative modernities' coexisting in the modern world, so is it necessary to believe in the possibility of alternative technologies capable of creating and sustaining non-conforming clusters, communities, environments.

Our intention is for the pavilion of the Republic of Uzbekistan to represent a departure from the classical paradigm of participation in the International Art Exhibition, according to which the pavilion is understood primarily as a container for artefacts. Inspired by the environment within which al-Khwārizmī himself operated, we aim for the pavilion to become a space of the production of perception and the exchange of ideas — a 'garden of knowledge,' so to speak, in which heterogenous voices, from within and outside the field of artistic production, can converge and overlap. We conceive of this space as a place of meditation but also of composition, in which it is possible to question the greater order of things, and to consider the trajectory of the histories of art, science, technology, philosophy, and innovation from new perspectives.

Throughout the course of the seven months of the Art Biennale, artists, scholars, historians, scientists, writers, and philosophers will be invited to address the possibility of alternative modernities, not so much attempting to replace the current image of modernity as to expand it in recognition of its deep origins — in distant, and unexpected, times and places.

the legacy of al-khwārizmī

amanulla buriev

Muḥammad ibn Mūsā al-Khwārizmī (783, Khiva – 850, Baghdad) is known in the history of science as a world-famous scholar who created works on mathematics, astronomy, geography, and history. He received his primary education in Khiva, then in the Arab Caliphate, and when in 809 al-Ma'mūn became the governor of the Khurasan region, al-Khwārizmī was gathered with other scholars in his palace in Merv.[1]

In 813, al-Ma'mūn became the caliph and ruled the Arab Caliphate. In 819, he moved to the capital, Baghdad, where he paid great attention to the development of the economy and science by inviting scholars from Merv and supporting their achievements in science.

From this, an academic institution — similar to the Academy of Sciences — was founded in Baghdad which became known as *Bayt al-Ḥikmah* (House of Wisdom). In this centre, many scientists who had mastered the scientific achievements of Ancient Greece and India elaborated the translations of important works and developed new research based on these writings. Astronomical observatories were built in Baghdad (828) and around Damascus (831). Yahya ibn Abi Mansur directed the observatory in Baghdad where al-Khwārizmī also worked. Al-Khwārizmī worked mainly during the years of the caliph al-Ma'mūn's reign (813–833) and partly under the ones of al-Mu'tasim (833–842) and al-Wāthiq (842–847).

al-jabr w'al-muqābalah

Al-Khwārizmī was very engaged within the scientific community in Baghdad and acquired fame for his works. He wrote extensively on the science of algebra, composing an essay on mathematics called *Kitāb al-Mukhtaṣar fī Ḥisāb al-Jabr w'al-Muqābalah* (The Compendious Book on Calculation by Completion and Balancing).

The term 'algebra' comes from the word *al-jabr* used in the title of the book by al-Khwārizmī which, in essence, means algebraic calculation; it has been used in practice since the author's time and gave its title to the discipline.

This work, starting from the time of its creation, was widely used in everyday tasks (drawing up wills, distribution of inheritance, various issues of jurisprudence, drafting trade agreements, measuring land plots, planning irrigation networks, solving various geometric problems), and was also used as a textbook. It was translated into Latin in the 12th century, after which it became widespread in European science communities. The word *al-jabr* began to be pronounced as algebra.

The book of al-Khwārizmī *al-Jabr w'al-Muqābalah* consists of three parts. In the first part, general mathematics questions (including equations of the first and second categories) are raised, and algebraic problems are explained through various examples. The second and third parts of the book contain information about wills and everyday problems with legal solutions (Muslim jurisprudence).

The next work of the scientist is called *Kitāb al-Hīsab al-Hind* (Book of Indian Arithmetic, of which another name is On the Calculation with Hindu Numerals, in short: Arithmetic), which establishes the commonly used ten digits (nine digits from one to nine, plus zero) and the execution with their help of various arithmetic problems on specific examples of calculus. This technique, originally invented in the field of Indian science, gained worldwide fame after the simplification of al-Khwārizmī, and became a kind of revolution in mathematical science. The decimal system for counting became widespread, first in the Arab Caliphate, then in Europe, and, finally, around the world. The elements of this simple method were based on the calculus of the algorithm (arithmetic methods, mathematical problems, computing), and the term algorithm, which originated from the name of the scientist al-Khwārizmī, entered the disciplines of science everywhere, reaching its current use in digital information systems.

1 Ahmad al-Farghāni, Ahmad ibn Abdallah al-Marwazī, known as Habash al-Hasīb, al-Abbas ibn Saīd al-Jāwhari, Muḥammad ibn Mūsā al-Khwārizmī.

Another work by al-Khwārizmī is known under the name *Zij* (Astronomical Tables) and is the first among the astronomical works compiled in the Middle Ages. It should be noted that at that time, in the science of the East, *Zijes* occupied a prestigious place among astronomical works. The most perfect *Zij* in Baghdad during the reign of caliph al-Ma'mūn was the *Zij* composed under the leadership of al-Khwārizmī (c. 840). The geographic coordinates calculated in the observatories built during the reign of al-Ma'mūn were reflected in this particular *Zij*. "The Zijes of al-Ma'mūn" no longer exists today, but its contents are described in *Zij of al-Khwārizmī*. Excerpts from it are also included in al-Farghani's work on the astrolabe.

Zij of al-Khwārizmī consists of thirty-seven chapters and one hundred sixteen tables. It contains information about calendars, about the equations of motion of the sun, the moon, planets, and the zodiac, about calculus tables of sines, etc.

Al-Khwārizmī composed two works on the astrolabe (*asturlob*), a device widely used in astronomical observations in the Middle Ages, and one on the creation of a sundial. The astrolabe was used to determine geographic coordinates on the earth, time, the azimuth of objects, the time of rising and setting of stars, and the measuring of horizontal angles.

determination of the size of the earth

One of the topics related to the geographical activity of al-Khwārizmī is the determination of the size of the earth. Studies were carried out in the al-Ma'mūn Academy in Baghdad for that purpose. One of the projects in which al-Khwārizmī participated in was an expedition organised by the Baghdad Observatory in 828 to measure the circumference of one degree of the earth's surface's meridian. This is described in detail in Abū al-Rayḥān al-Bīrūnī's essay, *Mas'ud Canon*. It says that, at one time, the caliph al-Ma'mūn had a doubt regarding a measurement of a study conducted by ancient Greek scientists. The uncertainty over the length of one degree of the earth's meridian led him to carry out new measurements. For this, an order was issued to organise an expedition with astronomers, surveyors, and auxiliary workers, to prepare instruments and measuring tools, and to find a suitable place.

The chosen place for the measurements was the steppe located at a distance of twelve *farsakh* from Baghdad and forty-three *farsakh* from Samarra, between thirty-five and thirty-six degrees. The resulting measurement read as: one degree equalling to fifty-six miles. If shifted into kilometres, then the magnitude of the earth along the meridian would be equal to 40,252 kilometres; according to modern measurements, it is approximately 40,000 kilometres.

world map

It is known that there was a world map created by scholars engaged in scientific research in astronomy and geography during the reign of caliph al-Ma'mūn. Based on the world maps created by the ancient Greek scientists Marinus of Tyre and Ptolemy, al-Khwārizmī oversaw the work on a new map of the world and introduced many new materials. As this map was created during the reign of caliph al-Ma'mūn, it became historically known as "The Map of Ma'mūn."

"The Map of Ma'mūn" went on to be quite influential; for instance, the Arab geographer al-Mas'udi (10th century) writes that he used it in his scientific research. A single copy of "The Map of Ma'mūn" has survived; it is now preserved in a 14th century manuscript in Egypt. The scientific value of this map is in the significant different perspective that it presents from the map of the world in Ptolemy's *Guide to Geography*.

On Ptolemy's world map, the world ocean is surrounded by dry land, i.e. the map is based on a continental concept, where the Eurasian continent is stretched and connected, as a result of which the Indian and Pacific oceans look like a single closed body of water. On the map created by al-Khwārizmī, the land is surrounded by the world's ocean, meaning that, in it, we see the contemporary oceanic concept.

The oceanic concept on the world map of al-Khwārizmī is firmly established in eastern geographical literature. Abū al-Rayḥān al-Bīrūnī in the 11th century, Najib Bakran in the 13th century in the state of Khorezmshahs-Anushteginids, and Ḥāfiẓ-i Abrū in the 15th century in the state of Temurids created world maps based on the model of al-Khwārizmī's map of the world. The importance of this innovation from the scientific point of view is, firstly, that it became possible to represent the vastness of the world's oceans in comparison with land, and, secondly, it became possible to assume the presence of other parts of the world.

kitāb sūrat al-ard

The essay on geography *Kitāb Sūrat al-Ard* (Book of the Description of the Earth) written by al-Khwārizmī, containing maps and comments to them, is of great importance in science. The compilation of this work made al-Khwārizmī the founder of geography in the East. At present, only one manuscript of this work has survived. Discovered by the

German Arabist scholar W. Spitt in the Cairo library, he managed to bring this manuscript back to Europe; it is currently kept in the library of Strasbourg, France.

The manuscript, rewritten in 428 Hijri in the month of Ramadan (1037, June–July), is composed of a total of forty-eight leaves (ninety-six pages) written in Arabic and rewritten in Naskh script. The full title of the book is *The Book of the Description of the Earth Concerning the Cities, Mountains, Seas, Islands, and Rivers, Extracted by Abū Ja'far Muḥammad ibn Mūsā al-Khwārizmī from the book al-Jughrāfiyā composed by Claudius Ptolemy*. Al-Khwārizmī, again, introduced many new corrections and practical applications to it.

The work of al-Khwārizmī gives first a description of cities, followed by the names of mountains, seas, and islands, and, in the end, a description of rivers. From this, we can assume the book is compiled following the study of these maps. According to the ideas of Ptolemy, oecumene (the inhabited part of the earth) consists of three parts (Europe, Libya (Africa), and Asia) on which cities, mountains, rivers, etc. are located. He divides the earth's surface north of the equator into twenty-one zones and, overall, divides oecumene into ninety-four dioceses (provinces). On this base, al-Khwārizmī proposes a new division of the earth's surface into fifty-six regions and seven climates.

seven climates

Generally, the seven climates is a geographical concept which is associated with the history of the division of the earth's surface into natural, political, and administrative parts. According to the information of Abu Rayhan Biruni, the Indians divided the earth into nine parts and each part was called a *konda*. In the ancient world, the Iranians divided the earth into seven parts, each called *kishwar*. The ancient Greeks divided the earth into seven climates (in Arabic *īklīm*) according to the astronomical principles.

Their boundaries were determined by parallel lines along the equator stretching from east to west with a difference of half an hour on a summer's day. The southernmost line began where the summer solstice line was thirteen hours long and moved north each half an hour apart. This division roughly corresponds to modern geographic areas. Ancient Greek *klima* meant the inclination of the earth's surface towards the sun's rays. According to the principles of seven climates, the territory of Uzbekistan falls on the fourth, fifth, and sixth climates.

There are significant differences in the works of Ptolemy and al-Khwārizmī, as well as in the description of the territory of Central Asia. In one of the tables (maps) in the essay of Ptolemy *Guide to Geography*, an image of Central Asia and adjacent territories is shown where several dioceses and more than thirty cities are indicated, as well as mountains, rivers, and the territorial location of some tribes (Tochars, Massagets, Scythians). But the entire nomenclature is given in ancient Greek, and it is difficult to determine their modern locations. In *The Description of the Earth* by al-Khwārizmī the description of geographical objects is also provided, including cities, regions, mountains, and rivers in Central Asia, but they differ from the descriptions of Ptolemy.

The Caspian Sea is mentioned by two names on Ptolemy's map as Caspian and Girkan; al-Khwārizmī gives four of its names: the sea of Khwarazm, the sea of Djurdjan, the sea of Tabaristan, and the sea of Daylam, and then mentions that all of these form one sea. He describes accurately its size, the large rivers flowing into it, as well as cities and mountains in its vicinity. As the Aral Sea is not indicated on Ptolemy's map, the first cartographic data of it are given in *The Description of the Earth* by al-Khwārizmī. The Amu Darya on the map of Ptolemy is given under the name Oxus and flows into the Caspian Sea.

It is mentioned by al-Khwārizmī under the name of the Balkh river. In the Middle Ages, Balkh was one of the significant cities near the Amu Darya and, therefore, it is referred to as the Balkh river in written sources. He correctly represented the direction of the flow of the river; the river first flows near Balkh, then near the capital of Khwarazm (i.e. the ancient capital of Khwarazm, the city of Kath), and finally reaches the state of Khwarazm itself (Eli Khwarazm) to flow through the territory and into the lake (i.e. the Aral Sea). The Syr Darya on the map of Ptolemy is given under the name Jaxartes. It begins from three streams in the Comed Mountains (Pamir), and flows into the Caspian Sea. In the work of al-Khwārizmī, the direction of the Syr Darya is given correctly; it flows into the Aral Sea. The Murghab river in al-Khwārizmī's work is given as a river without a name, but its direction is correctly indicated; it flows near the cities of Merverrood and Merv, and in the lower parts ends in the sands, as at present.

The geographical locations of the main cities of Central Asia[2] are indicated correctly in the work of al-Khwārizmī. If the cities indicated by al-Khwārizmī are placed on a map, it is clear that he only covered the most famous cities, mainly located along trade routes, since it was difficult to get information about the settlements that were far from the main lines. In the work of al-Khwārizmī, the provided names of cities are located along the Great Silk Road, which followed the course of the trade caravans travelling from Central Asia to China.

One of the main differences in the writings of Ptolemy and al-Khwārizmī is the spelling of the names of geographical objects: Ptolemy gives them in Greek transliteration,[3] while al-Khwārizmī follows the Eastern tradition.[4] The descriptions of the regions in the writings of Ptolemy and al-Khwārizmī differ. On the territory of Central Asia and adjacent lands, the names of the regions of Hyrcania,

2 Bukhara, Samarkand, Amul, Usrushana, Khujand, Akhsikath.
3 Margiana, Sogdiana, Bactriana.
4 Mecca, Madina, Baghdad, Sham, Azerbaijan, Tabaristan, Kabul, Samarkand, Bukhara, Usrushana, Shash, Turk, Tuguzguz, Sarandib, etc.

Margiana, Sogdiana, and Bactria are shown on Ptolemy's world map. The book of al-Khwārizmī *Kitāb Sūrat al-Ard* mentions the names of the regions of Shash and Tarband, Khwarazm and the Country of Turkic people (Ard at-Turk). In general, al-Khwārizmī more accurately describes the territory of Central Asia: Mount Elbrus, Mount Turkmen-Khorasan, Kopet Dag, Pamir, Turkestan ridge, Western Tien Shan, Caspian and Aral Seas, Amu Darya and Syr Darya, Khwarazm state, Shash, and Tarband regions.

kitāb al-tarīkh

We know about al-Khwārizmī's work *Kitāb al-Tarīkh* (Book of History) that has become known to us through separate fragments that have survived in the works of other authors,[5] as well as the composition *Tārīkh al-Khulafā* (History of the Caliphs). The surviving passages contain chronological and historical information: the dates of birth and death of the Prophet Muhammad, the time when the revelation came to him, events related to the history of Islam; the spread of Islam during the reigns of the Umayyads and Abbasids; some events about the conquest of the territories of Iraq, Iran, and Khorasan by the Arabs; solar and lunar eclipses, earthquakes, etc.

study of the scientific heritage of al-khwārizmī

The scientific heritage of al-Khwārizmī has been studied by scientists from various disciplines all over the world for many centuries, including by the famous scientist Aḥmad al-Farghānī who lived at the same time as al-Khwārizmī. The well-known scientist Abū al-Rayḥān al-Bīrūnī, years later, also used the works of al-Khwārizmī in his research. They mention the name of al-Khwārizmī and his works, and express their opinions on certain scientific problems he touched upon.

In the European scientific community, interest in

5 Biruni, Yaqut Hamawi, al-Ya'qubi, Elias Bar Shinaya, Hamza al-Isfahani, al-Tabari, Ahmad ibn Tayfur, Ibn Badrun.

the scientific heritage of al-Khwārizmī appeared in the 19th century. The works of the scientist were published, including *al-Jabr w'al-Muqābalah*, *Hisāb al-Hind*, *Zij*, *Kitāb Sūrat al-Ard*, two works on the astrolabe, and an essay on making a sundial.

the algorithm's journey from east to west

ayesha saldhana

Imagine yourself in Baghdad, the great Abbasid capital, at the height of its glory in the 9th century. It is probably the largest city in the world at this point, and the centre of Arabic culture and letters. But while it is Arabic-speaking, its population is drawn from many places. We will return to Baghdad shortly, but first, let's take a trip to the east. Leaving Baghdad by the Khurasan gate, we'll join the great Khurasan trunk road. It is part of the network of roads used by the *barīd*, the official postal and intelligence service of the Abbasid caliphate. This road has existed for thousands of years, connecting Mesopotamia to the Iranian plateau and beyond.

It then goes on to Nishapur, and eventually across the desert to reach the Oxus, and after that Bukhara and Samarkand. The main road continues to the borders of China, but, all along it, other roads branch off — to Tabriz, Isfahan, Herat, Tashkent. It is the branch leading to Bukhara that interests us, because it takes us to Urgench in Khwarazm.

And why does Khwarazm interest us? Because that is the probable birthplace of renowned 9th-century polymath al-Khwārizmī, as his name indicated — Khwārizmī meaning from Khwarazm, one of the oldest centres of civilisation in central Asia. Zoroastrian texts mention *Airyanem Vaejah*, the "expanse of the Aryans," meaning the homeland of the early Iranians. Some scholars believe that it was centred on Khwarazm. Zoroastrianism is one of the world's oldest living religions, which developed from an ancient Indo-Iranian religion around three and a half thousand years ago. It is believed to have taken root in Central Asia, and from there spread to Iran.

However, the Zoroastrianism practised in ancient Khwarazm was not the same as in Iran; it was a local version of Zoroastrianism mixed with survivals from earlier beliefs and local cults. Even after the Muslim conquest of Khwarazm in the late 7th and early 8th centuries, pre-Islamic languages and cultural traits persisted in the region. According to historian E. E. Nerazik, "Overall, the culture of Khwarazm was the product of a complex interaction between, on the one hand, dominant, profoundly traditional local elements and, on the other, those brought by an immigrant population and arising from the country's historical and cultural contacts."

It is possible that al-Khwārizmī's forebears were Zoroastrian, as some historians include the epithet al-Majūsi — meaning Zoroastrian — in his name. He was Muslim, but being from Khwarazm, he would have been exposed to a variety of cultural influences. Central Asia had long been a junction of routes going east and west crossing those going north and south, which meant it had absorbed elements from many cultures and religions. In addition, the regions of Transoxiana and Khwarazm were flourishing agricultural areas, and their merchants carried on long-distance trade; there were Khwarazmian trading colonies as far west as southern Russia.

The historian Xinru Liu argues that it was in large part due to this eclectic cultural foundation that Central Asia produced so many outstanding politicians, religious leaders and scientists during this era, between 700 and 1100. Today, they are usually referred to as Islamic, or set in the context of Persian Islamic heritage, with little acknowledgement of their Central Asian origins.

So why was al-Khwārizmī drawn to Baghdad, and what

did he do there? Baghdad had been founded in 762 as the seat of power of the Abbasid caliphate, which covered an area larger than the Roman empire at its height. Just fifty years later, the city had become the largest in the world, famed for its wealth and splendour, with an estimated half million inhabitants.

The seventh Abbasid caliph al-Ma'mūn (The Trusted), who ruled from 813 until his death in 833, was known for his love of knowledge. He became one of the greatest patrons of science in Islamic history, and set in motion a tremendously fertile period of scholarship and learning. This was in part enabled by the introduction of paper-making technology at the beginning of the Abbasid period; the ability to produce paper easily meant that Baghdad soon had numerous paper shops, booksellers, and libraries.

Other Abbasid caliphs had supported scholarship, including al-Ma'mūn's father, Hārūn al-Rashīd, but al-Ma'mūn was passionate about it — rulers he defeated would often be required to give him the contents of their libraries instead of gold — and, during his reign, scholars from all over the caliphate were drawn to Baghdad.

He founded an institution which became known as the *Bayt al-Ḥikmah*, the House of Wisdom, described by the historian Philip Hitti as "a combination of library, academy and translation bureau." Emissaries were sent far and wide to gather manuscripts, and scholars were employed to copy, translate, and comment on the major works of Greek, Persian, and Indian philosophies and sciences. The House of Wisdom included an astronomical observatory and, according to some scholars, it was the most important educational institution since the Alexandrian Museion that was founded in the 3rd century BCE.

Today we don't know where exactly in Baghdad the *Bayt al-Ḥikmah* was located or what it looked like. It is possible that its scholars were not all based within it and, in physical terms, it may have been simply a library. But we know that it attracted philosophers and scientists from many places, and made Baghdad an unrivalled centre of learning. The translators reflected the linguistic and religious diversity of the Abbasid caliphate, and the Greek works were usually translated by Syriac-speaking Christian scholars, sometimes directly from Greek, sometimes via Syriac versions. This 'translation movement'—a name given to it more recently—influenced not only Muslim intellectual life but that of the Latin West for centuries to come.

Al-Khwārizmī would have been attracted to Baghdad by the opportunities it afforded. He worked in the House of Wisdom as a mathematician, geographer and astronomer, and, according to some accounts, was appointed head librarian. While at the *Bayt al-Ḥikmah*, and along his astronomical and geographical works, al-Khwārizmī wrote two books on arithmetic and algebra that would play an immensely important role in the history of mathematics, and would make his name known throughout Europe.

These books were written at the request of the caliph al-Ma'mūn: a book on algebra, and one on calculation using Hindu-Arabic numerals. The word 'algebra' itself is derived from the title of the first book, *Kitāb al-Mukhtasar fī Hisāb al-Jabr w'al-Muqābalah* (The Compendious Book on Calculation by Completion and Balancing), in which the term *al-jabr* means 'resetting.'

The second, which survives only in Latin translation, gave us the word 'algorithm.' The Latin term *Dixit Algorizmi* (Thus spake al-Khwārizmī) led first to 'algorismi,' or 'algorism,' used to mean the numeral system with nine digits and zero (as opposed to Roman numerals), and, eventually, to describe a procedural framework for accomplishing a particular task—an algorithm. Another variant of algorism, 'augrym,' was used by Geoffrey Chaucer in *The Miller's Prologue and Tale*—"His Almageste, and bookes

grete and smale, His astrelabie, longynge for his art, His augrym stones layen faire apart, On shelves couched at his beddes heed"—and similar uses of such forms to denote calculation with Hindu-Arabic numerals are commonly found in European literature from the 13th to the 17th centuries.

The mathematician and historian of science Louis Karpinski noted that al-Khwārizmī's work "marks the beginning of that period of mathematical history in which analysis assumed a place on a level with geometry." Algebra allowed mathematics to develop in new, broader ways. While al-Khwārizmī did not invent the concept of algebra or the algorithm, he integrated principles expressed in Indian and Greek works, and articulated them in a clear and practical way for the first time. As Kevin Brock describes in *Rhetoric and the Algorithm*: "Although the idea of algorithmic procedure has been a part of human culture and behaviour long before the ninth century CE, it is through al-Khwārizmī's writing that the algorithm becomes codified as a procedural framework whose functionality is articulated through a specific grammar; specifically, for al-Khwārizmī and his work, this grammar would later come to be called algebra. For al-Khwārizmī and for mathematicians since, the algorithm was the procedural framework through which a mathematical equation would be calculated. By constructing a framework to which a mathematician could adhere in order to solve discrete problems, the capabilities of symbolic systems to reflect logical procedures were suddenly clearly articulated."

Al-Khwārizmī's work became known in Europe some centuries after his death through various translations and adaptations. In the 12th century, his book on algebra was translated into Latin by both Robert of Chester (working in Segovia, in Spain) and Gerard of Cremona (in Toledo in Spain), and later influenced the work of mathematicians Abraham bar Hiyya in Spain and Leonardo of Pisa (also known as Fibonacci) in Italy. Its influence in Europe was substantial; until the 16th century, it was used as the principal mathematical textbook in European universities.

The fact that it was so widely used was in fact al-Khwārizmī's intention; he set out to write a book that could be of practical help, saying it would be confined "to what is easiest and most useful in arithmetic, such as men constantly require in cases of inheritance, legacies, partition, lawsuits, and trade, and in all their dealings with one another, or where the measuring of lands, the digging of canals, geometrical computations, and other objects of various sorts and kinds are concerned."

According to Louis Karpinski, writing in 1915, "Mathematical science in Europe was more vitally influenced by al-Khwārizmī than by any other writer from the time of the Greeks to Regiomontanus (1436–1476). Through his arithmetic, presenting the Hindu art of reckoning, he revolutionised the common processes of calculation and through his algebra he laid the foundation for modern analysis." Before even considering al-Khwārizmī's other works, through these two books alone—one which gave us the word algorithm, the other which gave us the concept of the algorithm—he shaped today's world.

automatic legacies: on the banū mūsā brothers and 1100 years of musical sequencing machines

maxwell neely-cohen

I recently watched a four-year-old child interact with a drum machine for the first time in her life. After observing one of our programs, a single line of drums, she took over. She immediately began creating complex percussion patterns, lighting up buttons into looping sequences, twisting knobs on filters and pitches. She seemed to instantly grasp the fundamental exchange, that she could communicate something to this machine, and it would remember it, and play it back, over and over. It was a mimic, a storeroom, a magic mirror, a conversation.

In the 9th century, the three Banū Mūsā brothers, then working at the House of Wisdom in Baghdad, built an 'automatic flute' and included the design in their treatise *The Instrument Which Plays by Itself.* Patterns were programmed into rotating discs that controlled a hydraulic system, flowing water and pressure to pipes of air that would blow at different pitches.

This musical instrument is the earliest programmable machine in historical records. The first programmable machine was not for calculating the movements of stars, nor for business transactions, but a device for entering and returning a sequence of notes. We have been programming machines to make music for 1100 years.

What happens if we view electronic music, computer music, or algorithmic music as ancient arts? What if they have lived inside us, in our dances, in our sense of rhythm and pitch for longer than we can recognise? What if experiencing music as a programmable art has a generational memory that goes back long before the transistor and the logic gate? What if the Banū Mūsā brothers have been with us this whole time?

All musical instruments, save our bodies, are machines. Even the most minimal percussive form—a stick slammed against a hard surface—is an imitation of hand tool technology. Playing an instrument is a collaboration with a mechanical entity, a duet between biological control and engineered material made possible by constructors who may never see that stage. Musical instruments are some of the most intensely iterated human creations. They are perfected over generations; a dance between makers and players shifting designs, slight tweaks over centuries, and violent innovations in ages of upheaval or inspiration.

Automatic instruments had existed for centuries before the Banū Mūsā brothers ever built their flute. Most notably the great Greek mathematician Archimedes of Syracuse had designed automatic wind instruments a thousand years before, but these were all designed to repeat an initial setting. The Banū Mūsā flute was specifically built so that guests could come and encode a tune, only then to hear it played back at them. It was designed to impress and entertain travellers and visiting friends. The interaction was an invitation, proof that they were not being tricked by a player hiding in a box or behind a curtain. Unlike many of the Banū Mūsā's trick vessels and designs, the flute's mechanism was visible. It showed its secrets. It allowed itself to be open to your programming.

This, the ability to make an instrument programmable, to give it the ability to encode and remember, was a cosmic leap in engineering, a complete redefinition of what a machine could or should be. It is easy to focus on digital computers' ability to 'compute,' to calculate. But computers are not just calculators. They combine two other crucial elements: they are clocks and they are ledgers, memory

machines that are capable of recording, recalling, and repeating while keeping time and keeping rhythm.

The Banū Mūsā brothers had the necessary imagination to wonder what would happen if they could give a machine memory. In the Round City of Baghdad, a city not even a generation old that had already become the most populous in the world, they did it.

The history of electronic music is a history of origin stories. They repeat and recycle, reaching back further into the past. Techno was rising from Detroit in industrial decline, Kraftwerk was building new sounds in post-war Germany, Leon Theremin in his teenage laboratory, and the Banū Mūsā brothers in the House of Wisdom in 9th century Baghdad.

When I think of the Banū Mūsā brothers, I wish we did not know so little about them. I wish I knew them more fully. I wish I had a sense of their quirks, their banter, their subtle expressions. I want to know what they dreamt about, what they left unfulfilled. We know that there were three of them—Abū Ja'far Muḥammad ibn Mūsā ibn Shākir, Abū al-Qāsim Aḥmad ibn Mūsā ibn Shākir, and Al-Ḥasan ibn Mūsā ibn Shākir, and they lived in the 9th century in Baghdad. We know that their father, Mūsā ibn Shākir, was a highwayman in Khorasan who eventually somehow rose to become a court astronomer of the then Governor of Khorasan, al-Ma'mūn (what a story that must have been). After Mūsā ibn Shākir's death, al-Ma'mūn became the guardian of Mūsā's three sons and then happened to succeed his brother as the seventh caliph of the Abbasid caliphate.

We know that al-Ma'mūn placed the three young brothers to study in the House of Wisdom in Baghdad, where they eventually became great scholars, masters of geometry, engineering, and astronomy. Some of the dozens of written works they produced survived. We know their *Book of Ingenious Devices* describes one hundred mechanisms and designs for automata, tricks, and hacks conceived to enthrall and amuse audiences with engineering marvels. Valves spontaneously opening to spout wine when water is poured into a vessel, lamps that dim themselves without human input, automatic cranks, and fountains. We know their *Book on the Measurement of Plane and Spherical Figures* is a foundational work of medieval geometry, and includes proofs previously unseen in the works of Greek mathematicians. And we know that they designed an automatic flute conceived to replicate inputted sequences of music, the first musical sequencer, and arguably, therefore, the first programmable machine.

We only know all of this through scraps. The unlikely paper survivors that accidentally made their way into the right hands: the right monk copying something down, the right scroll spared from a siege, the right academic taking a photograph of a weathered page.

I have always hoped that I will live long enough to see the uncovering of a previously undiscovered ancient library. Hence, the faith that somewhere in the world, buried under asphalt, dirt, and sand, there are the remnants of a structure filled with preserved papyrus, wax, and vellum, so that, if you could dig in the right place, you could read the lost poetry that made us, you could fill in the gaps that dominate our hazy looks backward.

Until then, I try to imagine the Banū Mūsā brothers; I try to invent the details of their lives. When I look at machines that make music, when I twist a knob controlling a filter, plug a patch cable, build a string of code that creates a syncopated avalanche of drums overseeing a dancefloor in the dead of night, I think of them, and try to remember. I try to summon their rhythms, their thoughts, their tricks, as well as the memories of all the other lost inventors that must lie somewhere hidden; the ones whose scraps did not survive, and whose machines lie buried.

who makes the map, makes us

eddie blake and christopher burman

Today, the map lies scattered across billions of data points — infinite subjective views on digital screens, all updating in real-time. Far from being a unifying, stabilising phenomenon as it once was, the map is now fractured. How did we get here, and what does this mean for our worldview?

Arguably, the trajectory that has led us to Uber and Google Maps started when al-Khwārizmī compiled *Kitāb Sūrat al-Ard* (The Book of the Description of the Earth), a book that encapsulated the whole known world into a single edition. Distilling something as complex as the world into a single book was, and still is, a dramatic feat of imaginative abstraction. In that process, the world had been reformed — the territory transposed onto the map. In this essay, we discuss what is so important about the map, how it has evolved, and the unnerving idea that whoever makes the map, also makes us.

The Book and al-Khwārizmī's wider output were highly influential for generations of map-makers. In c. 830, he was a key figure in the production of the pioneering world map commissioned by caliph al-Ma'mūn. In the 11th century cartographical collection, *The Book of Curiosities*,[1] several maps appear to be largely based on al-Khwārizmī's data tables. Similarly, al-Khwārizmī's influential *Zij* — or collected volume of astronomical data — would also prove influential, being republished centuries after al-Khwārizmī's death in the *Toledan Tables*, a key source for medieval astronomy.[2] What made al-Khwārizmī's map-making influential wasn't the visual representations, or even the visible graphics at all, but the way he calculated data and articulated new mathematical tools.[3] His contribution was the

"The World map of the Caliph al-Ma'mūn," 833 Kitāb Masālik al-Absār by ibn Fadlallāh al-Umarī (d. 1349), MS 2797/1 Ahmet III Collection, Topkapı Sarayı Library, Istanbul

unseen infrastructure, the dark matter of coding, which underpins a map's visual representation.

Al-Khwārizmī's expansion of spherical trigonometric techniques, in turn, enlarged the measurable world as foundational tools in mapping and projection for a millennium. Perhaps the foremost practical aspiration of his time was to find accurate calculations of Qibla:[4] the direction of Mecca. But the underlying logic of this practical application from the Middle Ages also lays the groundwork for the contemporary mathematical operations which underpin data processing within Geographic Information Systems (GIS) and more broadly across Geodesy.

Fluency with algebraic calculation, knowledge of gnomonics (the design of sundials), astronomy, and the astrolabe (the design of mechanical models of the universe) is what enabled al-Khwārizmī to compile such accurate data. Taken together, we may consider his prodigious output of mathematical knowledge an embryonic foray into the production of big data—from abstract foundational trigonometric values to astronomical data and cartographic locations. Such data would ultimately become the basis of how the world is ordered. In al-Khwārizmī's work, we can see an early expression of the now commonplace powerful relationship between reality, abstraction, and data.

While superficially neutral surveys of ground truth, maps are of course anything but ideologically passive. Architects and urban planners instinctively separate the idea of the map from the most fundamental tool in their work, the plan, but it may be more instructive to consider them as connected cousins. Understanding the differences between the map and the plan is not immediately obvious. In fact, they can be superficially indistinguishable. Both represent less than what is actually there, by distilling information and setting up a hierarchy of what is important or not. There is a difference of intent also: plans are

1 Yossef Rapoport, Emilie Savage-Smith, *An Eleventh-Century Egyptian Guide to the Universe, The Book of Curiosities*, Brill, 2014.

2 Gerald J. Toomer, "Al-Khwarizmi," in Charles Coulston Gillispie (ed.), *Dictionary of Scientific Biography*, vol. 7, Gale Cengage, 1981.

3 Ahmad ibn Yahya ibn Fadlallāh al-Umarī, "The Mamunic World Map."

4 Edward S. Kennedy, "Mathematical Geography," in Roshdi Rashed (ed.), *Encyclopedia of the History of Arabic Science*, vol. 1, Routledge, 1996.

propositional, maps are descriptive. The map is a space in which we share the location of discovered objects. The plan reveals the order of things that have been or will be arranged.

Historically, map-makers refined the boundaries between what was known and what wasn't. What existed outside — *terra incognita* — constituted a call to discovery and imagination. As far-flung cities entered geography, they became elements of military strategies and trade networks. All places were once uncharted space. The map makes room for the plan.

A map is a series of symbolic gestures, a series of tricks and abstractions; scale, symbols, keys, orientation, all work to quickly communicate something unfathomably complex. These tricks work through a kind of map infrastructure, made up of projections, grids, and tabulated data. Yet, in the age of screens, we have another conceptual leap to make: resolution. It is the measure of an image, which quantifies how much information exists in a space. It is an estranged cousin of scale. When we can zoom and scroll, suddenly resolution becomes the key quality that allows us to see through the layers of representation and glimpse the data beneath. The higher the resolution, the closer to reality we get. But even at the highest resolution, the map doesn't become the territory.

Comparing 'the map' and 'the territory' is a philosophical issue as old as mapping itself. It is possible to forget that the elementary difference between the two is that 'maps' exist by virtue of a trick — by mathematical projection — abstracting the near-spherical earth into a two-dimensional geometry. This process is an example of the human capacity to abstract, simplify, and approximate. So, when we ask "who makes the map" we are also asking what kind of abstraction is taking place. Grids, coordinate systems, and projections do not physically exist out there

in hard reality. They occur in the conceptual space of possibilities in which geographic knowledge exists.

In Islamic medieval maps, the earth is most commonly shown as a circle, sometimes an oval, only occasionally a rectangle.[5] The circle usually showed the poles reversed with the South at the top and represented a simplified projection of the single hemisphere that was believed to be inhabited. In this graphic construction, we can see what the map-makers' contemporaries believed the world to be like, and perhaps what they wished the world to be like.

the shape of the earth

In *The Book of the Description of the Earth*, al-Khwārizmī expands directly from Ptolemy's contributions to cartography and the original invention of the science of geography. *The Geography* of Ptolemy (and, in turn, al-Khwārizmī) locates objects and places in relation to the whole, across the unfolded surface of the planet, rather than with each other. Ptolemy also proposed several map projections, the most complete attempt to systematise the coordinates through which places might be located.[6]

Geography, in its classical form, was the study of where things are relative to the greater planetary whole, rather than each other. For al-Khwārizmī, his map data could represent something akin to an objective grounded truth about the world, which could be continually refined and made more accurate. Any map, however, encodes a world view — co-locating the viewer and the observed — guiding the reader through a territory and, therefore, inscribing it. In turn, the map reshapes the represented territory.

A feature of our contemporary world so comprehensively mapped is that there is no outside to the geographic boundary of knowledge. Instead, the focus of analysis is on charting all things and their interactions, all the time. The binary between mapped and unknown gives way to refresh

5 Cyrus Alai, "Mapping the Mediterranean: By the Cartographers of Medieval Islamic Societies," in *Journal of the International Map Collectors' Society*, March 2018, no.152.
6 O.A.W. Dilke, "The Culmination of Greek Cartography in Ptolemy," in J.B. Harley, David Woodward (eds.), *The History of Cartography Volume 1: Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean*, The University of Chicago Press, 1987.

rates and image analysis artefacts. When did we last scan how reliable is the algorithm? The 16-inch pixels of the GeoEye-1 satellites give way to the 1cm-per-pixel resolutions of real-time drone feeds and hungry laser-focused eyes of autonomous vehicles.

Contemporary neurobiology can shed light on this subject. How we conceive of space, increasingly appears to inform how memory and knowledge are structured in our brains. The rife spatial metaphors throughout language seem to stem from the map-like structures of memory. We can see this demonstrated in the physical neural mechanisms at play in the most basic functions of perception such as neurons known as grid cells and place cells. These neurons, roughly speaking, allow us to orientate ourselves, and help us locate things respectively.[7] A core difference between these two neural architectures is that place cells encode specific objects and landmarks in relation to each other, while grid cells operate as a hexagonal coordinate system. Here, in the most basic unit of our cognition, is the basis for the map and the plan.

über alles

One might assume that al-Khwārizmī was familiar with the politics that enabled his scholarly pursuits. His work was underwritten by the patronage of the caliph and the House of Wisdom. The work was at the core of a top-down cultural and political programme to absorb and develop the knowledge of the Hellenistic world initiated by the caliphs, the so-called 'translation movement.' The maps not only encode a worldview, but project an idea of worldly power.

No matter how abstract the field one works in, it is inevitably tethered back to the social reality of a political context. Today the equivalent of al-Khwārizmī's work is being carried out by the software engineers and data-wranglers of planetary-scale platforms such as Uber.

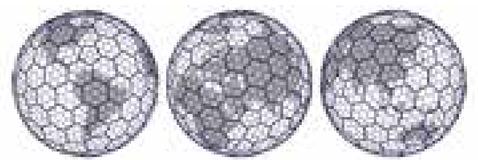
7 Jordana Cepelewicz, "The Brain Maps Out Ideas and Memories Like Spaces," in *Quanta Magazine*, January 14, 2019.

Alongside its core businesses, Uber has played a key role in the engineering of rapidly scalable data infrastructures. In the past few years, Uber has been broken and reformed by its own popularity. As user numbers exploded, the vast number of trips and locations flowing through the core technology meant that the infrastructure had to be rebuilt. The Uber app originally spawning from a single monolithic codebase was 'rearchitected' into a distributed system of robust 'micro-services.'

This was a daunting task given the scale of its operations, but one that has attracted many of the world's most capable developers. One output has been H3,[8] a new approach to global mapping utilising nested hexagons (and pentagons) to form a universal grid system that scales for the entire earth without the exaggerated extremes of other cartographic projections.

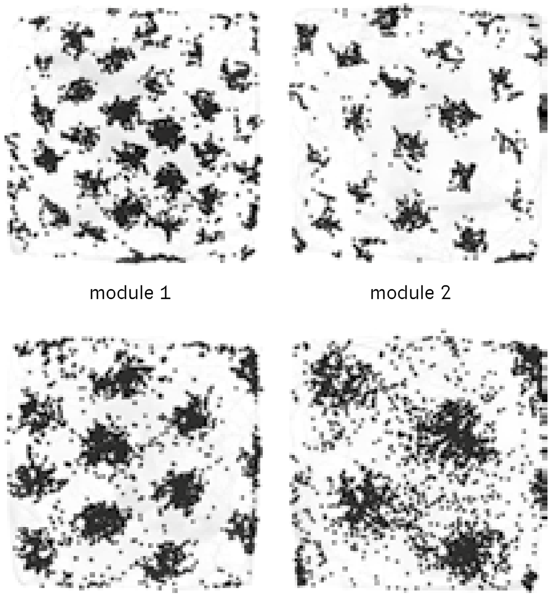
H3 is an example of a "discrete global grid system."[9] Such grids are generated by "recursive tessellation" so that each scale or resolution of the grid is formed of nested smaller versions of the same pattern, allowing for theoretically infinite scaling while using grid elements of different sizes within the same mapping. So, for instance, a large empty region can occupy far less of the memory overheads compared to a dense city. Hexagons (rather than squares) allow for a much faster computational addressability by storing every location with a single 64-bit integer, as opposed to longer and more computationally costly latitude and longitude. These hexagons also help compensate for a problem within urban data visualisation at the scale of street networks. The problem lies in using a square

H3: Uber's Hexagonal Hierarchical Spatial Index



8 "Hexagonal Hierarchical Geospatial Indexing System," 2018, *h3geo.org*.

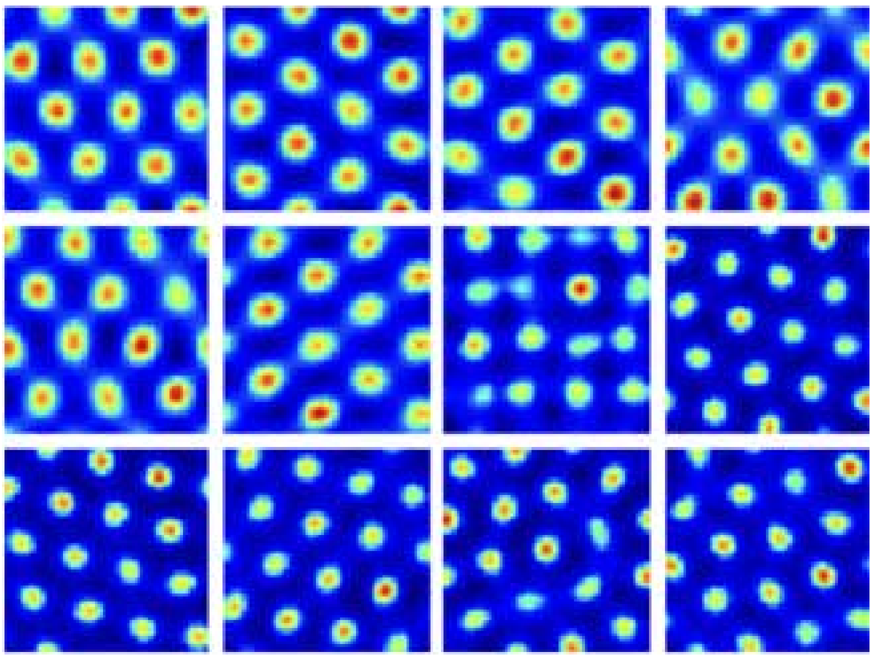
9 "OGC DGGS Standards Working Group," *www.ogc.org/projects/groups/dggsswg*.



left
A unified theory for the origin of grid cells through the lens of pattern formation, Ben Sorscher, Gabriel C. Mel, Surya Ganguli, Samuel A. Ocko. 2019, Advances in Neural Information Processing Systems 32 (NeurIPS 2019). Results of multi-grid pattern forming dynamics with nonnegativity constraint show regular hexagonal grids across multiple spatial scales

— 25 cm

below
Grid cell firing patterns; bird's eye view. See Tor Stensola and Edvard I. Moser, "Grid Cells and Spatial Maps in Entorhinal Cortex and Hippocampus," 2016



grid to distribute data coordinates when overlaid with cities built according to particularly strong grids. This problem gets worse if the grids nearly align.

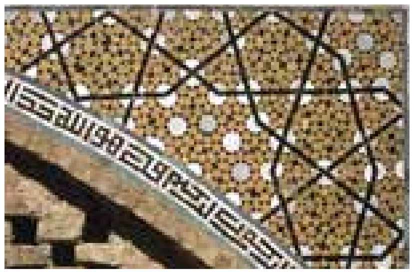
H3 anticipates a world where data production continues to explode, driven by an exponential growth in sensors and cameras required for automated vehicles. Crack open the boot of Uber's last generation of experimental autonomous cars and you will find a colossal rig of CPUs, GPUs, and storage processing data points so numerous that wireless networks cannot currently provide the bandwidth to fully transmit them. This is the engine of the next cartography, underscored by machine intelligence.

Uber's mapping system — and even perhaps the images of our neural grid cells — are curiously reminiscent of the geometric patterns found within Islamic architecture. The earliest examples of this hexagon-based pattern first appeared towards the end of al-Khwārizmī's life in 836 at the Great Mosque of Kairouan in Tunisia. It has been argued that the emergence of such patterns was influenced by the work of al-Khwārizmī and his contemporaries to reinterpret and expand upon the mathematics of Euclidean geometry,[10] especially within the context of Islamic cosmology. As such we might see maps (and the way they are constructed) as artefacts that allow us to glimpse some of the most fundamental workings of our minds. Understood in this way, maps are part of a cyclical cultural production, where they are both the product and the manufacturer of minds.

Our worldview can appear so stable and consistent with the facts as we perceive them, that it sometimes appears to be as unimpeachable as revealed truth. But by scratching the surface, we find that the underpinning of any worldview is a construct. Through grids, coordinate systems, projections, or tabulated data, we make maps that order, distil, and re-present the world, in turn,

10 Yahya Abdullahi, Mohamed Rashid Bin Embi, "Evolution of Islamic Geometric Patterns," in *Frontiers of Architectural Research*, 2013, vol. 2, pp. 243–251.

altering our perceptions of it. We live in an era when the construction and configuration of such knowledge are undergoing a revolution as dramatic as the original contributions of al-Khwārizmī. We are already feeling the tremors of this reconfiguration. We should pay attention to the construction of this knowledge, because whoever makes the maps, ultimately makes us.



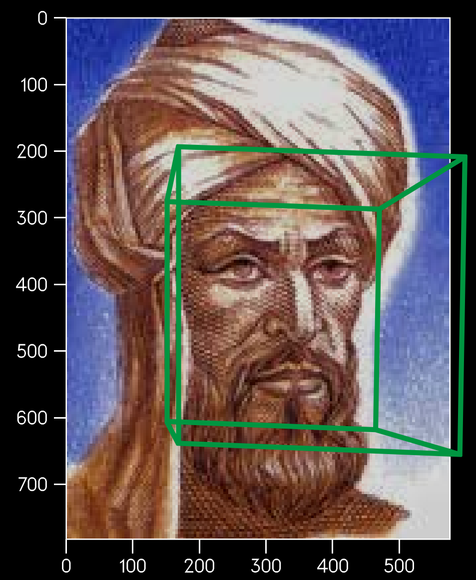
Girih tile subdivision found in the decagonal girih pattern on a spandrel from the Darb-e Imam shrine in Isfahan

Incomplete tile panel (ca. 1430), attributed to Damascus, Syria

Hexagonal pattern bottle, 9th–10th
century, attributed to Iran

3D face reconstruction of al-khwārizmī from 2D images

ali ghomashchi



In this project, multiple state-of-the-art deep learning algorithms were used to generate a 3D face reconstruction of al-Khwārizmī from 2D images.

3D morphable face model

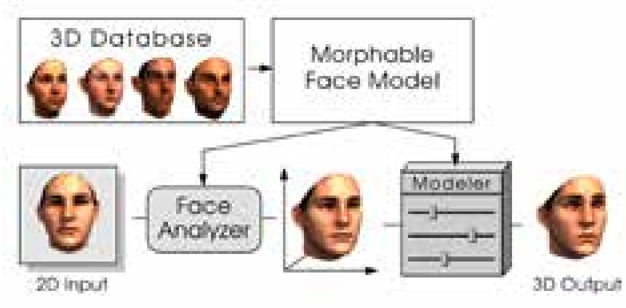
3D Morphable Face Model (3DMM) was first introduced and presented in 1999 by Blanz and Vetter[1] as a tool for general face representation and a principled approach to image analysis. It has been incorporated into many state-of-the-art solutions for face analysis. The 3DMM is a generative model for face appearance and shape that is based on two key principles:

1 All faces are in dense point-to-point correspondences, usually established from a set of example faces in a training stage, and then maintained for further processing. Because of this, linear combinations of faces can be defined in a meaningful way for producing morphologically realistic faces.

2 Facial shape and colour are separated and disentangled from external factors such as illumination and camera parameters.

The continuously improving algorithms and recent advances in deep convolutional neural networks have generated new interest in 3D Morphable Model (3DMM) and facilitated reconstructing detailed human models from single images with impressive results.

1 Volker Blanz, Thomas Vetter, "A Morphable Model for the Synthesis of 3D Faces," in *ACM Transactions on Graphics* (SIGGRAPH '99: Proceedings of the 26th annual conference on Computer graphics and interactive techniques), July 1999, pp. 187-194.



The visual abstract of the seminal work by Blanz and Vetter (1999). It proposes a statistical model for 3D face reconstruction from 2D images and enables controlled manipulation a parametric face space. See: Bernhard Egger et al., "3D Morphable Face Models – Past, Present and Future," in *ACM Transactions on Graphics*, vol 39, no. 5, October 2020, pp. 1–38

face detection and space alignment

This algorithm uses cascaded deep convolutional networks to predict face and landmark locations (left eye, right eye, nose, mouth-left, mouth-right) adopted from Facenet's MTCNN.[2] The pipeline includes three stages:

1 An algorithm employs a fully convolutional network, called Proposal Network (P-Net), to get the facial windows and their bounding box regression vectors candidates. Then, these candidates are calibrated based on the estimated bounding box regression vectors. After that, it employs non-maximum suppression (NMS) to combine highly overlapped candidates.

2 In the next phase, the candidates are then fed to another CNN, called Refine Network (R-Net), which further rejects a large number of false candidates, runs calibration with bounding box regression, and conducts non-maximum suppression.

3 In this stage, the algorithm aims to identify face regions similar to the second stage but with more supervision. The output of this network is five facial landmarks' positions.

2 Kaipeng Zhang et al., "Joint Face Detection and Alignment Using Multitask Cascaded Convolutional Networks," in *IEEE Signal Processing Letters*, vol. 23, no. 10, October 2016, pp. 1499–1503. See also: Jianzhu Guo et al., "Towards Fast, Accurate and Stable 3D Dense Face Alignment," in *Computer Vision – ECCV 2020: 16th European Conference*, Glasgow, Proceedings, Part XIX, August 2020, pp. 152–168.

3D dense face alignment

Facial landmark localisation, known as face alignment and human pose estimation, is one of the most challenging problems in computer vision. With recent advancements in Deep Learning and, in particular, Convolutional Neural Networks, the latest algorithms have shown unprecedented accuracies and have pushed boundaries. The following sixty-eight landmarks and pose estimations have been made using the state-of-the-art 2D and 3D Face Alignment Convolutional Neural Networks algorithms.[3]

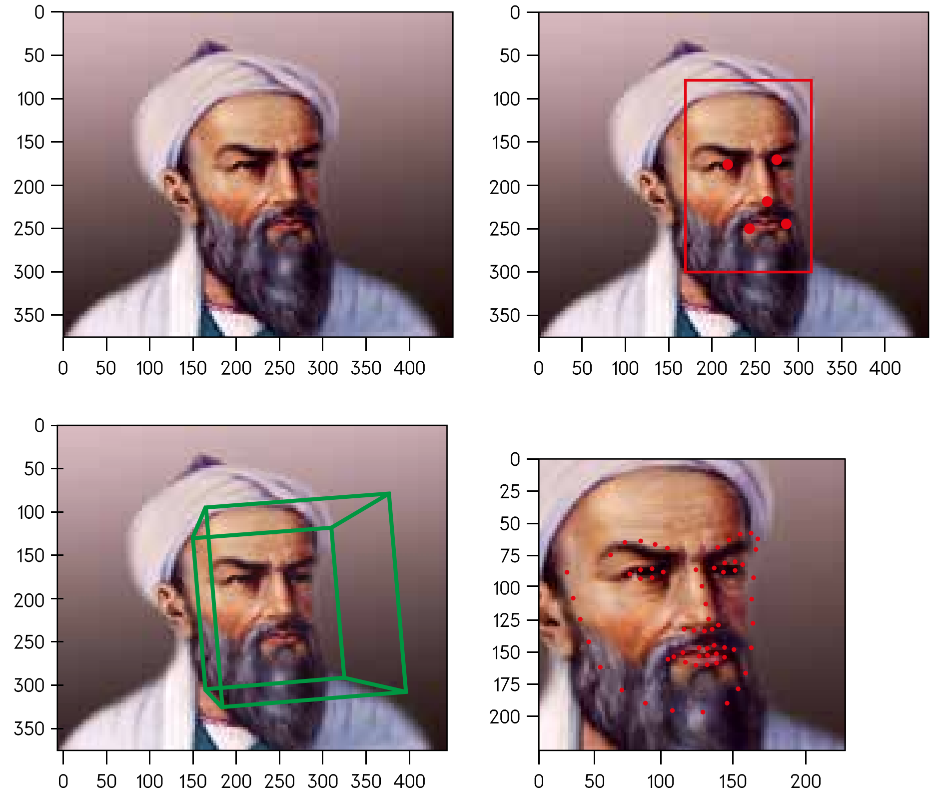
depth estimation and 3D face reconstruction using CNNS

Finally, two state-of-the-art algorithms were used to generate depth estimation, texture mapping, and 3D face reconstruction, both with impressive results.

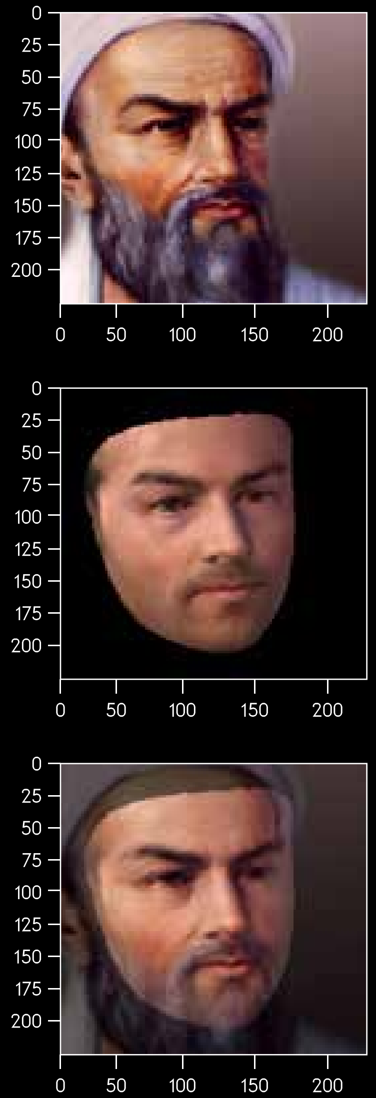
The first method uses CNN to regress coefficients of a 3DMM face model, which exploits hybrid-level image information for weakly supervised learning.[4]

The second method uses a 2D representation called UV position map, which records the 3D shape of a complete face in UV space, then trains a simple Convolutional Neural Network to regress it from a single 2D image.[5]

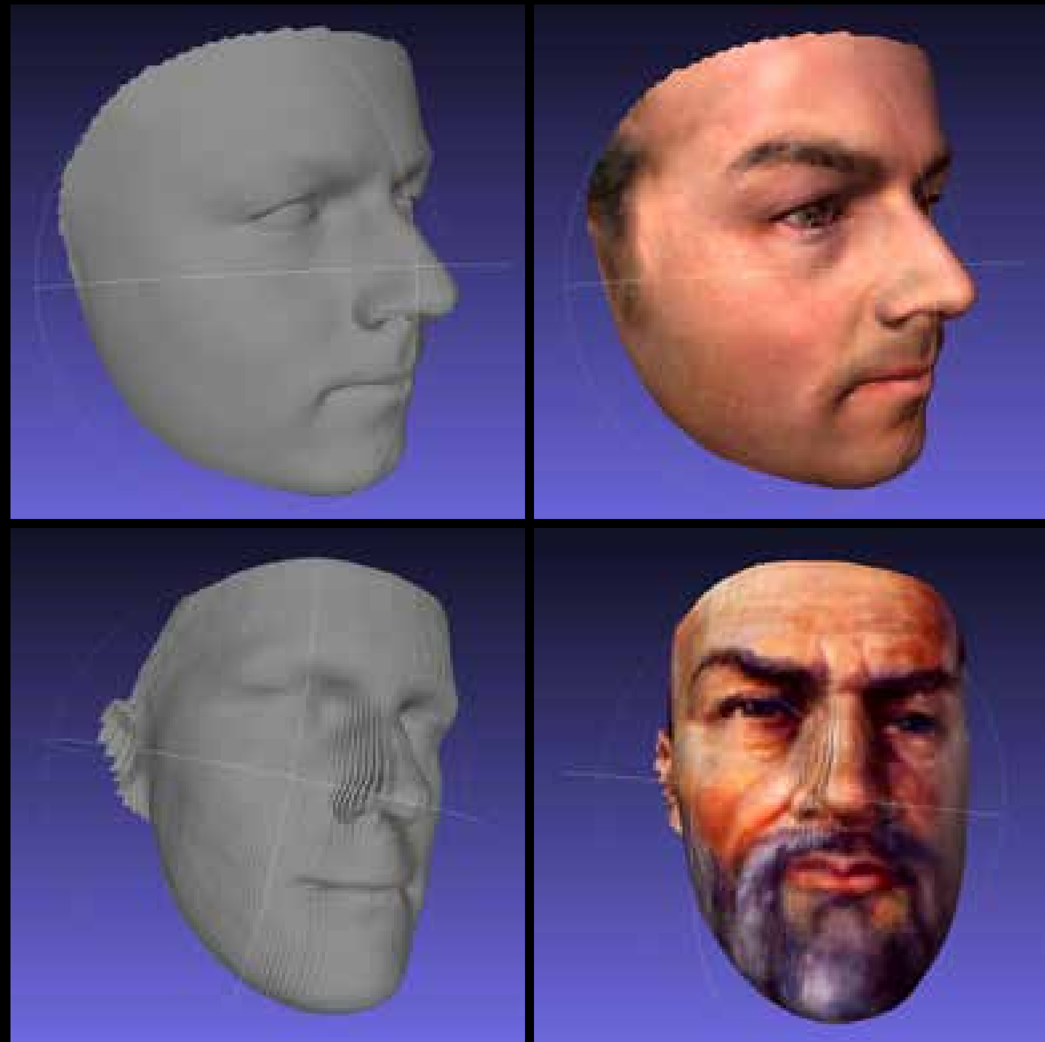
3 Adrian Bulat, Georgios Tzimiropoulos, "How Far Are We From Solving the 2D & 3D Face Alignment Problem?," in *2017 IEEE International Conference on Computer Vision*, 2017, pp. 1021-30.
4 Yu Deng et al., "Accurate 3D Face Reconstruction With Weakly-Supervised Learning," in *2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops*, 2019, pp. 285–295.
5 Yao Feng et al., "Joint 3D Face Reconstruction and Dense Alignment with Position Map Regression Network," in *Computer Vision – ECCV*, 2018, pp. 557–574.



from top left, clockwork
Al-Khwārizmī; Bounding box and facial landmark keypoints; Cropped images after alignment and 68 facial landmark point; 3D pose estimation



Reconstruction image aligned with
the input image using the first method



3D output mesh and reconstructed
face using the first method (*top*),
and the second method (*bottom*)

a labour of translation

ilaria speri

A teacher walks into a library with a class of middle-school students. [Cheerful music] She calls for silence and promptly proceeds to assign a task: each group has to research the impact that a certain era of history had on the modern world. The most fortunate pupils get the Ancient Greeks and Romans, while the last group is allotted a seemingly harder challenge: the Dark Ages. The reaction is immediate: "Boring." The dejected trio makes its way into another room, where a grumpy librarian doesn't seem willing to help: "There never was a period of history so poorly named. And I suppose someone has been filling your heads with the usual nonsense, haven't they? A thousand wasted years, a black hole in history, am I right?" and sends them away.

[Mysterious music] After an impertinent provocation—"Who cares? Everyone knows that the Greeks and the Romans invented everything"—he pulls out an ancient volume bound in leather and gold, which once thrown onto the table, comes alive in a sparkling whirlwind of colourful smoke and glittering symbols, enveloping the room. The man is now wearing a turban and a richly decorated costume in place of his suit and tie. [Epic music] "Welcome to the Dark Ages, or as they should be known, the Golden Ages. There are things you should know."[1]

Despite the college uniforms, the proper British accent, the dusty wooden furniture, and the obvious soundtrack, the scene depicted is not the start of a new episode of the Harry Potter saga, but the introductory trailer to "1001 Inventions from Arabic Science," a blockbuster exhibition launched in 2006 by the Foundation of Science, Technology and Civilisation in Manchester. The non-profit organisation was founded that same year by a group of British engineers, scientists, and physicians, most of Middle-Eastern and South-Asian origins, with the aim of raising awareness of the creative Golden Age of Arabic sciences. So far, the exhibition and educational project — partnered by UNESCO, among other international institutions — has involved forty cities across the world with an overall headcount of fifteen million visitors (as well as endless engagement on social media).

Such a massive production caught the eye of Sonja Brentjes: a historian of science and mathematics specialised in ancient Islam, operating at the Max Planck Institute for the History of Science in Berlin. Arguing that the exhibition contributors, whom she dubbed as amateurs, "have extracted portions of academic narratives, effectively removed their richness in detail and rearranged them as outmoded tales of glory, success, priority and progress,"[2] she accused the organisers of misleading their audience in the understanding of a far richer, more articulated subject. She then invited historians, scientists, and curators to react to the historical mistakes which were then pinpointed in the resulting project *1001 Distortions: How (Not) to Narrate History of Science, Medicine and Technology in Non-Western Cultures* was published in 2016 as a response to the misrepresentation of the sciences and their histories in various political and historical contexts. Among scientific and historical amendments, the book offers an insight into the struggle of historians against European colonial and neo-colonial narratives that "exclude most people on the globe from any participation in the world's intellectual and technological past and present"[3] and Europe's

1 "About 1001 Inventions," 1001 Inventions, *www.1001inventions.com/about.*

2 Sonja Brentjes, "Introduction: On Narratives of Amateurs and Professionals," in Sonja Brentjes, Taner Edis, Lutz Richter-Bernburg (eds.), *1001 Inventions: 1001 Distortions of Islamic History of Sciences*, Ergon Verlag, 2016, p. 9.

3 Ibid.

resistance to accepting a pluralist historiography of civilisation and modernity — especially when it comes to Muslim contributions.

Among the protagonists of both the exhibition and its counter-book is the *Bayt al-Ḥikmah*, commonly — yet quite arbitrarily — translated as the House of Wisdom:[4] a library, translation agency, and research hub which operated, flourished, and eventually declined between the 8th and 11th centuries under the Abbasid period in the new, magnificent capital of the Arab-Islamic Empire: Baghdad. The vicissitudes, people, and scientific progress revolving within and around this entity mark a period of innovation and progress with no equals, namely the Golden Age that spanned from the 9th to the 14th centuries, in conjunction with the Middle Ages in Europe following the fall of the Western Roman Empire. As we will see later, the use of the term 'entity,' rather than 'place,' is not by chance, as historical accounts do not seem to prove the existence of a single dedicated venue, leaving room for speculation that the House of Wisdom may, in fact, have been a web of numerous institutions, or a constellation of intellectual activities with no particular spatial connotations. It is also important to stress that the term 'Arabic' in this context does not refer to a blood lineage but to the predominant and official language deployed by an entire scientific community of diverse provenience and religion — Muslim, Christians, and Jews from right across the Empire, including Iraq, Iran, Egypt, Syria, and Spain — over some seven hundred years.[5] The result of these exchanges and interactions was immense, and their contributions were decisive for Europe's rise out of the Middle Ages and into that of a scientific revolution.

While the existence of the House of Wisdom as a library would be nothing unique — apart from its enormous potential size, — being rooted in a tradition of private Islamic book collections, the activities that took place within it

4 Lutz Richter-Bernburg, "Potemkin in Baghdad: The Abbasid 'House of Wisdom' as Constructed by 1001 Inventions," in *1001 Inventions: 1001 Distortions*, op. cit., p. 129.

5 Jim al-Khalili, *Pathfinder: The Golden Age of Arabic Science*, Penguin Books, 2010.

were in direct intellectual continuity with the growing expansion of the translation movement that had been operating since the mid-7th century. Led by an unquenchable thirst for knowledge, this movement embarked on the mammoth task of translating the entire scientific literature available from Greek, Roman, Persian, Indian, and Chinese to Arabic (initially via Syriac, an Aramaic language used by Christian Syrians).
Technology played a fundamental role: following the importation of papermaking techniques from China, Baghdad was particularly receptive to the innovation, and the first paper mills had already appeared by the end of the 8th century, facilitated by the abundance of raw materials such as linen and hemp. These were followed by major developments in the manufacturing and binding of books, and in the production of materials such as inks, glues, and dyes. Demand grew exponentially. Thanks to these favourable conditions, brilliant scholars of various traditions were attracted by Baghdad's vitality, where they were now able to engage with each other while building upon a vast, shared, and accessible baseline of knowledge.

After its initial appearance as a private book repository during the reign of Hārūn al-Rashīd, the House of Wisdom developed in a spectacular fashion during the reign of al-Ma'mūn (813–833), whose obsessive intuition to "seek knowledge wherever he could find it"[6] is traceable to varied and semi-realistic reasons, which span from the Abbasid caliphs' commercial and cultural ties with the Persians, up to the caliph's encounter with the Greek philosopher Aristotle in a dream. In practical terms, indeed, the expansion of the institution was the result of the political, economic, and intellectual conditions that afforded its very existence. Among these, there was a system of patronage promoted by the caliph and supported by wealthy administrators, courtiers, and private individuals, who guaranteed

6 Ali A. Olomi, "The House of Wisdom. The Research Capital of the Middle Ages," (podcast), 2021, *www.wonderspodcast.com/house-of-wisdom.*

substantial economic support to scholars, while benefitting from the concrete and profitable advantages of scientific research, as well as maintaining their political influence within the caliph's entourage.

Decades after the birth of Islam, al-Ma'mūn sympathised with, and later officially embraced, the Mutazilite movement: a school of rationalist thoughts aimed at harmonising religion and reason, as well as envisioning indeterminism and the notion of free will. In this light, and in accordance with the religious duty to seek enlightenment, the caliph's ambition was to enhance the understanding of the Koran through the expansion of knowledge of *alsamawāt* and *wal'arth* (the heavens and the earth).[7] Al-Ma'mūn himself fomented this spirit of curiosity, tolerance, and open-mindedness that would foster scientific investigation in an unprecedented way. It was al-Ma'mūn who enrolled two of the most illustrious thinkers of his time to lead the development of the House of Wisdom and its production: Abū Yūsuf Ya'qūb ibn Isḥāq al-Kindī and the Persian Abū Ja'far Muḥammad ibn Mūsā al-Khwārizmī, who respectively went down in history as the first Arab philosopher and as the father of algebra, among other things. For many years, knowledge underwent a process of systematisation and absorption, and the attempt to create links between Hellenic, Platonic, and Aristotelian thought with Islamic principles led to robust intellectual movements. Theology and philosophy became a possible path by which to access the divine.[8]

Historical accounts and reports handed down over the centuries have to be treated with extreme caution — a striking example: the participation of female scholars in the House of Wisdom, as depicted in "1001 Inventions," "can safely be relegated to the realm of the imaginary."[9] Nevertheless, the absence of evidence does not constitute evidence of absence. Far from the mires of historical

7 Jim al-Khalili, *Pathfinder*, op. cit.
8 Ali A. Olomi, "The House of Wisdom," op. cit.
9 Lutz Richter-Bernburg, "Potemkin in Baghdad," op. cit.

punctuality, what may be interesting to glean from the lack of information is what concerns the architectural features and dimensions of the House of Wisdom as a space (or as a network of spaces) as it allows us to break away from contingency and focus on the methods and processes underlying its existence as a self-transforming and transformative entity, as a living organism. The mythological allure that still surrounds it testifies not only to the concrete scientific achievements in themselves but also to the conditions that allowed those very achievements to germinate, mistakes and all.

The precious intuition — or inevitable choice? — of the translation movement was that the act of translating was not to be intended as a mere transposition of content but as a continuous process of revision, comparison, completion, discussion, correction, evolution, and dissemination of knowledge. Inheriting the practices of *kalām*, a form of dialectical argument deployed by early Muslim theorists, their practice envisaged a close relationship between research and technology, along with mutual exchanges and practical applications, in keeping with a "spirit of rational inquiry,"[10] surprisingly akin to what we know as the modern scientific method: an approach to investigating phenomena based on the gathering of data through observation and measurement, and the subsequent formulation and testing of hypotheses. Accessibility was also at stake. It is mind-blowing to think of al-Khwārizmī's choice to elaborate mathematical treatises in prose, including numbers: a way to make science readable even to those without specific knowledge outside that of written Arabic. An act of care, a declaration of intentions pointing toward the future. A labour of translation.

For its natural outcome in the written form, the transmission of scientific knowledge is an effective tool for the understanding of historical circumstances across various

10 Jim Al-Khalili, *Pathfinder*, op. cit.

civilisations. However, it is interesting to notice that at the times of the House of Wisdom, poetry and mathematics were deeply intertwined, and the discipline of Arabic grammar was reaching early maturity. The relationship between words, languages, and sciences continued to change in shape, as did meanings along with it. Despite — or because of — being intrinsically embedded in temporal, spatial, and cultural disconnections, translation can function as a framework to echo, reverberate, and disclose stories "by means of reframing an entire environment, and provide an afterlife to a specific narrative."[11] This act of mediation/translation is made possible in the presence of certain enabling conditions, unsurprisingly similar to those handed down by the scholars of the Abbasid period in Baghdad: safe and diverse spaces of togetherness, freedom of research, interdisciplinarity, absence of censorship and self-censorship, "universal reach and syncretism."[12]

Samir Kassir was well aware of the continuous nature of the human path, and he outright refused the tendency to break down history into sealed compartments of defeat or success. In his latest contribution *Being Arab: The Arab Malaise*,[13] Kassir draws a conceptual line that from the splendour and following decline of the Abbasid reign led up to *al-Nahda* (Arab awakening), the period of great cultural vitality that involved the Arabic-speaking countries of the Ottoman Empire in the mid-18th and 19th centuries. In particular, he highlighted the role of the enhancement of written Arabic in the process of contamination with other cultures. This period, once again, saw the proliferation of lexicographers, translators, and polygraphs, who expanded the language in order to welcome new words and concepts to reflect the latest intellectual needs of the people. This experience provides a valuable suggestion in terms of methodological approaches and research paths to pursue: among

11 Lina Mounzer in "Thinking Through Crisis: Heritage, Mediation and Translation," tba21 on_stage (podcast), s02e04, May 31, 2021.

12 Samir Kassir, *Considérations sur le malheur arabe*, Actes Sud, 2004.

13 For two decades, the historian and journalist Samir Kassir (1960–2005) devoted himself to the intellectual and political life of Lebanon. He was murdered on June 2, 2005 in Beirut. *Being Arab* was his last book.

the tangible beneficial consequences of this process was the exponential enrichment of the region's long history of poetry, and the new opportunities provided for less-explored literary genres, such as the novel.

Whenever its appearance, we can assert with some degree of certainty that the House of Wisdom fell into ruins in 1258 during the siege of Baghdad at the hands of the Mongolian army. Merely according to legend, but too poignant not to be reported, it is said that during the destruction of the *Bayt al-Ḥikmah*, so many manuscripts fell into the Tigris that its waters turned black from the ink. The knowledge it managed to produce, however, did not wash away. All it takes is the will to read.

probability walk

michael kessler

Before the thinking mouth, through the lowered larynx emanating sounds capable of resolving signs of objects as sequences of vowels and consonants, the body functioned as a primary medium for conveying information. Poetics of the body are based on the spatial distance to the Other: the white eye skin that encloses the gaze inspects the visual field of the opposite; the twitching of the muscles, the pulsation of the guts, the rhythm of the gait, and the movement of the hands are modules that work together, providing information about the affective semantics of physical actions. As the organism is gradually transformed through changes in the environment and interactions with objects, the control of the body in rhythmic walking creates a sense of consciousness: the self emerges and sends out its somatic signals.

After a neurological connection is established between the images of the body and the images of things, a ritual is formed as a synchronisation of collective walking. Experience is externalised: the cyclical phenomena of nature is repeated on an abstract level in a space defined by magic demarcation. At first, this bounded area has no real environmental impact; at most, sodium salt, flour, ocher, or chalk mark the holy place. Almost virtually, the field is staked out by the actors who have become aware of themselves, for example in the form of a square or another geometric figure whose centre always remains empty, unoccupied, open as an intelligible abyss, as a thousand-fold beginning. Rhythmic sequences gradually generate the concrete space of the temple, but already the ritual comes as a coded artifact in the world, determined solely by the formalised movements of bodies. It may be that an actor calls four vowels in all the cardinal directions — the air escapes unhindered from the mouth. He thereby designates the knots of the ritual system. In between demonic lines and edges, ghostly vectors, paths, relations, and routes open up. Or he stays in place and turns the grasslands into a circle (loop).

The square creates a new space within the territory, as well as the ability to systematically convey information. The actor participates in an experience that alters the mental coordinates. The world is recalibrated: consciousness changed, a cult established, sacrifices made. Every object on this side of the sensible borders becomes a sacred object, a relic for the future. Participation in this experience in the newly created space penetrates deeper into the entrails of the actors than language ever could. How could language describe a state of being out-of-self in the remote interior that is far from its source? The actors listen in rhythm to each other's bodies, their sound, their movement, their direction, thereby opening up the vibratory field of a mimetic culture. For the time being, moaning, chanting, and poetry arise from ritual dance, the imitative play: prosody is about to emerge.

However, the vowels are already known since the first phonetic marking of the four cardinal directions. Without the trachea narrows, the phonation stream flows out of the pharynx. Added to this are the consonants, the noisy voices that must be overcome while uttering in order to break down resistance; the respiratory flow stops, and the vocal tract is narrowed. Meaningful language happens through rhythmic modules of alternating sounds. Individual syllables are emphasised by higher breathing pressure and prolonged. The tone and its contour structure the voice — the speech

apparatus gets moving. Like the ritual — this feast of the body — and the built space — that hypostasis of cultic practice — language is also an artifact, a foreign body in the vibrating environment. Linguistic communication is the effect of a mechanical syntax consisting of constantly changing fragments of signifiers. The normalised system of the Greek alphabet appears: soon words are written on stone, on wax, on paper, coded in bits and bytes in the sequential change of vowels and consonants. From narration to counting, the transition is effortless: analogous to the letters, odd and even numbers are distinguished (among which are occasional prime numbers, following an order which still exceeds our imagination. The zeta function is still waiting for the singer who sings the praise of her in a dissonant song).

The virus is not the language, but the mind has taken root in it and detached it from the environment. Objects are named. Sign bearers refer to denotations as words, names evoke concepts and meaning. The language itself becomes the tool of meaning — it is spiritualised by it.

In the following episode, spoken language as a sonic memory receives an artificial upgrade through the script. At this point, Andrey Markov appears with his probabilistic chains. In one of these rare marriages of poetry and mathematics, he liberates the text of the poem of meaning. His eyes fall on the code, which even makes possible the transfer of semantic contents to a consciousness: sequences of vowels and consonants and the probability of the next sound type, represented by a character. Each character becomes an independent event, the probability of which is determined solely by the event that immediately precedes it. The text becomes the vibrating body, the physical object, the object among objects in the material world. By this circumstance, the words of a poem unexpectedly become the signposts for the principal mechanisms of electronic and digital communication at the speed of light. Language is atomised, characters reveal a life of their own, sounds point ways into unexplored areas. Not only gene sequences are structured like a language... The world is recalibrated.

Information is collected within a dynamic field in different states. States refer with links to other states, which in turn are linked to other states by hyperlinks. It opens up a possibility space of endless paths. The ritual of the present is thus revealed in this going back and forth between the states, whereby the behaviour of the actor depends only on the state in which he is currently located. The actor of this ritual is memoryless, his desire for physical communication immeasurable.

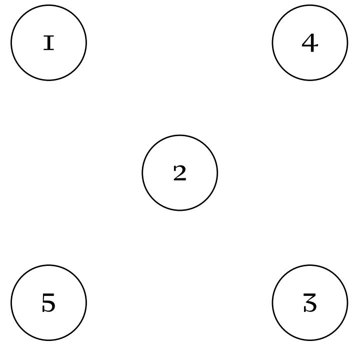
selected sources

Samuel Beckett, *Quad II*, Süd-deutscher Rundfunk, 1981

Andrei Andreyevich Markov, "An Example of Statistical Investigation of the Text *Eugene Onegin* Concerning the Connection of Samples in Chains," Lecture at the physical-mathematical faculty, Royal Academy of Sciences, St. Petersburg, January 23, 1913

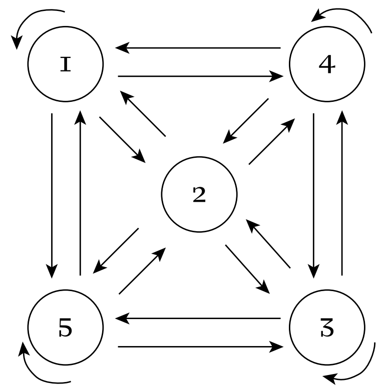
Input graph for n=5 states.

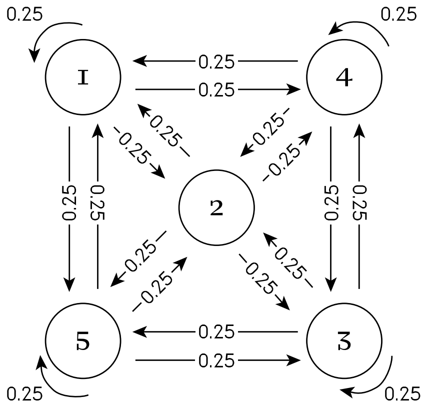
A piece for n players, corporeal or virtual. The players (1, 2, ..., n) pace the given area, which is given by n states numbered from 1 to n.



Hyperlinks between the states.

Between the states there are hyperlinks, which are represented by arrows. They act as possible routes of the players. Each state contains a fixed set of hyperlinks, and each link a reference to some other state. The players move randomly from state to state. However, players can also stay self-referential in their place—except in the centre, which represents the abyss where nobody wants to stay.





Each arrow is assigned a transition probability (p) of 0.25.

The transition matrix specifys the behaviour of each player: each row represents a discrete probability distribution—the entries fully specify the behaviour of the players’ next pace, giving the probability of pacing to each state.

$$
\begin{bmatrix}
0.25 & 0.25 & 0 & 0.25 & 0.25 \\
0.25 & 0 & 0.25 & 0.25 & 0.25 \\
0 & 0.25 & 0.25 & 0.25 & 0.25 \\
0.25 & 0.25 & 0.25 & 0.25 & 0 \\
0.25 & 0.25 & 0.25 & 0.25 & 0.25
\end{bmatrix}
$$

The probability that a player after e.g. 5 courses repeats themselves is $(0.25)^5 = 2^{10}$.

The player can start anywhere, because the probability that a random player eventually winds up on any particular state is the same for all starting states. The iterations are repeated until the first player has visited the same state for the n time. It represents the abort criterion of the piece. The entropy is being maximised. The future can not be repeated.

the incredible story of algo & i

vera van der burg

To create a better understanding of an algorithms' workings, this story explores a possible collaboration and companionship based on mutual learning. This is a story between a self-learning algorithm and a designer.

september 30th, 2018, 21:55

I realised a new species has been created. One that never gets tired, that acts extremely fast, that does not waver by social pressure, has no emotional experience, and no inexplicable intuition. One that, without a grumble, can make a decision. One that can predict action without much interference of its gut. Machines have been created to have the ability to learn, to be taught, to get better over time, without precise instructions. Based on this learning, they seem to make quite reliable, trustworthy decisions on convoluted disputes in human life.

The idea of this 'new species' with their own rules of logic and perceptual systems sounds like an alluring and exciting tool for me to use as a designer. Using an 'external intelligence' and its new ways of 'seeing' the world that comes with it could lead to unexpected forms of interaction — and perhaps new ways for me to see things I might not have seen before. Perhaps it would create a new form of empathy. Perhaps the interaction could teach me about the complex world behind the mathematical code.

On one hand, self-learning algorithms are being applauded, introduced as 'life-improvers,' facilitating or smoothing our daily life. On the other hand, I hear warnings. That we are encouraging our own destruction and heading towards a world in which machines rule because we tend to give these systems a huge amount of responsibility on our lives. The current media landscape regarding Artificial Intelligence is exploding, simultaneously acting as an algorithms' PR agency and their most ruthless critic.

The black-box character of an algorithm makes me feel distanced from this entity that tries so hard to get a close understanding of me and my world. Artificial neurons are programmed to get to know me, yet I do not know them. An externalised cognition that finds its inspiration from my brain — yet my brain cannot comprehend this artificial intelligence. A machine with a mind that tries to find out who I am, yet I have no clue who they are. A neural net that tries to find out what I see, yet I cannot understand what they see. I fear this incomprehension dislikes this mistrust. How can I fight this fear, this distrust of the unknown?

Simultaneously, the black-box character of these systems frightens me. Why do we relinquish decision-making to something we do not genuinely understand? How can we trust these systems if little effort is made to truly comprehend them? I wonder, can I get to know these systems better by doing what I like to do: design? Complementary to this, can I design with these systems? If designing is about finding new ways and new perspectives, can an algorithm help by practicing its set of rules and 'ways of seeing' to existing things?

october 1st, 2018, 11:40

As human beings, we tend to empathise and attribute human characteristics towards nonliving, non-human things. Anthropomorphism is a natural tendency that makes us see faces in sockets, smiles in car-fronts, and stroke our laptop while crashing in the hope it will reboot. It is exactly this anthropomorphic tendency that can lead

to misconceptions on what machine learning should be able to do. Self-learning algorithms are increasingly being used to replace human-like tasks, and with this comes the inevitable tendency to appreciate them as if they need to act, and therefore work exactly like us. I find the use of 'human' terminologies like 'learning' and 'intelligence' quite misleading. This assumes that when the machines perform as a human, then they would be a human.

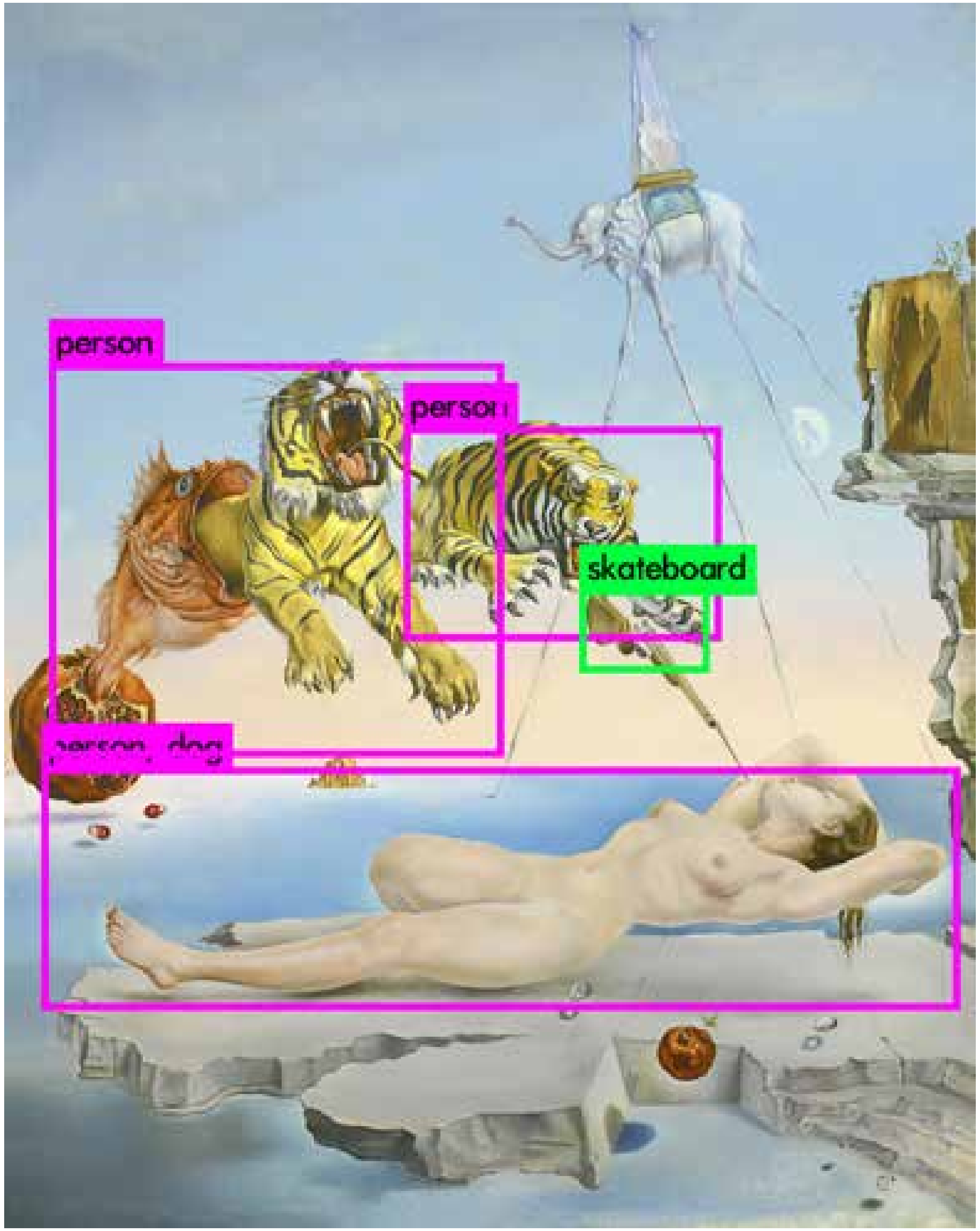
If machines can execute similar tasks as humans, such as driving a car or recognising a face, that does not inevitably mean they are 'intelligent' or 'like us.' It just means that these systems operate in the way they are supposed to. The question of whether an AI is 'intelligent' is, therefore, a pointless question or, at least, a question I cannot answer. Machines are not people and perhaps I should not expect them to be.

However, anthropomorphism can contribute to the establishment of a relationship between a human and non-human agent. Thinking of an algorithm as being a little creature makes talking about it easier and probably talking to it as well. I might enjoy this algorithm more if I imagine it is alive.

october 1st, 2018, 11:50

I gave my object recognition algorithm a name: Algo — so the communication would proceed in a friendly and personified way. To provide Algo with the knowledge I thought it needed, I consulted the internet to hunt for a dataset. A dataset of images to be precise, this being the medium through which Algo understands and learns. I found an open-source, pre-curated dataset filled with objects of mundane design to train Algo on, ranging from chairs, tables, lamps...

I felt ready to start communicating with Algo and perhaps share our mutual interests in design objects.



To start this communication, I showed a photo I made of a small chair to his freshly trained network and asked him a simple question: "what do you see?" The photo did not depict the most conventional chair, but one that every human being would be able to recognise as the construct of a 'chair.'

After presenting the image to Algo, something peculiar happened. Algo pointed out that he saw a chair. However, he also distinguished four other objects in the photo that I had not seen myself. Additionally, he gave the objects a ranking order, backing it up with a certain statistical prediction. "Chair" was at number two with only 8.6% certainty. It was easily surpassed by "Knife" (76.5%), but the probability that he saw a chair was still higher than seeing a "Kitchen" (6.8%), "Tulip" (5.5%), or "Rose" (1.73%). Recognising an object in a probabilistic sense was a phenomenon that was new for me, as a human.

october 6th, 2018, 09:30

I had to take a step back and reflect on what Algo was trying to say to me. I started to think about Algo's early form when he was just a numerical structure, an algebraic code without any data to learn from. I went back to the moment that I trained Algo on the pre-curated dataset. This was the moment I gave Algo knowledge, a world to learn from. This pre-curation of the visual imagery found in this dataset was something I had taken for granted. In other words, I had assumed that the category that was labeled "chair" would be filled with photos of chairs and not with, say, cats. If my assumption had been wrong, however, Algo would not know any better than chairs being cats. Therefore, if I would create a dataset, or knowledge-world for Algo, it would be up to me to match the right label with the corresponding images in order to resemble my own perceptual world.

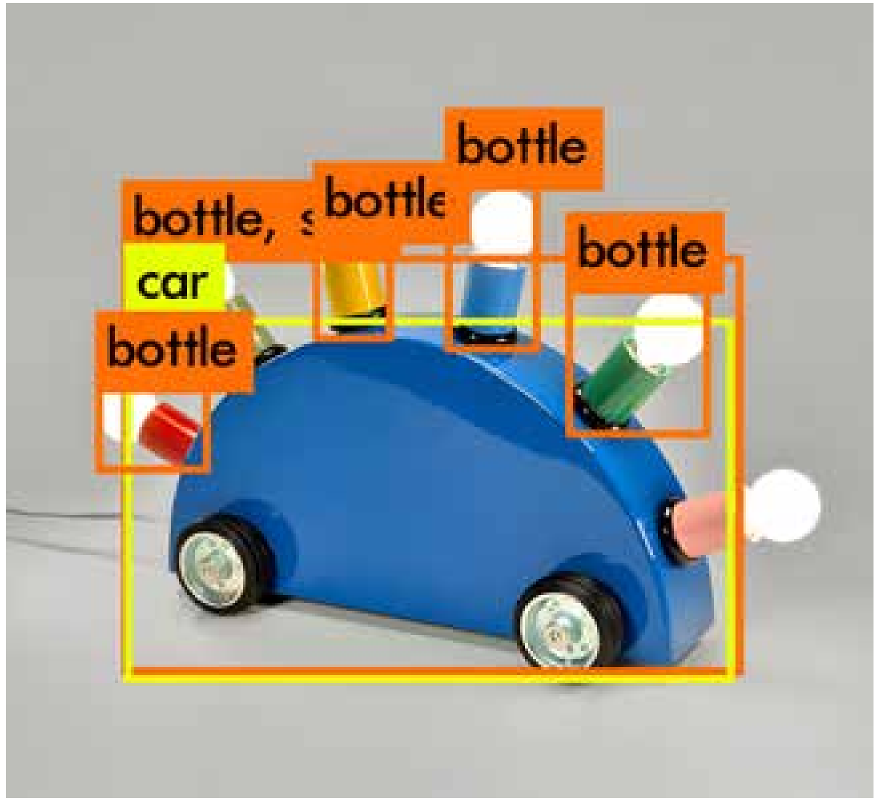
During our communication about the image of the chair, I wondered: was the role of Algo an autonomous one, or was it solely myself acting in the process? Did Algo actually speak to me, or did it just communicate what I taught him back to me? Did I actually speak to myself, while Algo did nothing more than reveal a pattern?

Then it hits me. In the end, I was the ultimate creator and master of Algo's world. I had the powerful position to decide what Algo knew and could know about my perceptual world. If I wanted Algo to think that chairs were cats, I could present him with data and train him on this. He would, with no questioning, believe me. This got me thinking about the nature of our conversation. The conversation that we had up until now was not a conversation with Algo, but a conversation with myself—mediated by Algo.

october 27th, 2018, 15:00

If the conversation between myself and Algo was actually a mediated conversation with myself, I figured that if I would continue this process, I could make it a bit more interesting. Perhaps, I could learn something about myself through the eyes of Algo. Therefore, I wanted to adapt Algo's dataset into one that was more subjective and fine-tuned towards my own ideas and my own concepts. Perhaps, I could make it so subjective that it could resemble my emotions—or at least my emotional view of the world.

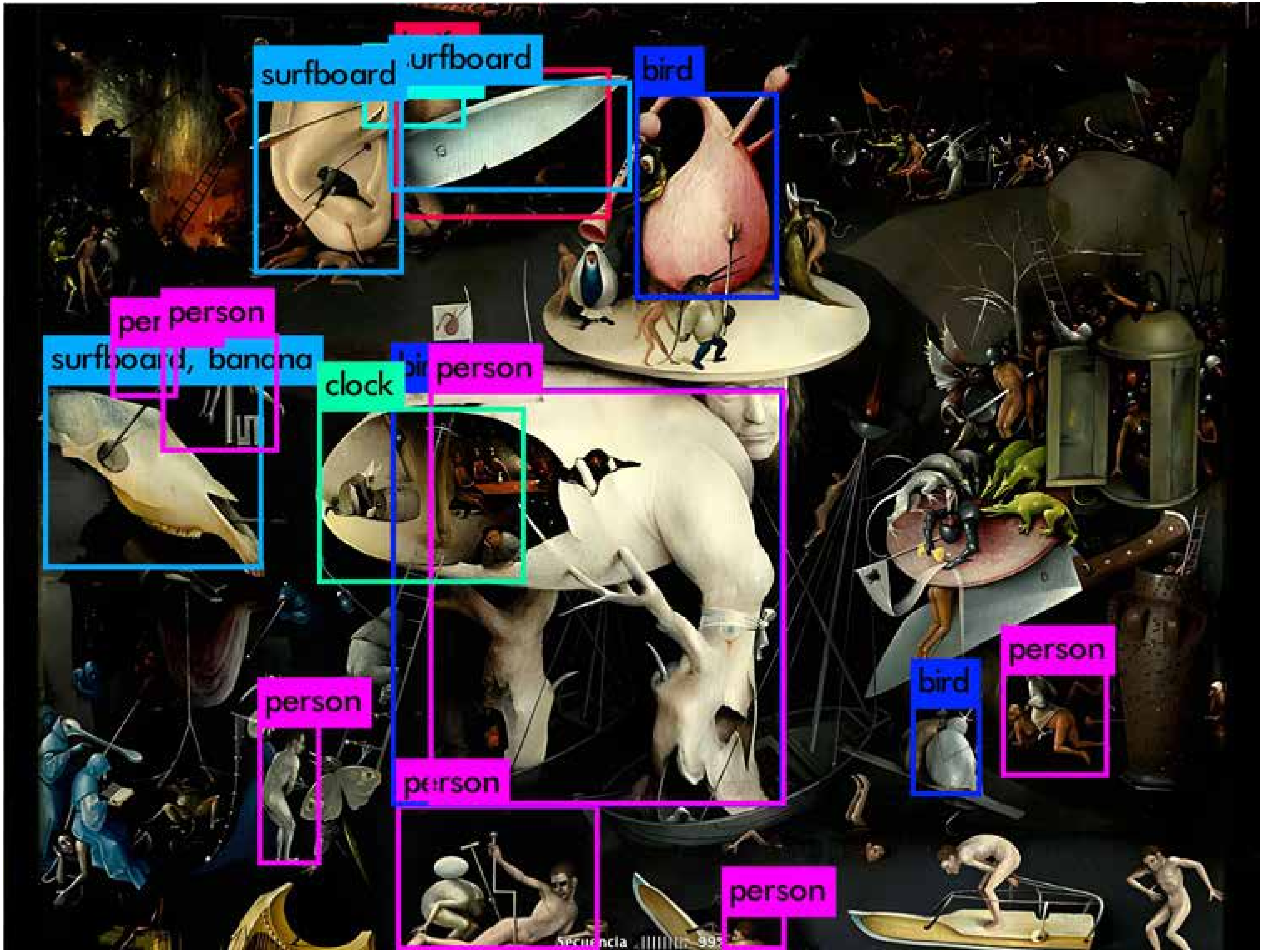
Instead of working with objective constructs like tables, chairs, knives—the mundane objects—I chose to work with emotional concepts like love, jealousy, intimidation, and melancholia. How to make an emotional dataset? How to train Algo on jealousy? How to train Algo on my jealousy? What images would this category resemble? The answer to that question was up to me. I could let my imagination flow and find visual imagery that would, according to only me, suit these new categories.



october 28th, 2018, 09:02

A hunt for images started. I searched the deepest corners of the internet to create emotional datasets, bearing in mind: the bigger the dataset, the better Algo becomes in performing its task. Each time I found an image, I asked myself: to what emotional category would this one belong? Does it resemble love, hate, or loneliness? Or is it shame, or wrath?

After selecting over a thousand new images that all resembled at least one of the emotions I categorised, I retrained Algo on his new, emotional world of knowledge. This training session took longer than the first one. I figured this must have been because Algo had difficulties in finding a convincing pattern in the emotional imagery. This could be because the emotional images were not as coherent as


surfboard
urfboard
bird
per
person
surfboard, banana
clock
person
person
person
bird
person
person
Secuencia

‘objective’ images of chairs or knives, but rather personal interpretations of what the images contained. Nonetheless, Algo always obeyed my orders.

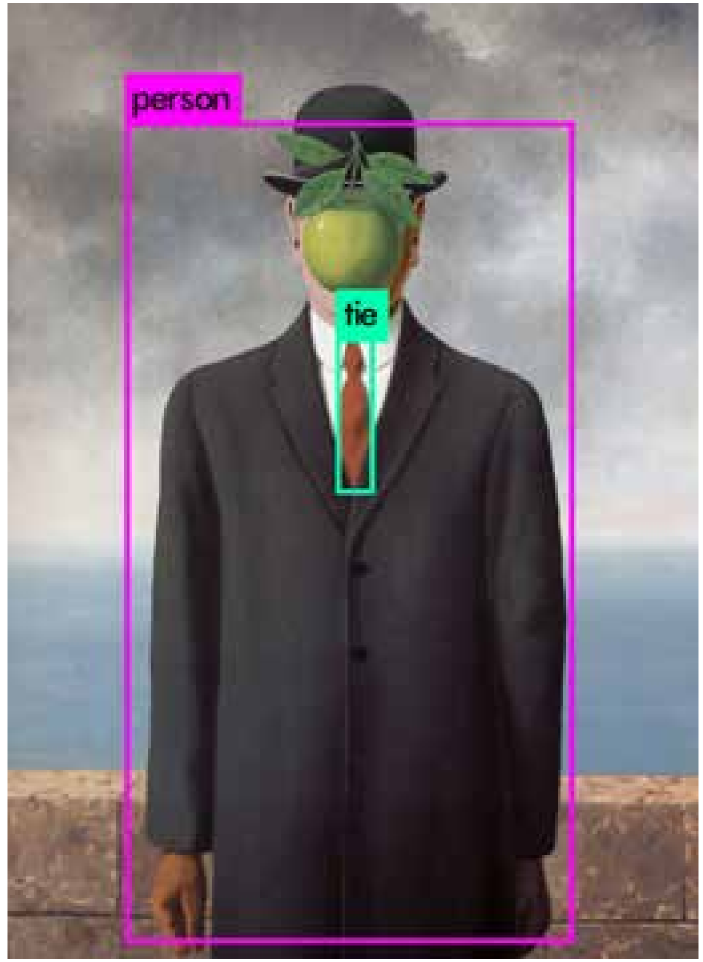
It managed to retrain itself on the new datasets, as it did manage to find certain patterns. To maintain a design of communication similar to the one I had in the first conversation, I presented, again, an image of a chair to Algo as a starting point. Highest value: Perverse = 0.998%. According to Algo, it was a very perverse chair. Or was it according to me?

november 30, 2018, 19:20

In trying to find an ‘objective’ speaker in Algo, I ended up with the most subjective speaker of all. The communication between Algo’s output and my own interpretations resulted in a return route towards myself. I assumed a certain ‘objectivity’ existed within Algo. Something autonomous. Or at least something that operated outside of myself.

I was looking for a voice, Algo’s voice. However, I found out, it was my own. Algo’s knowledge was a reflection of my knowledge. Algo functioned as a mirror I could look into. This mirror did not only show a reflection, but it showed myself from a new perspective, through the notion of pattern recognition. I was able to embed my values and ideas into Algo, only for him to reveal what I did not know about myself. Without me, there is no Algo, but would there be less of me, without Algo? I started to wonder: can I use Algo, not as a tool to design, but as a tool to self-reflect? What if we would rethink how we could train our machines and algorithms while embracing the fact that they can resemble a subjective view, and perhaps help us with getting to know ourselves better?

Relating towards an algorithm as an anthropomorphised companion gave me an insight into his true nature. Algo knew about me more than I ever expected in the first place.



From the beginning he was part of me, therefore, his intentions were always my intentions. Algo lived somewhere inside of me, even though he displayed his performances in the safe environment of my laptop screen. I felt like I lifted the veil of the black box, only to discover a version of myself was hidden under it. Did this make me less frightened, though?

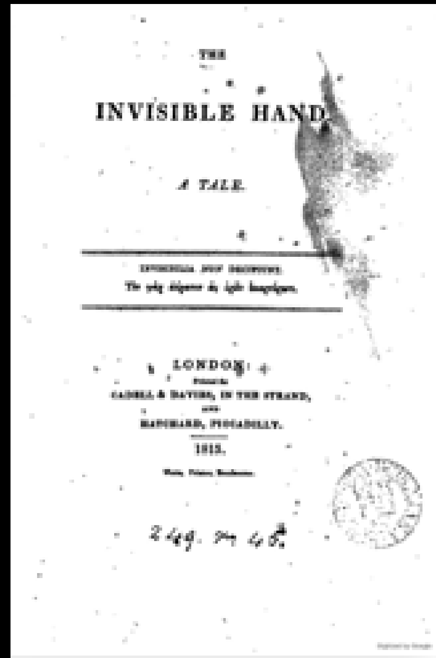
Do I now trust self-learning algorithmic systems enough to work with them in the future? Do I trust myself enough? I realise now, it was never Algo to be afraid of in the first place. It was the one that controlled him. Me.


97% theatrical
perhaps:
I am surrounded but
still I feel lonely
62% self-aware
73% alienated
47% hypocritical
63% modesty
90% levitation
53% control
78% foolish


88% persuasion
86% pride
90% jealousy
74% seductive

a digital genealogy of the algorithm

dámaso randulfe



THE

INVISIBLE HAND

A TALE.

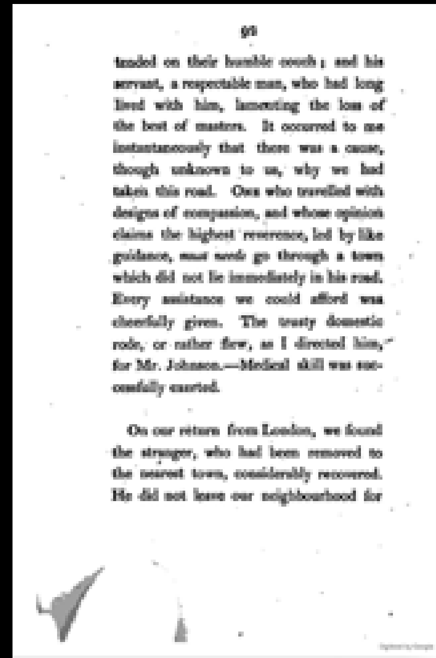
LONDON:

CADELL & DAVIES, IN THE STRAND,

AND

HATCHARD, PICCADILLY.

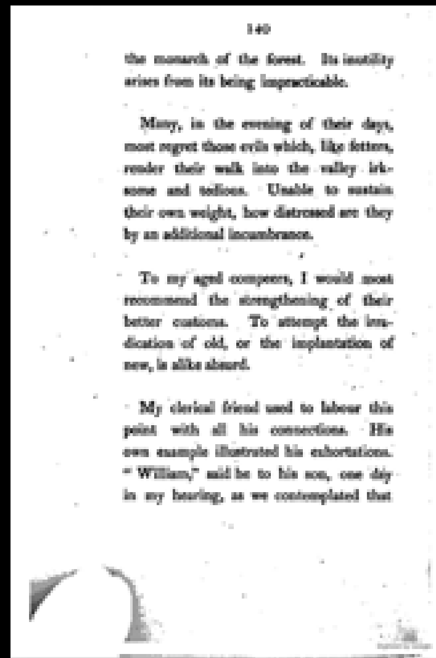
1815.



98

tended on their humble couch; and his servant, a respectable man, who had long lived with him, lamenting the loss of the best of masters. It occurred to me instantaneously that there was a cause, though unknown to us, why we had taken this road. One who travelled with designs of compassion, and whose opinion claims the highest reverence, led by like guidance, must needs go through a town which did not lie immediately in his road. Every assistance we could afford was cheerfully given. The trusty domestic rode, or rather flew, as I directed him, for Mr. Johnson.—Medical skill was successfully exerted.

On our return from London, we found the stranger, who had been removed to the nearest town, considerably recovered. He did not leave our neighbourhood for



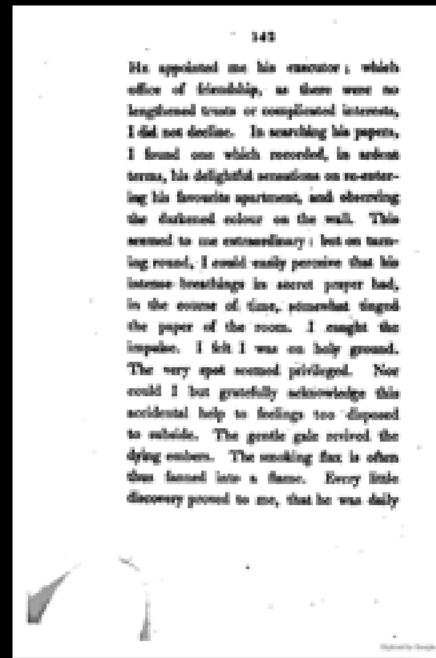
140

the monarch of the forest. Its inutility arises from its being impracticable.

Many, in the evening of their days, most regret those evils which, like fetters, render their walk into the valley irksome and tedious. Unable to sustain their own weight, how distressed are they by an additional incumbrance.

To my aged compeers, I would most recommend the strengthening of their better customs. To attempt the eradication of old, or the implantation of new, is alike absurd.

My clerical friend used to labour this point with all his connections. His own example illustrated his exhortations. "William," said he to his son, one day in my hearing, as we contemplated that



142

He appointed me his executor; which office of friendship, as there were no lengthened trusts or complicated interests, I did not decline. In searching his papers, I found one which recorded, in ardent terms, his delightful sensations on re-entering his favourite apartment, and observing the darkened colour on the wall. This seemed to me extraordinary: but on turning round, I could easily perceive that his intense breathings in secret prayer had, in the course of time, somewhat tinged the paper of the room. I caught the impulse. I felt I was on holy ground. The very spot seemed privileged. Nor could I but gratefully acknowledge this accidental help to feelings too disposed to subside. The gentle gale revived the dying embers. The smoking flax is often thus fanned into a flame. Every little discovery proved to me, that he was daily

"Invisibilia non decipiunt:" the things unseen do not deceive. The motto appears in the title page of *The Invisible Hand*, a 19th-century religious fiction digitised by Google Books.[1] Scrolling through its pages, I notice that some of the scans feature half-moon-shaped shadows at their bottom left margins. Other editions of the same novel, also on Google Books, show variations of these ghostly shapes. They seem to become more frequent towards the end of the book. It is only upon reaching the back cover that I come across the cause of the shadows. Wearing pink finger cots, the hand of a worker hired to turn the pages of *The Invisible Hand* has escaped Google's automatic error detection mechanisms.

This hand turned footnote attests both to the mythical nature of full automation, and to the long-established efforts to erase the traces of human labour in *most* mechanical processes. From the first attempts of mechanising the division of mental labour, "to make machines look intelligent it was necessary that the sources of their power, the labour force which surrounded and ran them, be rendered invisible."[2] Occasionally casting its shadow in the margins of a public domain book, the overworked hand caught by Google Books' scans belongs to the gendered and racialised lineage of what Donna Haraway calls "nimble fingers" that labours invisibly in the integrated circuit.[3]

1 W. Clayton, *The Invisible Hand: A Tale*, D. Longworth, 1815. Available at: *books.google.co.uk/books?id=GHRCqBWSMYAC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=true.*

2 Simon Schaffer, "Babbage's Intelligence: Calculating Engines and the Factory System," *Critical Inquiry*, vol. 21, no. 1, 1994, p. 204.

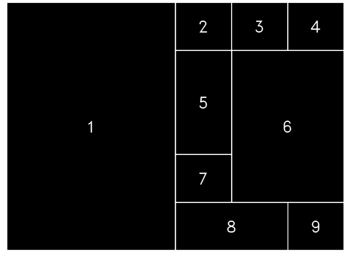
3 Donna J. Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in Id., *Simians, Cyborgs, and Women: The Reinvention of Nature*, Routledge, 1991, pp. 149-181.

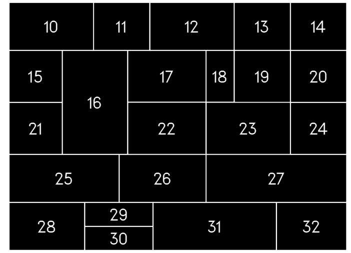
Nimble fingers and hands illuminate the deep history of algorithms and their emergence from "a mundane division of space, time, labour, and social relations."[4] The use of tools and the repetition of sequences of instructions transformed our ancestors' hands and eventually made them human. As Friedrich Engels writes in a famed passage of his unfinished *Dialectics of Nature*, "the hand is not only the organ of labour, *it is also the product of labour*."[5] Hands are more than executive appendages. They are self-reflective limbs that communicate, handle, deliberate, grasp, and think. As the primordial digital organs, hands gave rise to the symbolic form of numbers and abstract calculation techniques. They complicate the opposition of conception and execution, of concretion and abstraction, and blur the clear-cut divisions drawn between manual, social, perceptual, and cognitive labour.

Spanning digital labour and social rituals, histories of automation, mnemonics and divination practices, the following panels of images trace a five-fingered genealogy of the algorithm and the often-invisibilised labour that animates intelligent machines.

4 Matteo Pasquinelli, "Three Thousand Years of Algorithmic Rituals: The Emergence of AI from the Computation of Space," in *e-flux*, June 2019.

5 Friedrich Engels, "The Part Played by Labour in the Transition from Ape to Man," in *Dialectics of Nature*, Foreign Languages Press, 1954, p. 230.





following spreads

plate I
products of labour

1. 40,000-year-old hand stencil, Sulawesi, Indonesia, ph. Kinez Riza **2.** Ifa priest, Oyo, Nigeria, RMN **3.** Vasily Tropinin, *Lace maker*, 1823 **4.** Manufacture of electronic components for the Apollo guidance computer, *Computer for Apollo*, film still, MIT, 1965 **5.** C.W. Wightman working on a prototype for the first Perceptron, Cornell University, 1958 **6.** Weaver setting the loom, ph. Hands Carpets **7.** Hans Hollein, *MAN transFORMS*, 1976 **8.** Marvin Minsky, Minsky Arm, MIT, 1967–73 **9.** Diego Velázquez, *Old Woman Frying Eggs*, c. 1618

plate II
digital algorithms

10. Pieter Aertsen, *Two Women Cooking*, 1562 **11.** Photograph from mobile phone detection camera, Transport for NSW **12.** Egyptian tomb figure of a woman grinding corn, c. 2500 BCE **13.** Map of the Nile from *The Book of Curiosities*, c. 1190–1210 **14.** Ruth Matilda Anderson, *Galician weaver*, 1928 **15.** Palestinian women grinding coffee beans, Library of Congress, 1905 **16.** J. Lomas, *Stirring a cooking pot in Umtali*, Zimbabwe, 1905 **17.** Werner van den Valckert, *A Man Cutting Tobacco*, c. 1600–1635 **18.** *A Man Scraping Chocolate*, NCMA, c. 1680–1780 **19.** Making bread in Oman, *wejhatt.com* **20.** Gerard Terborch, *A Woman Spinning*, c. 1652 **21.** Harun Farocki, *Die Worte des Vorsitzenden*, film still, 1967 **22.** Fishermen making a net in Sierra Leone, c.1910–1920 **23.** Jan Steen, *Baker Oostwaert and his wife*, 1658 **24.** Harun Farocki, *Der Ausdruck der Hände*, film still, 1997 **25.** Werner van den Valckert, *Four Regents of the Groot-Kramergild*, 1622 **26.** Carl Frederik von Breda, *Double portrait of philanthropist Carl Bernhard Wadström and Prince Peter Panah*, 1789 **27.** Display and keyboard of the Apollo Guidance Computer, ph. Draper Laboratories, 1966 **28.** Aktionsgruppe Starbuck, *Rekonstruktion eines Films von Holger Meins "Wie baue ich einen Molotow-Cocktail?,"* film still, 2001 **29.** Papermaking, Kashmir, 19th century **30.** Baker from *Hausbuch der Mendelschen Zwölfbrüderstiftung, Nürnberg*, 1426-1549 **31.** Werner van den Valckert, *Vier regenten en de binnenvader van het leprozenhuis te Amsterdam*, 1624 **32.** Harry Roseland, *The Writing Lesson*, c. 1900

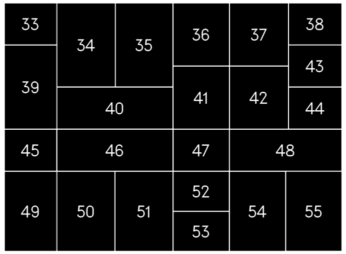


plate III
computation/self-reflectivity

33. Finger-counting, ph. George Marks **34.** A patient with four fingers learning to use them after surgery, ph. Fritz Goro, 1964 **35.** Laurent de La Hyre, *Allegory of Arithmetic*, 1650 **36.** Right-hand rule to determine the direction of wave propagation **37.** Mesoamerican abacus: the Nepohualtzintzin, M.E. Romero **38.** Jacob Köbel, *Merchant Using Abacus*, 1516 **39.** Seed divination, ph. G. Grandidier, c. 1930 **40.** Curta Model 1 calculator, CHM, 1943 **41.** Ifa divination, Ìlá Òràngún, ph. John Pemberton III, 1982 **42.** Khipu from Martín de Murúa, *Historia del origen, y genealogía real de los reyes ingas del Piru*, 1590 **43.** J.B.M. Bourgery, N.H. Jacob, *Traité complet de l'anatomie de l'homme*, 1831 **44.** *Woman Taking Care of Her Nails*, Underwood Archives, 1951 **45.** *A doctor bandaging a man's arm*, Wellcome Collection, 1929 **46.** *Inoculation against the plague in Mandalay*, Wellcome Collection, c. 1906 **47.** *Hanuman revealing Rama and Sita in his heart*, Wellcome Collection **48.** Pietro Berrettini, *Tabulae anatomicae*, c. 1618 **49.** N. Braun et al., "Experimental Inducibility of Supernumerary Phantom Limbs," 2020 **50.** Hand cream application, Kate Whitley **51.** Finger board for stretching contractions, R. Tait McKenzie, 1918 **52.** Robert Florey, *The Beast with Five Fingers*, film still, 1946 **53.** Burnt fingerprints of a migrant in Calais to avoid identification and deportation. From Sylvain George, *Qu'ils reposent en révolte*, 2011 **54.** *Carving out an artificial hand*, Wellcome Collection **55.** Mirror box used in the treatment of phantom limbs. From V. Ramachandran, D. Rogers-Ramachandran, *Synaesthesia in phantom limbs induced with mirrors*, 1996

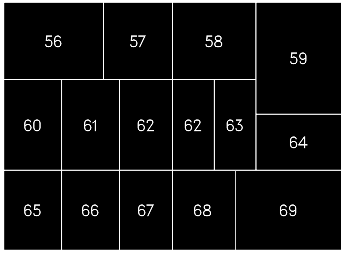


plate IV
hand mnemonics/hand reading

56. *Guidonian hand, a mnemonic device to assist singers in learning to sight-sing*, manuscript, 1274 **57.** *A work on the calculation of the calendar from Tlemcen*, Algeria, 1804 **58.** J.G. Job, *Anleitung zu denen curiösen Wissenschafften, nehmlich der Physiognomia, Chiromantia, Astrologia, Geomantia, ...*, 1717 **59.** Johann Hartlieb, *Die Kunst Chiromantia*, 1923 **60.** Guidonian hand from Petrus Tarteretus, *Expositio super summulas*, 1500 **61.** Guidonian hand from Giuseppe Frezza dalle Grotte, *Il Cantore ecclesiastico*, 1713 **62.** Correspondence between pulses and organs from *Waike xinfa zhenyan zhinan*, 1887 **63.** Francis Galton, *Finger Prints*, 1892 **64.** Apple Inc., "Magnetic sensor-based proximity sensing glove," US Patent 10,914,567 **65.** Hand mnemonics in the *Qieyun* **66.** Apple Inc., "VR glove capable of measuring the movement of individual finger and thumb bones," US Patent 10,877,557 **67.** Sculpture of Guidonian hand **68.** Astronomy and the calendar mnemonic hand from Anianus, *Compots cum commento*, 1489 **69.** Yaakov Ben Mordechai, *Rose of Jacob*, 1706

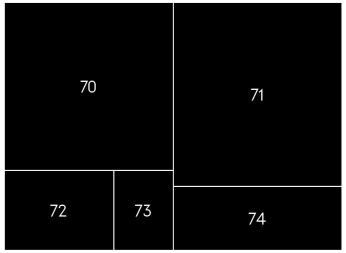


plate V
polymelia

70. "A Woman's Daily Activities: Work Load of Women in Africa," poster **71.** Stroboscopic image of the hands of Efraín Kurtz (negative), ph. Gjon Mili, 1945 **72.** Chronophotograph of blacksmiths at the anvil, Étienne-Jules Marey, 1894 **73.** Puma Robotic Sensor Arm, 1990/NASA/Dominic Hart **74.** *Durga, Kali, and the Matrikas Battle the Demon Raktabija*, detail, c. 1780

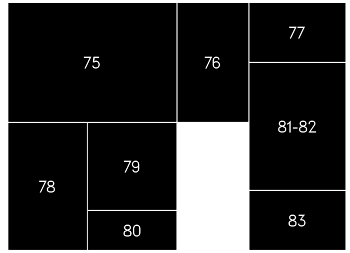


plate VI
automatic hands

75. Controlling robotic hand with remote glove, ph. Özgür Güvenç **76.** *The Basin* from a copy of al-Jazarī, *The Book of Knowledge of Ingenious Mechanical Devices*, 1315 **77.** Iron hand from *The Workes of That Famous Chirurgion Ambrose Parey*, 1634 **78.** Clovis Prévost, *La prothèse sculpture: Monestier–Lescoeur*, film still, 1977 **79.** Myoelectric hand from Mori Masahiro, *Energy*, 1970 **80.** Diagram showing a human chess master hiding inside the Mechanical Turk, the fake chess-playing machine constructed in 1770 by Wolfgang von Kempelen **81–82.** *Memex*, a hypothetical electromechanical device described by Vannevar Bush in 1945 **83.** *Project Xanadu*, the first self-designated hypertext project, from T. Nelson, "As We Will Think," 1972

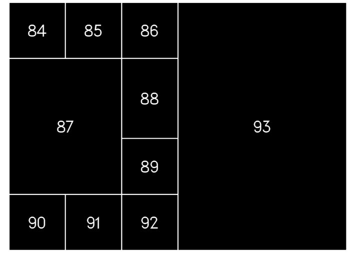
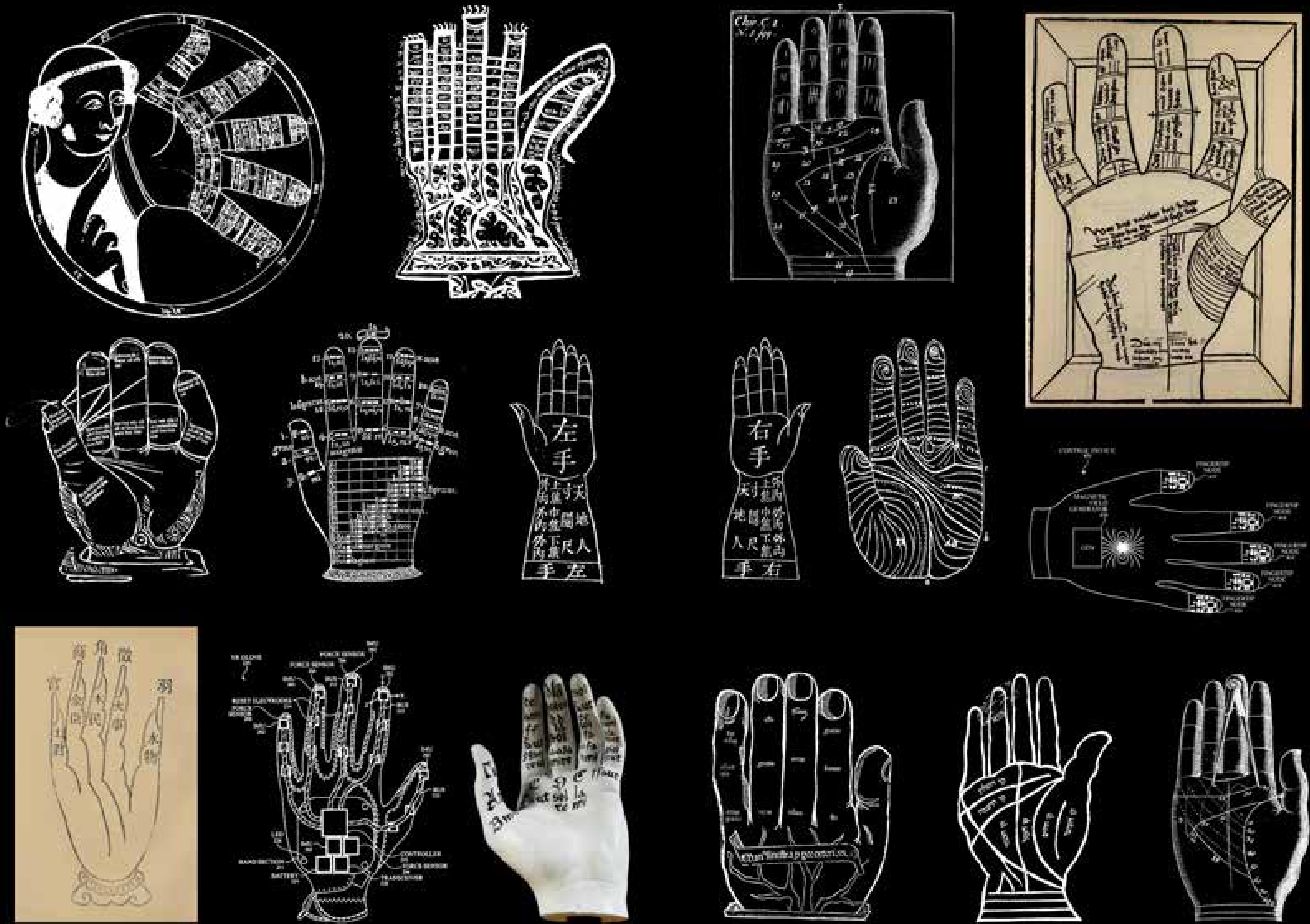


plate VII
intelligent machines

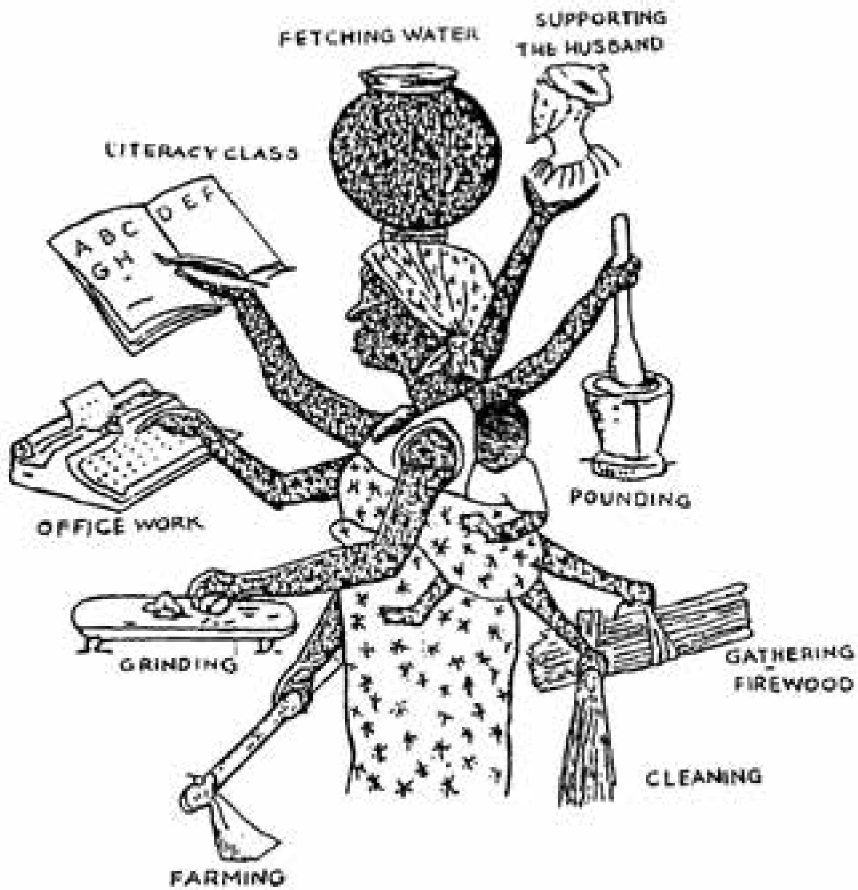
84. *A Fine Woven Silk in Memory of Joseph-Marie Jacquard*, detail, executed on the programmable Jacquard loom by Didier, Petit et Cie, 1839 **85.** Worker changing jacquard cards in a lace machine, 1918 **86.** Operator using a Hollerith pantograph to register data for a census form, Pictorial Press Ltd., 1940 **87.** Hand weaving of the core rope memory for the Apollo Guidance Computer, ph. Draper Laboratories, Raytheon, c. 1966 **88.** "Human computer" Doris Baron works with tape from machines measuring air pressure, NASA, 1955 **89.** Frank Rosenblatt in 1960 with a Mark I Perceptron **90.** Weaving algorithm traversing the fingers of a textile worker, c. 1990 **91.** *Computer for Apollo*, film still, MIT, 1965 **92.** Hand of a scanning operator in a Google Books' digitised copy of John Zephaniah Holwell, *India Tracts*, 1764 **93.** Erased hand of a scanning operator in a Google Books' digitised copy of F.G. Melcher, *Mother Goose's Melody*, 1794

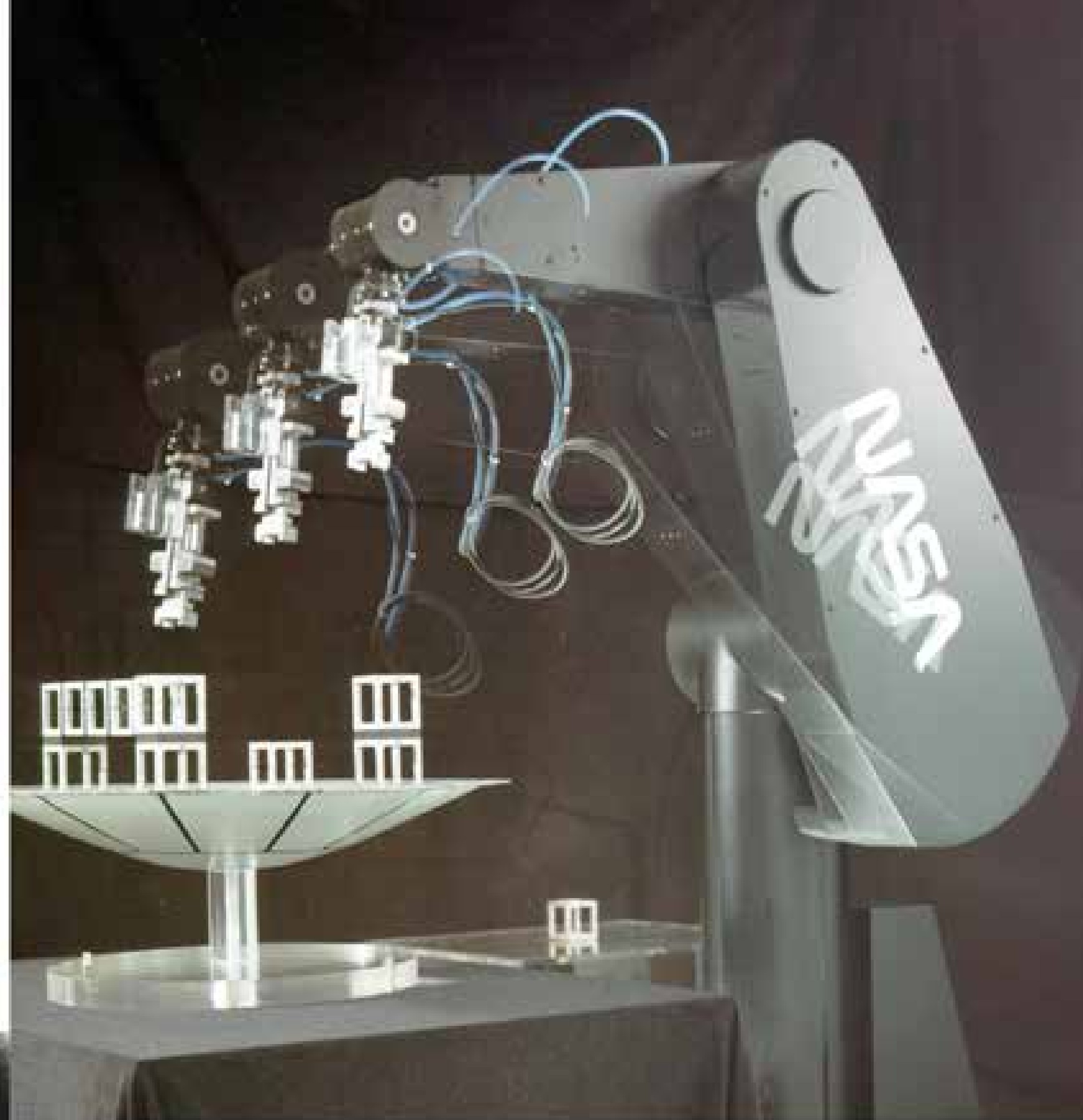


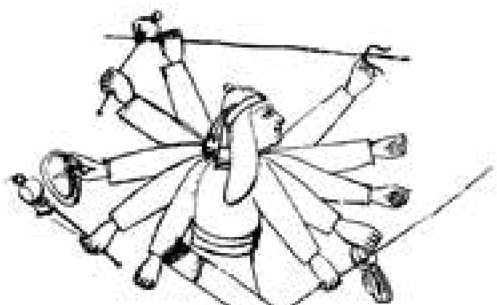
DIRECTION OF WAVE
PROPAGATION

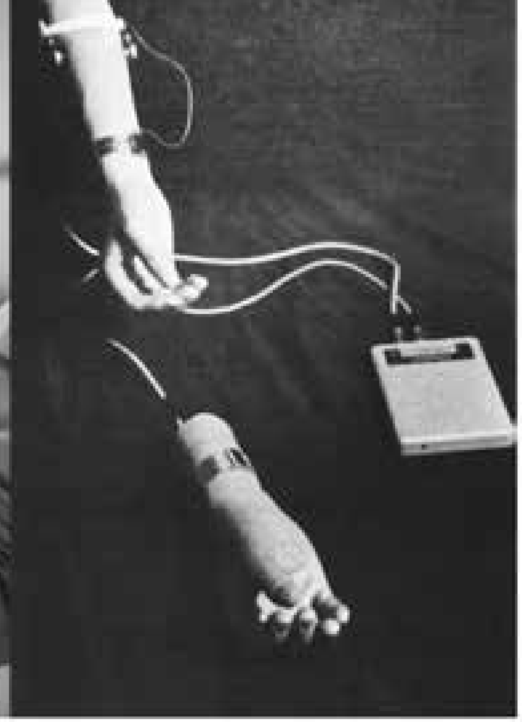
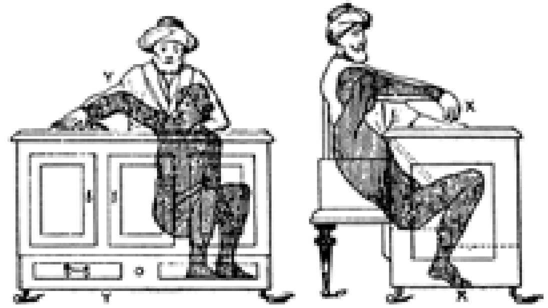
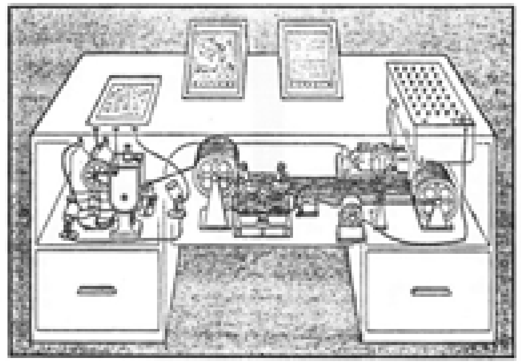


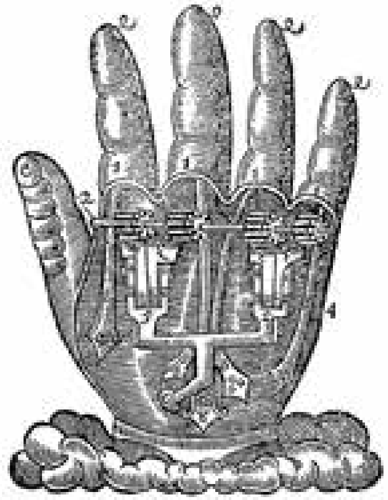
左手
右手

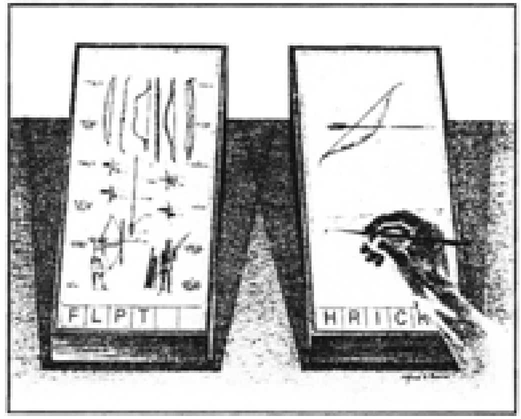
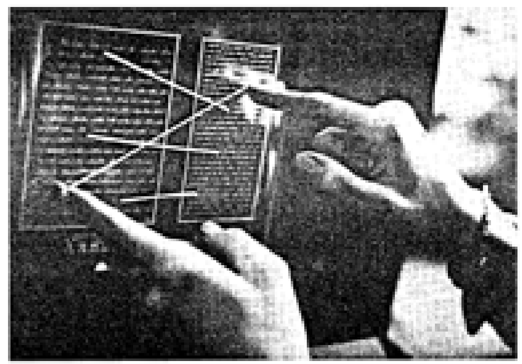

FETCHING WATER
SUPPORTING THE HUSBAND
LITERACY CLASS
A B C D E F
G H
OFFICE WORK
POUNDING
GRINDING
GATHERING FIREWOOD
CLEANING
FARMING


NASA






F L P T
H R I C K


geometric truths

sara raza

In my curatorial practice, I have employed geometry, a branch of the mathematical thinking sciences, to unpack two distinct areas of spatial studies: 'mental space,' which relates to logic, and 'real' actual geographical space. This has paved the way for the thematic and curatorial exploration of two distinct yet codependent spaces. As a curator and art historian invested in art practices that identify with the spaces and places connected to Central Asia and the Middle East, I am deeply interested in taking an idea-driven approach to exhibition making and use geometries metaphorically as a means of exploring the idea of origins.

In this text I retrospectively reflect upon the exhibition "But a Storm Is Blowing from Paradise," at the Guggenheim in New York, which I organised in 2016 in my capacity as the third and final curator of the Guggenheim UBS MAP Global Art Initiative for the Middle East and North Africa (2015–18).

The project was designed to diversify the Guggenheim Museum's American holdings, which were lacking in global art. In particular, these three regions were of great interest towards building up a critical art historical aggregate on the Global South that spoke to the museum's three principles of collecting: art of our time, non-objective painting, and art of abstraction. Concurrent to the collection building exercise was the mandate of composing an exhibition which was focused on the conceptual application of geometries to create an idea-driven narrative, not one purely informed by geographical myths. The exhibition travelled onto the

Galleria d'Arte Moderna in Milan in 2018, where it created a new site responsive dynamic in lieu with current European politics, especially those surrounding the issue of migration.

An important theoretical source for this exhibition was Jacques Derrida's 1962 essay "Edmund Husserl's Origin of Geometry: An Introduction," which provided the framework for furthering my ideas. Within his essay, Derrida drew upon the central thesis of mathematician and phenomenologist Husserl core argument for the "return to origins," which he believed was closely associated with geometry. Derrida further drew from Husserl argument for a closer analysis of historicity, not just history, which was perceived to be closely associated with geometric truth and human consciousness.

Curatorially, geometry functioned as a form of logical 'truth.' This was transferred to the exhibition context and was aimed at reactivating narratives surrounding origins to dispel misleading programs of truth, namely those that existed within the 21st century orientalist imagination. Through the deconstruction of several nonlinear histories and practices, I was able to concentrate on a project that deflected reductive analyses of art and ideas. My focus was on ideas that probed the semiotics of visual and cultural exchange by directly confronting the paired ideas of *place* and *space*. By exploiting the capacity of geometry to embrace and illuminate many other fields of enquiry, I was able to suggest alternative readings of some of the complex global histories.

I decided to employ the concept of a fragmented jigsaw puzzle. It was relayed within the exhibition's design as a metaphor for the dual region of West Asia and North Africa that had encountered (with the exception of Iran and Turkey) some form of physical Western occupation during the 18th and 19th centuries after the decline of the Ottoman empire, which paved the way for Britain and Europe to carve out its territory and exploit its newly

discovered colonies' resources. Attempting to probe the idea of physical and conceptual cannibalism of the region, exhibiting French-born artist Kader Attia's practice served as a necessary anchor that aimed to resolve the spatial conundrums of the region's colonial past through the dissection of architecture. Attia's study of the vernacular architecture of his family's native Algeria (which was colonised by the French in the 19th century) is presented within *Untitled (Ghardaïa)* (2009), a couscous sculpture of the 11th century ancient city of Ghardaia from the Mzab region. The epic piece explores the colonial legacy of French architects in Algeria, particularly citing Le Corbusier and Fernand Pouillon's s role in the 20th century as a frequent 'borrowers' of Algeria's indigenous architectural tropes. Through the metaphor reducing an entire city or heritage to couscous, Attia wittily invites the architects to dine while mocking their lack of proper acknowledgment of their works' inspiration and sources.

Another key component of this exhibition was to highlight the critical role of contraband within the exhibition's making, which was a deliberate strategy employed to tease out hidden truths and gage some of the urgent issues plaguing the region from a non-didactic perspective. It was crucial to consider the term as the unearthing of origins regarding cartography and heritage. An example within the exhibition was Tunisian-born artist Nadia Kaabi-Linke's *Flying Carpets* (2011), a suspended installation made from gridded stainless-steel frames hung by elastic threads. The piece poetically explored the increasing cases of illegal migration from Africa to Europe following the Arab Spring, whereby young men are 'smuggled' across the Mediterranean and seduced by the promise of economic prosperity arriving in cities such as the port of Venice, where this work was conceived. Travelling in confined containers and boats, their journeys are contrary to the exotic flying carpet rides that were made popular in 18th and 19th century Orientalist literature. To research the piece, Kaabi-Linke spent eight days observing immigrant street hawkers in Venice who sell counterfeit goods on rugs that can be easily be bundled up should the authorities arrive. She measured the carpets, and the Ponte del Sepolcro bridge where these traders congregated and took imprints of their rugs on the bridge. The light and airy feel of this sculptural installation is contrasted by its cage like resemblance, which cast intricate geometric shadows upon the gallery's walls, alluding to the idea of geometric consciousness and reverting back to the exhibition's central theme.

"But a Storm Is Blowing from Paradise" occupied a philosophical space where spatiality and human consciousness were interlaced and designed to open up a wider dialogue within the context of local and global histories, as well as re-histories, shifting centres and peripheries, which are essential to my curatorial practice. Thus 'mapping' multiple directions and entry points, which were not necessarily defined by geographical and cultural specificities, was key in order to arrive at the location of 'multiple' origins compounded by the artistic spirit of resistance and truth.

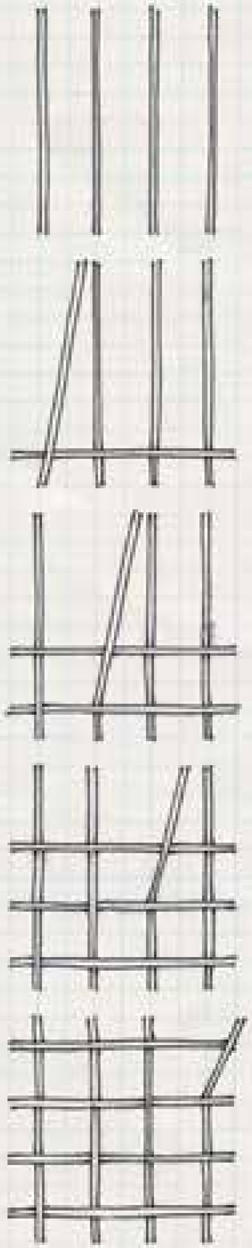
weaving code

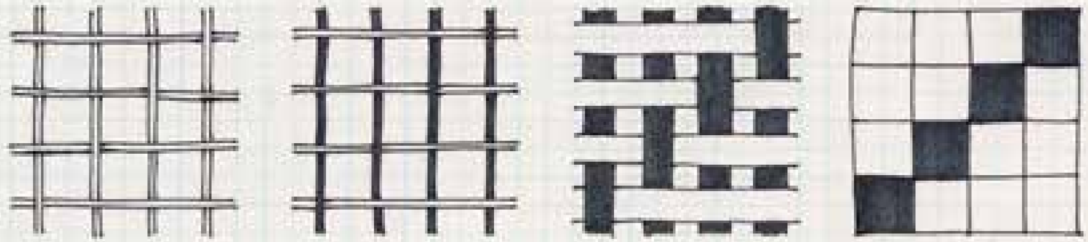
camilla colombo and amandine david

The programming language composed of 0s and 1s finds its origin in the automation of looms, where punch cards generating patterns bore either a hole or flat surface. On a computer screen, the lines made of 0s and 1s are mathematical abstractions. For those who don't read this language, their logics seem depraved from any poetry, humanity, or relation to their context. This abstraction of coding can be a risk as it generates distance in decision making, using a language that carries social biases and human responsibility of decision making.

Because of its straightforward implementation in digital electronics circuitry the binary system is used by almost all computer-based devices. By engaging in a dialogue made of drawings and short writings, Camilla Colombo and Amandine David explore how this mathematical language originates from the materiality of threads and what it means in its daily applications.

What meaning can be instilled in devices through zero and ones? How can an abstract mathematical language translate the complex sensititvity of human intuitions? Can we find marks of human gestures in the codes animating our surroundings?





Reductionism

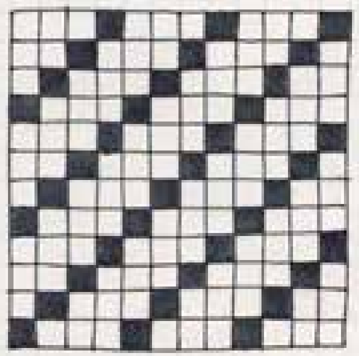
a procedure that reduces complex data and phenomena to simple terms.

Axiom

a statement that is taken to be true, to serve as a premise or starting point for further reasoning and arguments.

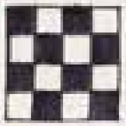
This exercise of transliteration from an alphabet to another allows to turn a given thing into a system. The automation of weaving looms during the industrial revolution thanks to - among many - Joseph-Marie Jacquard relied on this methodology, laying the basis for the use of the binary code in modern computers.

Once decided the axiom, the reduction can take place / the reduction is the basis for the axiom.



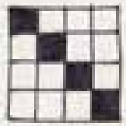
0 0 0 1 0 0 0 1 0 0 0 1
0 0 1 0 0 0 1 0 0 0 1 0
0 1 0 0 0 1 0 0 0 1 0 0
1 0 0 0 1 0 0 0 1 0 0 0
0 0 0 1 0 0 0 1 0 0 0 1
0 0 1 0 0 0 1 0 0 0 1 0
0 1 0 0 0 1 0 0 0 1 0 0
1 0 0 0 1 0 0 0 1 0 0 0
0 0 0 1 0 0 0 1 0 0 0 1
0 0 1 0 0 0 1 0 0 0 1 0
0 1 0 0 0 1 0 0 0 1 0 0
1 0 0 0 1 0 0 0 1 0 0 0

We agree that zeroiswhite and oneisblack as much as whiteislow and blackishigh to describe and establish the position of each thread to achieve a certain pattern.



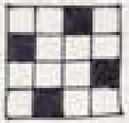
1 0 1 0
0 1 0 1
1 0 1 0
0 1 0 1

plain weave



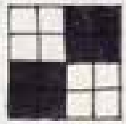
1 0 0 0
0 1 0 0
0 0 1 0
0 0 0 1

twill



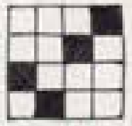
0 0 1 0
1 0 0 0
0 0 0 1
0 1 0 0

satin



0 0 1 1
0 0 1 1
1 1 0 0
1 1 0 0

basket weave



0 0 0 1
0 0 1 0
1 0 0 0
0 1 0 0

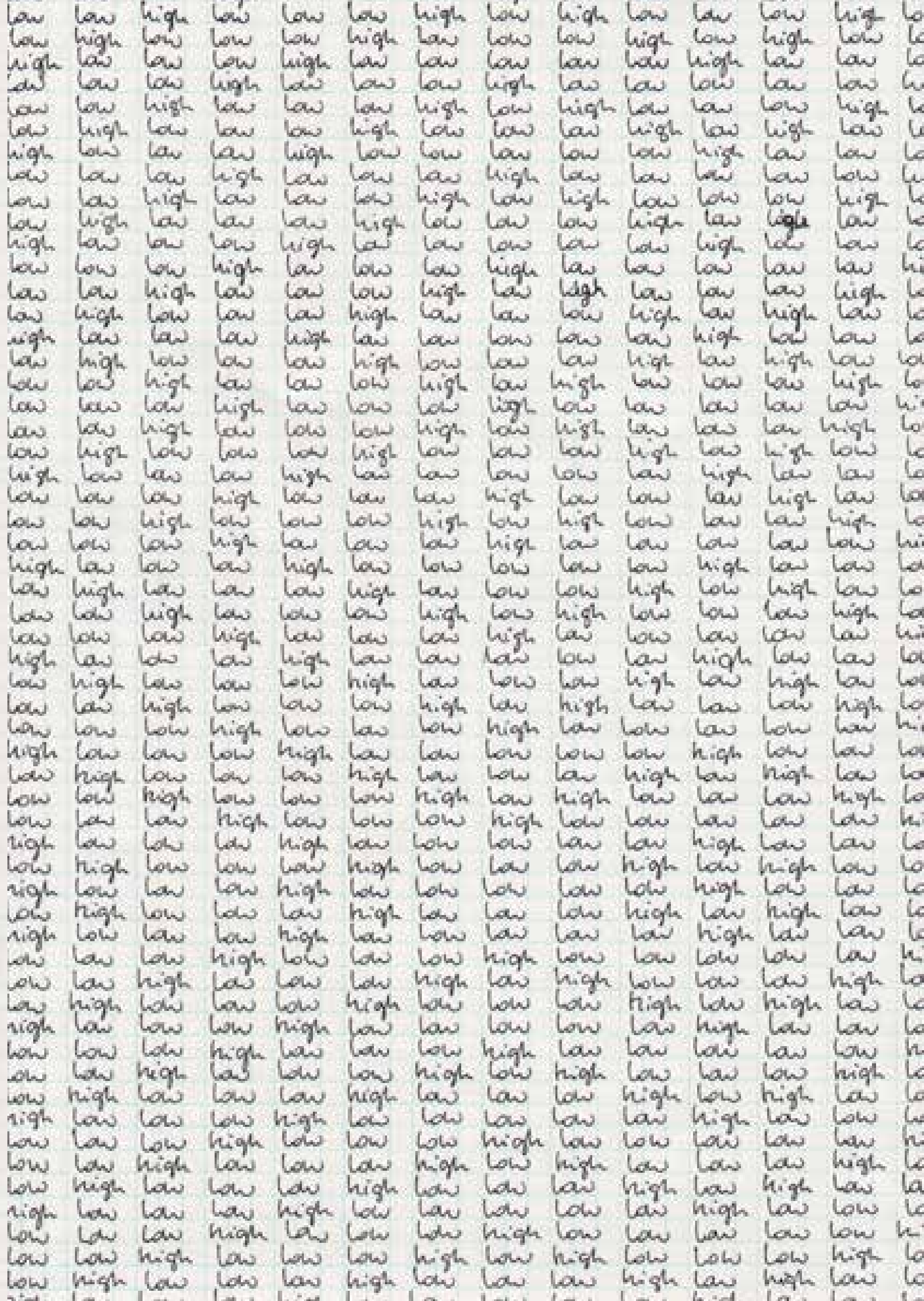
broken twill

Different weaving patterns carry different names, evoking a particular set of qualities, a particular history, a particular mastery, a particular geography, a particular physical outcome.

The know-how traditionally in the hands of weavers slid into the hands of coders; a language that is understood by the initiated - a grid of black and white squares or a sequence of 0's and 1's.

If the weaver can read the above,
The coder can read:

1
1 0
1 1
1 0 0
1 0 1
1 1 0
1 1 1
1 0 0 0
1 0 0 1
1 0 1 0
1 0 1 1
1 1 0 0
1 1 0 1
1 1 1 0
1 1 1 1
1 0 0 0 0
1 0 0 0 1
1 0 0 1 0
1 0 0 1 1
1 0 1 0 0
1 0 1 0 1
1 0 1 1 0
1 0 1 1 1
1 1 0 0 0
1 1 0 0 1
1 1 0 1 0
1 1 1 0 0
1 1 1 0 1
1 1 1 1 0
1 1 1 1 1
1 0 0 0 0 0
1 0 0 0 0 1
1 0 0 0 1 0
1 0 0 0 1 1



on the automation of aesthetic production: effects of algorithmic procedures in the arts

fabiano cocozza

> "Ideas can be works of art"
>
> from Sol LeWitt, "Sentences on Conceptual Art," in *0-9*, 1969

Since their conception algorithms had an undeniable impact on human society. From working to cooking, interacting with a device to playing an instrument, every aspect of modern life can be traced back to a series of planned tasks reduced to logical procedures to be performed. Moreover, with the invention of cryptocurrency—Bitcoin, 2009—the value of algorithms ceased to be a mere concept to became tangible, a real commodity that can be extracted—'mined'—and exchanged for solid money. Algorithms are ubiquitous and their impact goes way beyond technologies and economics. The procedural thinking had revolutionary effects on the art world too.

The application of algorithms in art can be dated back to the pre-historic knowledge of textiles and baskets weaving techniques. But it is from the 9th century with Islamic decorative arts that a step-by-step mathematical procedure was consciously implemented.[1] In Islamic decorative art, simple geometric modules were intersected and repeated infinitely to build extremely complex patterns. The modules disappear in the repetition and melt into a unified, intricate, and mathematically perfect design.

Bibi-Khanum mausoleum (Samarkand, Uzbekistan), credit: Shuhrataxmedov, Wikimedia Commons

Once defined, the strict rules of the algorithm turn the artist into a tool, leaving the work of art to be produced by the process alone. The artifact is like a plant sprouting and blossoming on its own. By means of repetition, artist and viewer are intended to perceive a sense of infiniteness. As for litanies, looping through the algorithm became the medium of elevation to a spiritual realm.

With the influential expansion of Islamic culture, the idea of algorithm was imported in the Western world as part of other relevant scientific discoveries. Its use in European art, though, was relegated to the 'less noble' field of craftsmanship.

1 Jacob M. Landau, "Islamic arts," in *Encyclopedia Britannica Online.*

The procedural thinking was applied in Western art only in the last century, possibly as a side effect of the groundbreaking invention of the computer. The algorithm was then rediscovered by contemporary artists and not used to pursue specific results — as in geometric combinations — but to investigate possibilities, as an independent form-generator.

"Arte Programmata" (Programmed Art) was a seminal exhibition organised by Bruno Munari and Giorgio Soavi in May 1962, at the Olivetti showroom in Milan, with a catalogue edited by Umberto Eco.[2] The exhibition was sponsored by Olivetti — which in the same years was producing revolutionary mainframe computers — and travelled the world with the support of the Smithsonian Institution. After the exhibition, several of the works exhibited became part of the permanent collection of MoMA New York.

The pieces of the exhibition were more like futuristic toys than canonical sculptures or paintings. Made with collages of tapes, bulbs, pipes, liquids, iron dust, and magnets. These artifacts were movable machines that could be operated to produce an infinite series of variations. They were intentionally constructed to produce chaos or, better, to investigate unseen outcomes.

Unlike other art movements (Abstract Expressionism, Action Painting, Neo Dada) where chaotic investigations were chosen once happened, the intent of Programmed Art was to generate chaos according to essential rules of statistical probability. As Umberto Eco noted, Programmed Art shifted from Divine Proportion to "Diabolic Disproportion [...] because [a programmed work of art] suspends the choice of possibilities in the indeterminate: once the basic element is fixed and the permutations programmed, the work does not consist of the most successful element, chosen among all the others, but precisely in the co-presence of all the thinkable elements."[3]

2 "Arte programmata. Arte cinetica. Opere moltiplicate. Opera aperta," Reprogrammed Art.

3 Umberto Eco, "La forma del disordine," in Sergio Morando (ed.), *Almanacco Letterario Bompiani*, Bompiani, 1962, trans. by the Author, p. 176.

Programmed Art aspired to be the tool to visualise the invisible as a service for the collectivity. Those works of art were "aids of imagination," translations of the natural reality that contemporary science was discovering — like the infinitely small of the sub-atomic, or the infinitely large of the astrophysics — but which was still unimaginable by many people.

As clearly pointed out by Eco, this art imitates nature "but not that nature that we see every day by perceptive habit, but the one we conceptually define in the laboratory [...] art imitates our way of interpreting and defining nature."[4] With Programmed Art, artist and viewer marvel witnessing an algorithm that generates something never seen before, something with results unexplored, a procedural investigation of the unknown.

Although sponsored by a manufacturer of computers, Programmed Art had very little to do with computers. It is in 1968 that Ernest Edmonds used a computer program in his work for the first time, the relief *Nineteen*, marking the birth of Computational art.[5]

At the beginning, the computer was employed only in the conception of the art piece, which subsequently had to be realised by the artist's hand. Later, plotters and monitors were adopted, and along with the development of computers capabilities, the evolution of Computational Art ran fast, open to possibilities never achievable before. Time-changing variables and interaction with the audience were included in the art piece. The work of art became an open system that reacted to its environment.

With the introduction of the computer in the art world, many questions arouse. Could a programmer be considered an artist? Could the outcome of a computer be considered a work of art or just a strange object? If algorithms were well accepted in other art fields (like scores for music, or plans for buildings, the role of the composer or

4 Umberto Eco, Ibid., p. 17.
5 See Francesca Franco, "Algorithmic Signs," exhibition, Fondazione Bevilacqua La Masa, Venice, 2017.

Ernest Edmonds, *Nineteen*, 1968-69, credit: Ernest Edmonds, Open access, *www.mdpi.com/2076-0752/7/1/3/htm*

Grazia Varisco, *Schema luminoso variabile, 9x9xX*, 1961, the work created for the exhibition "Arte Programmata," Showroom Olivetti, Milano, 1962 © Copyright Archivio Grazia Varisco the architect has never been contested), in visual arts the use of algorithms and the role of the artist as a programmer had to be explained.

Firstly, computational artists had to educate the audience to accept the computer as a medium, as much as a paintbrush or a chisel. Roman Verostko stated this concept clearly, "The [music] score itself is an algorithm — a procedure for constructing the musical experience. But the procedure for writing the music is another matter. Writing the musical score is always the creative work of the composer. We should not confuse the procedure by which the composer creates the composition with the procedure for performing the composition. Similarly, when it comes to algorithmic art we should not confuse the procedure by which the artist creates algorithms with the procedures by which the algorithms execute the work."[6]

The authorship of the artist working with procedural thinking needed to be reclaimed. It is with Conceptual Art that the question was settled once and for all. Stating the supremacy of pure idea over form, conceptual artists detached the work of art from its physical presence.

Even if speculative, the attention of programmed and computational artists was on the objects produced by their algorithms. Conceptual artists made a leap forward. They still employed various methods of procedural specification to produce art, but their focus was on the idea and not on the final outcome. The artifact became redundant as the work of art was the idea itself (or, at least, the instructions to materialise that idea).

Sol LeWitt, prominent conceptual artist and theorist, wrote in *Artforum* magazine in 1967, "In conceptual art the idea or concept is the most important aspect of the work [...] all of the planning and decisions are made beforehand and the execution is a perfunctory affair. The idea becomes a machine that makes the art. This kind of art

6 Roman Verostko, "Algorithms and the Artist," lecture at the Fourth International Symposium on Electronic Art – ISEA, Helsinki, September 1994.

is not theoretical or illustrative of theories; it is intuitive, it is involved with all types of mental processes and it is purposeless. It is usually free from the dependence on the skill of the artist as a craftsman."[7]

The intent, then, is to make the purest art possible, to detach the form from the subjectivity of the artist. Detached from purpose, execution and form. The work of art becomes words and instructions. It is no longer embodied in an object, it is no longer the result of an algorithm, it is the algorithm itself.

The algorithm can be a machine that makes art, and the work of art can be a program, a set of rules that solves (art related) problems. Therefore, the artist functions as a programmer. Again, according to Sol LeWitt, "To work with a plan that is pre-set is one way of avoiding subjectivity. It also obviates the necessity of designing each work in turn. The plan would design the work [...] the artist would select the basic form and rules that would govern the solution of the problem. [...] This eliminates the arbitrary, the capricious, and the subjective as much as possible. This is the reason for using this method."[8]

As for Islamic decorative art, in Conceptual art the role of the creator decreases in degree: the artist elaborates systems of rules and the work is only the result of their blind application.[9] The work of art became pure idea, pure process, pure algorithm.

In recent days, the advent of Artificial Intelligence and its adoption in the art field seemed to confuse things a bit. Works of art can now evolve by themselves and learn from other artifacts. Will then Artificial Intelligence substitute the artist? Can Artificial Intelligence become an artist?

If considered with attention, those questions are similar to the ones encountered before. Artificial Intelligence can be considered as a tool, a very complex and powerful one. The tasks that can be performed could

7 Sol LeWitt, "Paragraphs on Conceptual Art," in *Artforum*, vol. 5, no. 10, June 1967.
8 Ibid.

9 See Denys Riout, *Qu'est-ce que l'art moderne?*, Éditions Gallimard, 2000.

INSTRUCTION

● Turn on a radio.

At the first sound, turn it off.

George Brecht, *Instruction from Water Yam*, 1963, credit: © 2021 Artists Rights Society (ARS), New York / VG Bild-Kunst, Germany

be more complicated than the reiteration of geometric patterns, but the work of art is still the algorithm, and the artist is still the programmer.

The impact of algorithms in art is far to be finished or understood. To conclude with the words of computational artist, Ernest Edmonds, "The point that we [algorithmic artists] jointly discovered was that [...] algorithmic art represented art that engaged with the key issues that are part of modern life. [...] In the developed world, at least, we could argue that our lives are partly driven by algorithms and yet they remain an unexplored territory for many people. So this kind of art is engaged with contemporary life like no other. [...] the metaphor of the algorithm, as used in art, is surely a metaphor of life itself, as we know it today. So I argue that this work is in no way on the edge of contemporary art, but is at the very core of our contemporary concerns."[10] The inquiries of art with algorithms are more important than ever.

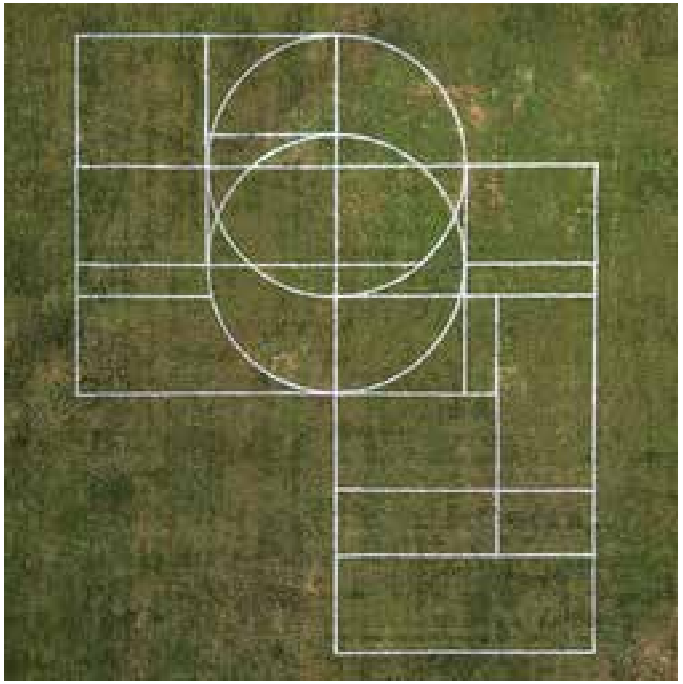
10 Ernest Edmonds, "Algorithmic Art Machines," in *Arts*, vol. 7, no. 1, January 2018.

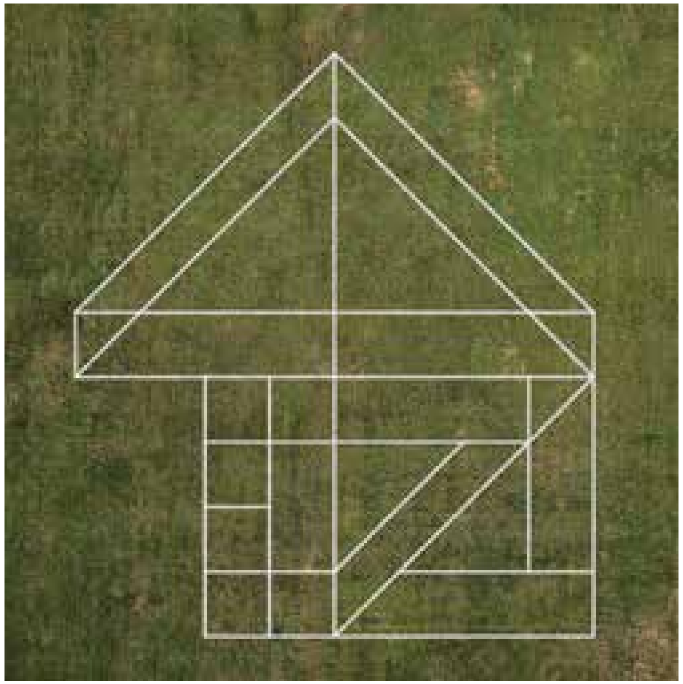
spake scapes

outpost office
ashley bigham
erik herrmann

Architecture is not the practice of building but of transmitting relationships across space and time. While the art of construction is often vague and imprecise, architectural methods of drawing and specification aspire to achieve lossless encoding and transmission of a design intent. This work exists at the messy liminal boundary between immaterial ideation and material labor. Despite the crescendo of digital innovations in the design and construction fields, contemporary architectural geometry is still greatly mimetic. In other words, today's methods of construction rely on the faithful reproduction of relationships recorded in static images and symbols. The algorithm, however, suggests potent forms of transmission across space and time that are not image-based but process-based.

In the Greek tradition, idealised geometry revealed the secrets of mathematics. Al-Khwārizmī's algorithmic methods departed from Greek geometry and its idealised harmonics by working in a verbal custom. His mathematical writing, developed before the widespread adaptation of symbolic code, is succinct, lucid, and notably modern. This linguistic model broke complex problems into discrete steps. For the contemporary programmer, al-Khwārizmī's well-defined and implementable instructions read like pseudocode, an artificial and informal language that helps programmers develop complex algorithms and software. Pseudocodes can take many forms to solve complex problems,





Completing the Square No. 1 installed at Waterman Farm, Columbus, Ohio, courtesy Outpost Office with Zachary Schumacher

so long as each step is discrete and executable. In other words, pseudocode must be computable. Conceptual artist Sol LeWitt's wall drawing instructions, for example, are a form of pseudocode. While no two wall drawing installations are precisely identical, the rigor of his instructions assures fidelity in each 'version' of a particular wall painting while also leaving suitable space for chance and happenstance arising from particularities of contexts, materials, and labor practices.

Our recent landscape paintings were made with a GPS-guided robot that utilises algorithmic instructions sets to produce large-scale temporary inscriptions at the intersection of algorithms, geometry, time, and geography. In the landscape, the painting robot acts as a draftsperson might and operates at an incredible scale, speed, and precision. Unlike a draftsperson, however, the device itself has no concept of the shape it is drawing. The robot's relationship to the world is defined only by algorithms, with UTM coordinates and vectors orchestrating its gliding movements. By following a programmed sequence of runs, turns, and stops, the robot realises complex notations in the world. Like Lewitt's wall paintings, no two robotic landscape paintings are identical. Factors as subtle as the direction of grass blades or humidity level ensure that each landscape painting is unique. The painting process is a negotiation between the disembodied algorithmic instructions and the material exigencies of the physical world.

Our latest drawing series began with an immersion into al-Khwārizmī's elegant algorithmic processes, particularly his method for completing the square. A precursor to the quadratic equation, this method can be described numerically. Yet, completing the square is both scaleless and infinite. With the aid of al-Khwārizmī's systematic logic, we developed an operational glossary for landscape paintings based on his work. The resulting drawings are not ideal shapes or mathematical proofs but mediated material forms that have been executed 6,000 miles away from the exhibition.

On a technical level, these landscape paintings require the coordination of geodesic technologies, including GPS guidance, UTM coordinate systems, photogrammetry, and autonomous flight controllers. Collectively, these systems orchestrate the scanning, rendering, surveillance of our terrestrial domain. The substrate of all these activities is algorithms. Ultimately, we hope these automated drawings reflect on the deep history of these methods and elucidate how al-Khwārizmī's work on the algorithm intertwined the fields of mathematics and geography, setting the stage for the way the contemporary world is now measured, tracked, and described.

Completing the Square No. 1 installed at Waterman Farm, Columbus, Ohio, courtesy Outpost Office with Zachary Schumacher

wires from the bottom of the sea

alessandro celli

The exponential acceleration of growth and innovation of today's new technologies—both software and hardware—doesn't reflect the uncanny fixity of the infrastructures they rely on. The backbone of the internet, although concealed behind the hyper-nervous dynamism of the digital realm, is static by nature. This immobility is a fundamental trait of today's data infrastructure and was inherited from political, economic, and social dynamics that took place almost two centuries ago.

The transoceanic submarine fiber optic cables that carry ninety-nine percent of the world's digital communication, have their roots in the development of telegraph technology in the late 18th century and derive from the politics, geographies, and colonial strategies of those countries that facilitated its creation and evolution. Today's internet cables are the direct descendants of the first telegraph infrastructure that started to populate the sea-beds around the world from the 1850s.

The relatively simple concept of the far-writer, the *télégraphe*, was a ground-breaking invention in the 1790s. The technological research that led to today's data infrastructure was initially fostered by the need of transmitting messages over long distances in short amounts of time, and through a simple procedure. Before that date, communication was subjugated to space and time, as content had to physically be carried and travel from sender to receiver. The concept of making it seemingly instantaneous enabled a radically new perspective for the diffusion and transmission of information. The telegraph annihilated physical limitations, allowing a metaphysical ubiquity that disrupted the earlier understanding of communication.[1] Before the 1840s, it took five to eight months for a letter to travel from Britain to India, and later, when steamships took over the mail service, it still took six weeks. The invention of the telegraph was therefore a true revolution in the eyes of the imperialists, such as the British empire.[2]

In 1791, French researcher Claude Chappe came up with the first functioning prototype of the *télégraphe*, encoding and decoding a message visually between towers set at sight distance, equipped with telescopes, codebooks, clocks, and black-and-white panels.[3] It was a cornerstone in the history of modern communication technologies. After almost half a century of usage and diffusion of the optical telegraph, the British empire took over its further development. It was the imperial thrust towards technological development and territorial expansion, as well as political interests, that laid the foundation for today's submarine fiber optic cable network. The rough embryonic layout of the telegraph infrastructure that was created was there to stay.

Technological progress, however, did not come without drawbacks, and the intentionality of such thrust was largely driven by British colonial strategies. Within the first half of the 19th century, the first experiments for the development of a long-distance wired telegraph over land led John Watkins Brett and his brother Jacob to fabricate and implement the innovative technology of submarine cables.[4] In 1850, they laid the first international telegraph line, connecting England and France with one submarine copper cable through the Channel, which was torn a few hours after its installation by a fisherman's anchor. The next year they laid a new cable alongside the first one, implemented with an iron sheathing, and this way it lasted safely throughout the next century. With these two

1 Shawn James Rosenheim, *The Cryptographic Imagination: Secret Writing from Edgar Poe to the Internet*, Johns Hopkins University Press, 1997, p. 93.
2 Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940*, Oxford University Press, 1988, p. 97.
3 Tom Standage, The Victorian Internet: *The Remarkable Story of the Telegraph and the Nineteenth Century's Online Pioneers*, Weidenfeld & Nicolson, 1998, p. 8. For a detailed history of Claude Chappe's optical telegraph see: Gerard J. Holzmann, Björn Pehrson, *The Early History of Data Networks*, IEEE Computer Society Press, 1995, pp. 47–90.

installations, the Brett brothers founded the Submarine Telegraph Company, which was one of the first private companies to enter the business of submarine cables.[5]

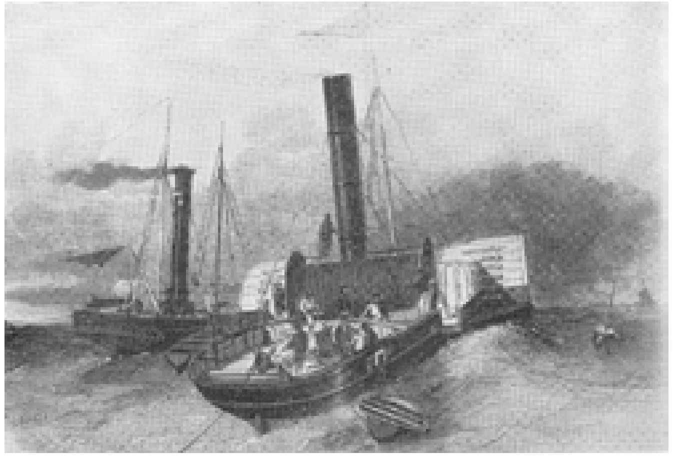
Since the foundation of the Submarine Telegraph Company, international telecommunications have always remained in private hands, given that they interconnected nations that would not let foreign government agencies operate on their soil. International communication companies were, and still are, hybrid entities: private by nature, but inevitably tied to their home governments.[6]

Although the initial submarine cable experiments were largely unsatisfactory and short-lived, the perseverance of the Brett brothers enabled them to pioneer what, in the words of the historian Bernard Finn, has been "the grand Victorian technology."[7]

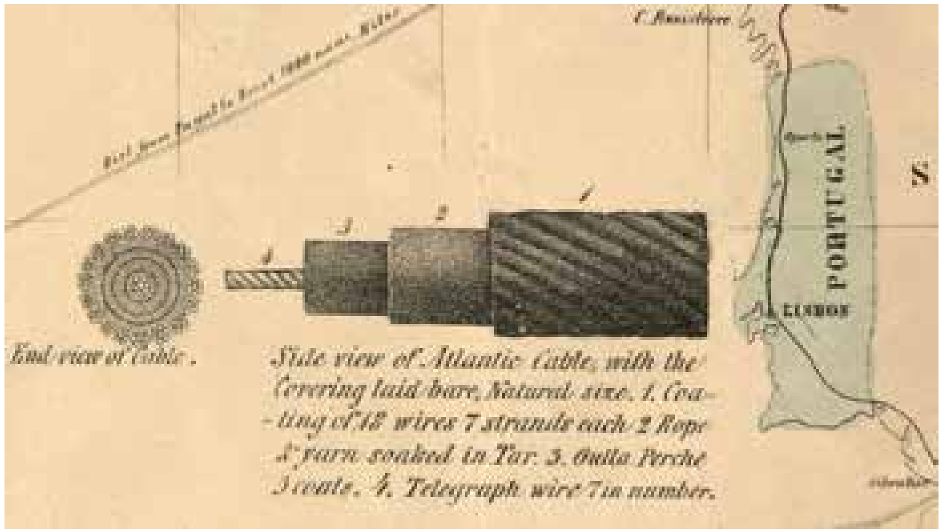
From the perspective of communication within a colonial empire, it was crucial for settlers around the world to develop an effective telegraph network. Therefore, the growing significance of long-distance communication contributed to the thrust that put in motion other technological researches, governmental strategies, and capital investments within the British empire. It took, in fact, two decades after land telegraphy was in use to develop all the complementary technologies necessary to the deployment and usage of submarine cables.

Two key challenges had to be faced in order to make the submarine cable system reality. The first one was to find the optimal cable routes and, the second one, to insulate the system from external interference. These challenges had a significant impact on the evolution of submarine cable technology. The first task was addressed with the employment of naval forces to sound the seabed's state, to find optimal routes for the cables to be laid. This implied mapping the formations of the sea bottom and its depth, to avoid excessive tension that could damage the cables, whilst

4 Gillian Cookson, *The Cable: Wire to the New World*, The History Press, 2012, pp. 6–8.
5 Bill Glover, Bill Burn, "The Submarine Telegraph Company," TL Design. See also: Jeffrey L. Kieve, *The Electric Telegraph*, David and Charles, 1973, pp. 101–103.
6 Daniel R. Headrick, Pascal Griset, "Submarine Telegraph Cables: Business and Politics, 1838–1939," *The Business History Review*, vol. 75, no. 3, 2001, pp. 543–578.
7 Bernard S. Finn, *Submarine telegraphy: the grand Victorian technology*, Science Museum, 1973. See also: Daniel R. Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century*, Oxford University Press, 1981, pp. 157–158.



The steamship Goliath laying the 1850 cable between Dover (England) and Cap Gris Nez (France). The task was carried out by The English Channel Submarine Telegraph Company, and the cable was manufactured by the Gutta Percha Company. See Kenneth Richardson Haigh, *Cableships and Submarine Cables*, Adlard Coles, 1968, p. 31



Detail of the end view and side view of the Atlantic Cable, taken from the Chart of the submarine Atlantic Telegraph, 1858. See W.J. Barker, *Chart of the submarine Atlantic Telegraph*, W.J. Barker & R.K. Kuhns, 1858. Map retrieved from the Library of Congress, *www.loc.gov/item/2013593216*

exploiting the familiar marine paths that had already been explored, and were known to the naval operators.

Therefore, the geography of underwater cable routes mirrored the one of British transportation and trade, becoming a means of support for global commerce. For the same reason, cable landing points often coincided with marine ports, ensuring direct accessibility of the new infrastructure for the shipping industry as well as exploiting the strategic nature of their geography.[8]

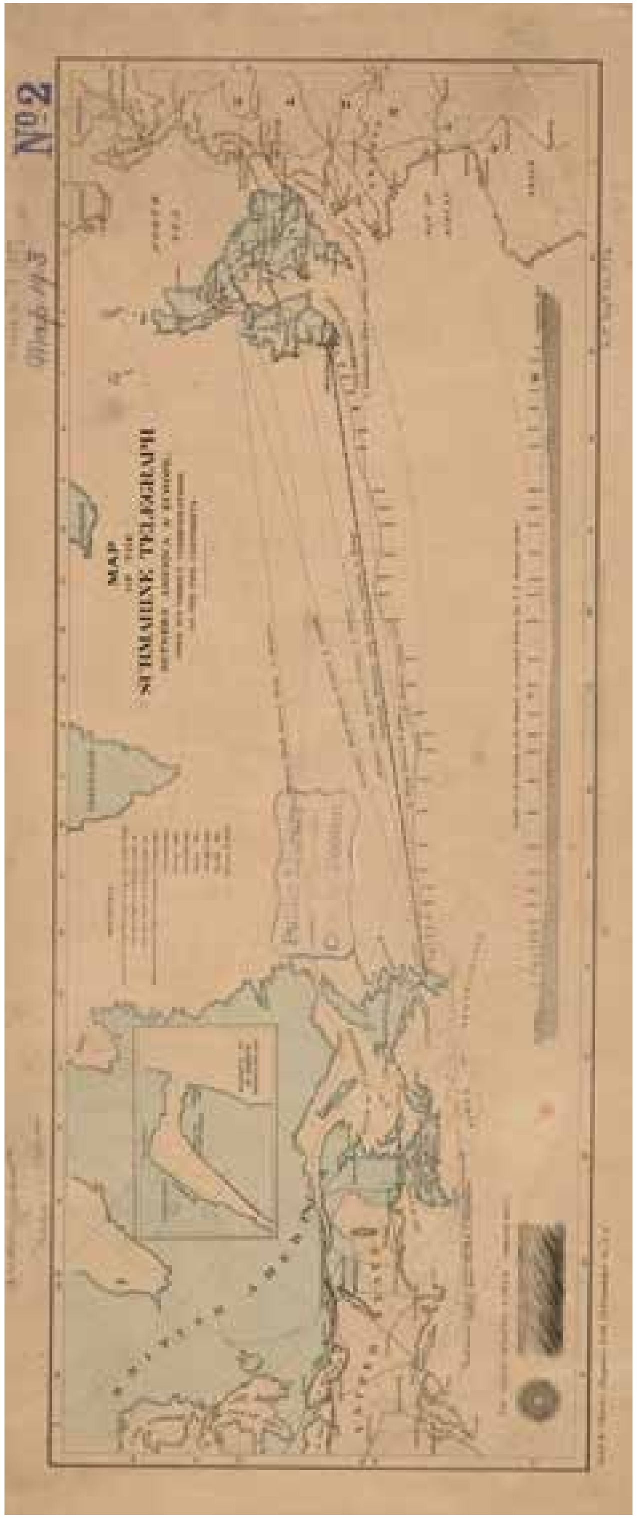
Given the significant amount of resources, time, and negotiations necessary to establish every new cable route, the telegraph geography that emerged was inherently of fixed nature. Maintaining the existing infrastructure, which has proven itself to be secure and has already been negotiated in the past, required less effort than negotiating new deals to substitute it with a new one. Such fixity became a fundamental trait of the telegraph network and still is today at the core of the worldwide submarine cable system that allows the internet to function. Today's rather conservative cable industry has changed little since the 19th century, as cabling techniques are similar to those of the past, and engineers lean towards what has already been tested.

Opposition to interference, be it natural, social, or political, allowed the cable network to get through existing ecologies, and to be isolated from the systems it crossed without being affected by them. The historical tendency towards complete insulation is another contributing ingredient to the stillness of the infrastructure, transforming turbulent environments into frictionless ones.[9]

The development of an effective form of insulation played an important role for the British empire to dominate the cable business throughout the second half of the 19th century. The submarine cables that the Brett brothers laid in the Channel in 1850 and 1851 would not

8 Nicole Starosielski, *The Undersea Network*, Duke University Press, 2015, p. 31.

9 Starosielski defines this phenomenon as strategies of insulation. Ibid., pp. 17–63.



Map of the first transatlantic submarine connections between America and Europe. Inset: Harbour of St. John's, Newfoundland. Includes distance chart, "Profile of the bottom of the Atlantic as sounded 1856 by the U.S. Steamer 'Arctic,'" and ill. of the "Great Atlantic cable (natural size)." Map reproduction courtesy of the Norman B. Leventhal Map & Education Center at the Boston Public Library. See Korff Brothers, *Map of the Submarine Telegraph Between America & Europe, with its Various Communications on the Two Continents*, Norman B. Leventhal Map & Education Center, 1857, *collections.leventhalmap.org/search/commonwealth:7h149w235*

have been possible if it wasn't for the insulating material coming from the Palaquium gutta, a tree widely present in the British colonies of Borneo and the Malay peninsula.[10]

From the sap of this Malaysian tree, it is possible to obtain gutta-percha, a good electrical insulator similar to latex, which British cable enterprises quickly adopted to drastically improve the duration of previous short-lived prototypes wrapped in tarred hemp and rubber. The Brett brothers pioneered the manufacturing process that paved the way for the cables to come in the next decades. The conductive copper wires of the cable were wrapped by a layer of gutta-percha to provide electrical insulation from water, and by an outer sheathing of iron to offer protection from mechanical disruption. Physical interference was, and still is today, the biggest threat to submarine cables' life-span: in the same way that the 1850 cable in the Channel was torn by a boat anchor, cables all over the world are damaged today by fishing equipment, sharks, earthquakes, people digging the seabed, and shipworms.[11]

The presence of Palaquium gutta in British colonies facilitated the empire's predominant role within the global cable business in the second half of the 1800s, given its control over gutta-percha's extraction and distribution. This led to a submarine cable 'craze' that made the global cable network grow from 15,000 nautical miles in 1866 to 200,000 in 1900, and therefore to an insatiable hunger for the plant. Unlike rubber, which can be harvested from individual trees for decades, gutta plants had to be felled, only to gather three hundred grams of sap from a mature eighteen metres tall tree.[12] The demand for gutta-percha between 1850 and 1930 became voracious, and it ended up destroying entire lowland forests in Indonesia and Malaysia, felling millions of trees, until the amount of gutta-percha needed to satisfy the endless telegraph growth became far greater than what could be realistically extracted.

10 Daniel R. Headrick, "Gutta Percha: A Case of Resource Depletion and International Rivalry," in *IEEE Technology and Society Magazine*, vol 6, no. 4, December, 1987, pp. 12-16.

11 Aisha Suliaman Alazri, "The Threat and Vulnerabilities of Submarine Cables in Information Security and Telecommunication," *International Journal Multimedia and Image Processing (IJMIP)*, vol. 8, no. 3, September 2018, pp. 432–437.

12 J. N. Dean, "The Insulation of Submarine Telephone Cable," in *Journal of the Royal Society of Arts*, vol. 103, no. 4944, 1955, p. 152.

"Branch, flowers and fruit of Isonandra gutta tree, Malaysia," 19th century illustration, Isonandra gutta is a synonym of Palaquium gutta. See Thomas Bolas, Arthur Barff, *The Journal of the Society for Arts*, vol. 28, no. 1450, Royal Society for the Encouragement of Arts, Manufactures and Commerce, 1880, p. 804, *www.jstor.org/stable/i40060895*

There were virtually no large gutta trees left in the area of Singapore around the 1850s, and they quickly became scarce in the Malay peninsula as well. This ecological disaster was a precursor to the environmental degradation that today often coincides with the evolution of contemporary capitalist infrastructures.[13]

The gutta-percha trade was a colonial one: exploiting a resource from the periphery of an empire, bringing it to its centre and processing it in ways not available to those at the periphery, to then ship it back to the periphery to reinforce the empire's power over it.[14] Moreover, the development and exploitation of such material were key for the British empire to establish a self-reinforcing loop of control over its colonies: taking advantage of its imperial and commercial power to gain more access to the gutta-percha extraction and distribution, facilitating the construction of the cable network that, in turn, reinforced its control over the colonial commerce.[15]

As the issue of protection from water was handled, with time, insulation morphed into a new layer of security. The depths of the oceans turned from concern to shield, keeping the fragile cables as far as possible from any form of interference. Contemporary data infrastructures present the same trait, inheriting the strategies that allowed the submarine telegraph network to reach its maturity in its early days.[16] In the same way that telegraph cables could last decades without setbacks, today's fiber optic cables are designed with the same principles in mind, to be concealed and insulated. The fixity that became idiosyncratic of the telegraph network is still thriving today, and the history of the infrastructure is embedded in its physicality.

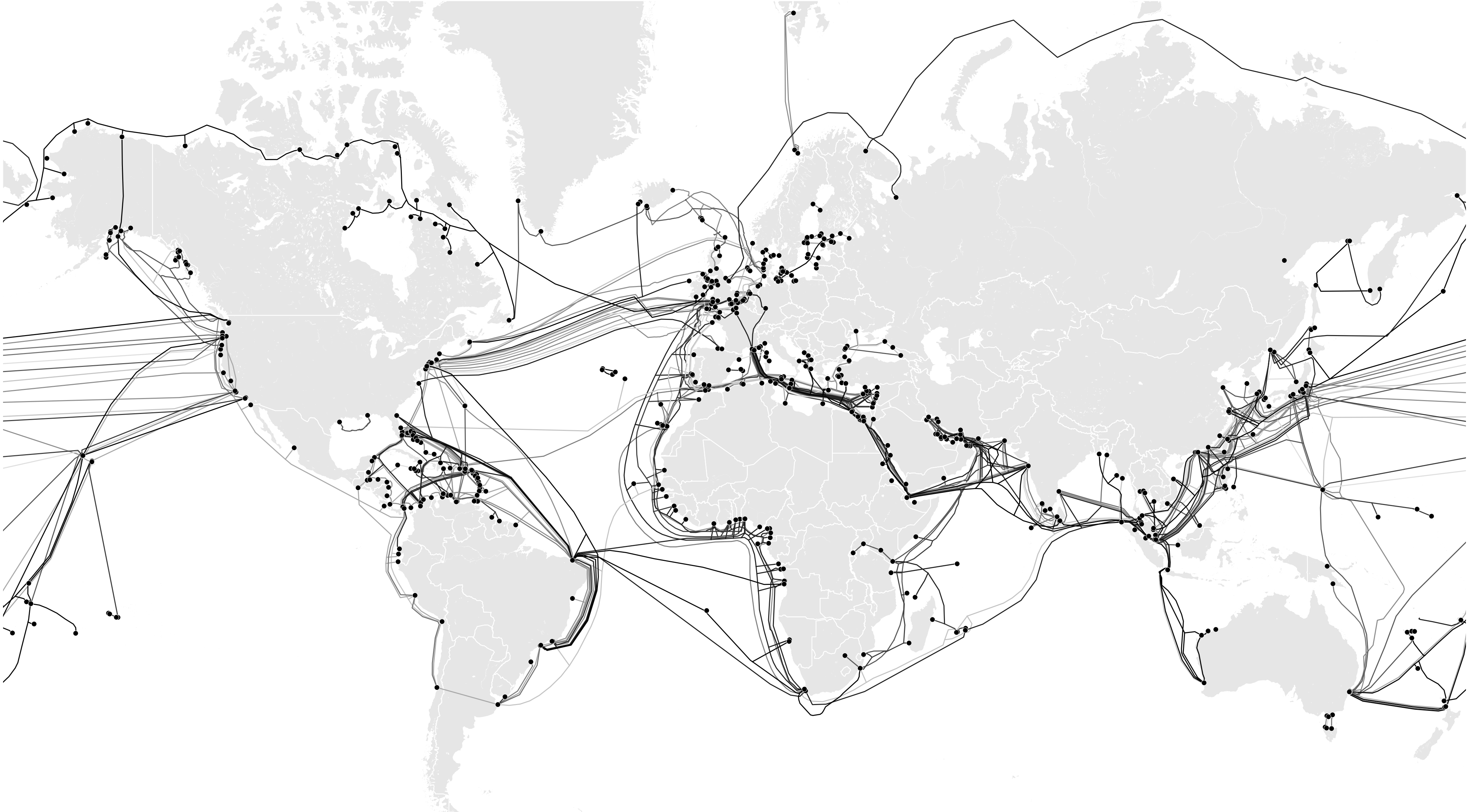
The hyper-nervous dynamism of today's media outlets, hardware, and software upgrades, and information proliferation is just the discernible consequence of telecommunication's development. Their backbone, in contrast, still resembles the same strategies, geographies, and odd slowness of the first telegraph cables, evolving at a much slower pace than the computing technological evolution lets us perceive.[17]

Today's data infrastructure also inherits its business structure from the telegraph of the Victorian age: private companies, like the Submarine Telegraph Company from the 1850s, still own, manage, control, and interconnect fiber optic submarine cables.
In addition to the sheer amount of cable companies operating today, tech giants such as Google, Facebook, Amazon, and Microsoft are entering the game as well, infiltrating the infrastructure and acquiring shares of existing cable providers.

13 Bruce J. Hunt, "Insulation for an Empire: Gutta-Percha and the Development of Electrical Measurement in Victorian Britain," in Frank A.J.L. James (ed.), *Semaphores to Short Waves*, Royal Society of Arts, 1998, p. 92. See also: John Tully, "A Victorian Ecological Disaster: Imperialism, the Telegraph, and Gutta-Percha," in *Journal of World History*, vol. 20, no. 4, 2009, p. 560.
14 Bruce J. Hunt, Ibid., p. 93.
15 Ibid, p. 86.
16 Bernard S. Finn, *Submarine telegraphy: the grand Victorian technology*, Science Museum, 1973, p. 11.
17 Slowness also derives from the contemporary desire to maintain backward compatibility, proceeding through mutation rather than outright break with the past. See Jean-François Blanchette, "A Material History of Bits," in *Journal of the American Society for Information Science and Technology*, vol. 62, no. 6, 2011, p. 1054.

Map of the telegraph communication cables laid around the globe as of 1903. Map reproduction courtesy of the Norman B. Leventhal Map & Education Center at the Boston Public Library. See C. van Hoven and International Telegraph Bureau (Bern, Switzerland). "Carte générale des grandes communications télégraphiques du monde, 1903," Norman B. Leventhal Map & Education Center, *collections.leventhalmap.org/search/commonwealth:7h149w11c*

The history embedded in the materiality of contemporary transoceanic submarine cables continues to define their existence. The infrastructure that today keeps our digital selves alive has its roots in a history that, although distant, outlines its functioning. Fiber optic cables still echo the ghosts of those British colonial strategies that were at the origin of the worldwide telegraph network.



World map of submarine communication cables and landing stations in 2015. Most of the principal routes recall the paths explored for the telegraph in the second half of the 19th century. See Greg Mahlknecht, *World map of submarine communication cables*, 2015, *cablemap.info/_default.aspx*

exploded firewall

shady elbassuoni and ibrahim kombarji

One way that al-Khwārizmī's name and legacy are celebrated today is on the gold plaque of the "Khwarizmi International Award" (KIA) held every year in Tehran since 1987 (just eight years after the Iranian Revolution). Scientists and engineers "who have made outstanding achievements in the fields of science and technology"[1] are awarded an engraved trophy with their names on a gold plaque.

The trophy is composed of a pale beige wooden base, two gold plated wings — representing al-Khwārizmī's knowledge spreading across cultures — as well as a perfect circular glass piece inspired by one of the early solar measuring tools of the glorious scientist.

This trophy is given annually in person by the President of Iran, marking this ceremony as "an exceptional opportunity for both Iranian and foreign participants to put their scientific achievements on display."[2] This award ceremony is initiated in "memory of Muḥammad Ibn Mūsā al-Khwārizmī, the great Iranian mathematician, and astronomer (770–840)" according to the website of the Khwārizmī International Award. In an attempt to access this website and its application process from Europe or the United States, users are denied access to the page: "You were protected from visiting this page by Kaspersky security. You can close this window with no risk."[3] This instant border control is what is known as a firewall measure, triggered by your internet browser, and "in compliance with" government based decisions of seizing or preventing access to some "untrustworthy"[4] pages. These measures are put in place "to protect EU operators from extra-territorial applications."[5]

The firewall is composed of 'bricks' of algorithms assembled one on top of the other in a way that prevents many scientists from sending their application forms (from the EU for instance) to this Iran based award. This also reinforces barriers of equal online access while revealing greater scientific and geopolitical biases.

Al-Khwārizmī's name was Latinised into Algorithmi and later entered the field of computing as algorithm. This essay will seek to reveal the complexities of a subtly *khwarizmic* world we live in. The KIA ceremony and website become the site of entanglement of cyber narratives constructed around algorithms.

In the field of architecture and construction, a firewall originally refers to the "wall intended to confine a fire within a line of adjacent building."[6] In an attempt to undermine a flammable — yet constructive — confusion with the firewall used on our computers, this essay will refer to the built firewall, made of tangible materials, as a fire-wall and the cyber firewall will be referred to as the firewall. This binary reading highlights the interdependencies between both walls, in their construction, partitioning, thickness and defensive performance.

The built fire-wall can be composed of bricks (fired clay and mixture), plasterboard blocks with rock wool insulation, aerated concrete block (that have intrinsic fire resistance properties), and countless other materials. The physicality of the fire-wall is governed by the context of the construction site and the duration required in slowing down the spread of fire for a given time (around four hours for performant fire-walls). These walls delimit areas in the building in such a way that the fire does not spread to the entire construction, thus dividing the building into smaller clusters. This also forms evacuation areas such as corridors and stairs that are "sufficiently fire resistant"[7] for a limited time, allowing residents to safely evacuate the building.

1 Khwarizmi International Award (KIA), *khwarizmi.ir/kia.*
2 Ibid.
3 Warning message from the Author's internet browser, 2021, 192.168.1.10.
4 David Molloy, "US government blocks Iran-affiliated news websites," BBC, June 23, 2021.
5 European Commission, "Council Regulation (EC) No. 2271/96: protecting against the effects of the extra-territorial application of legislation adopted by a third country, and actions based thereon or resulting therefrom," OJ L 309 29.11, November 22, 1996, p. 1.
6 *Standard fire prevention code,* Southern Building Code Congress International, 1986.
7 Ibid.

top
The 31st KIA Ceremony in presence of President Rouhani in 2018, ph. ImagingCoE

bottom
The 32nd KIA Award, ph. Maryam Kamyab

The term fire-wall later found its way into the field of computing as a way to designate firewalls. In 1987, engineers from the Digital Equipment Corporation — a major American company in the computer industry — first published a paper on the "firewall technology"[8] developing the notion of filter systems such as the packet filters. A firewall is thus a "network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules."[9] It "typically establishes a barrier between a trusted network and an untrusted network, such as the Internet."[10] Firewalls can be network based when they are positioned on LANs and intranets or host-based when they are implemented on the network host itself in order to protect the entire network traffic. The content of the browser then only flows to our screens when it is considered safe.

8 Digital Equipment Corporation, "Firewall technology," 1987.
9 Noureddine Boudriga, *Security of mobile communications,* CRC Press, Taylor & Francis Group, 2013.
10 Rolf Oppliger, "Internet Security: Firewalls and Beyond," in *Communications of the ACM,* vol. 40, no. 5, May 1997, pp. 92–102.

These firewalls are constructed of 'bricks' of algorithms such as packet filtering, proxies, dictionaries of IP addresses and gateways. Those simple 'bricks' are the intricate blocking mechanisms that perform in a firewall. The packet filtering firewalls, for instance, analyse and compare the webpage to a set of familiar packages and protocols, while the type that is the closest to an actual physical fire-wall is the proxy firewall that performs as a gatekeeper. It acts as an intermediary service between the external networks and the user's computer, preventing any direct contact between both. These proxy 'bricks' are considered as "heavy security"[11] and may interfere with incoming data — that are not threats — and thus slow down the functionality of the wall. The circuit-level gateway firewalls determine the legitimacy of the user's browsing's session, while the next-generation firewall (NGFW) allow for a deeper inspection of potential policy violations and malicious content. The NGFW also integrate 'bricks' of 'threat intelligence' reinforcing the defensive nature of the wall.

Firewalls are embedded in a geography. In fact, IP addresses — which are unique numerical labels assigned to each computer in a network — are an important part of firewalls and communicate the precise coordinates of a user. Internet policies and regulations are also embedded in a territorial logic. States are still attempting to craft their own geopolitical limits onto cyber space in part to regulate[12] the internet traffic operating inside and crossing through their borders. This is visible in the two sided diplomatic tone of China and the European Union on this matter. The 'Great Firewall' installed in China is an inescapable cyber wall that is enforced by the People's Republic of China in order to 'regulate' the internet inland. It is the entanglement of legislative and technological censorship that blocks access to a selection of foreign websites and slows down the internet traffic. The European Union is considering

11 Marcus Goncalves, *Firewalls: A Guide*, McGraw-Hill, 2000.

12 James Griffiths, *The Great Firewall of China: How to Build and Control an Alternative Version of the Internet*, Bloomsbury Publishing, 2019.

13 Nick Sohnemann et al., "New Developments in Digital Services," Study for the committee on the Internal Market and Consumer Protection, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg, 2020.

top
The 32nd Khawarizmi Award ceremony, ph. Maryam Kamyab

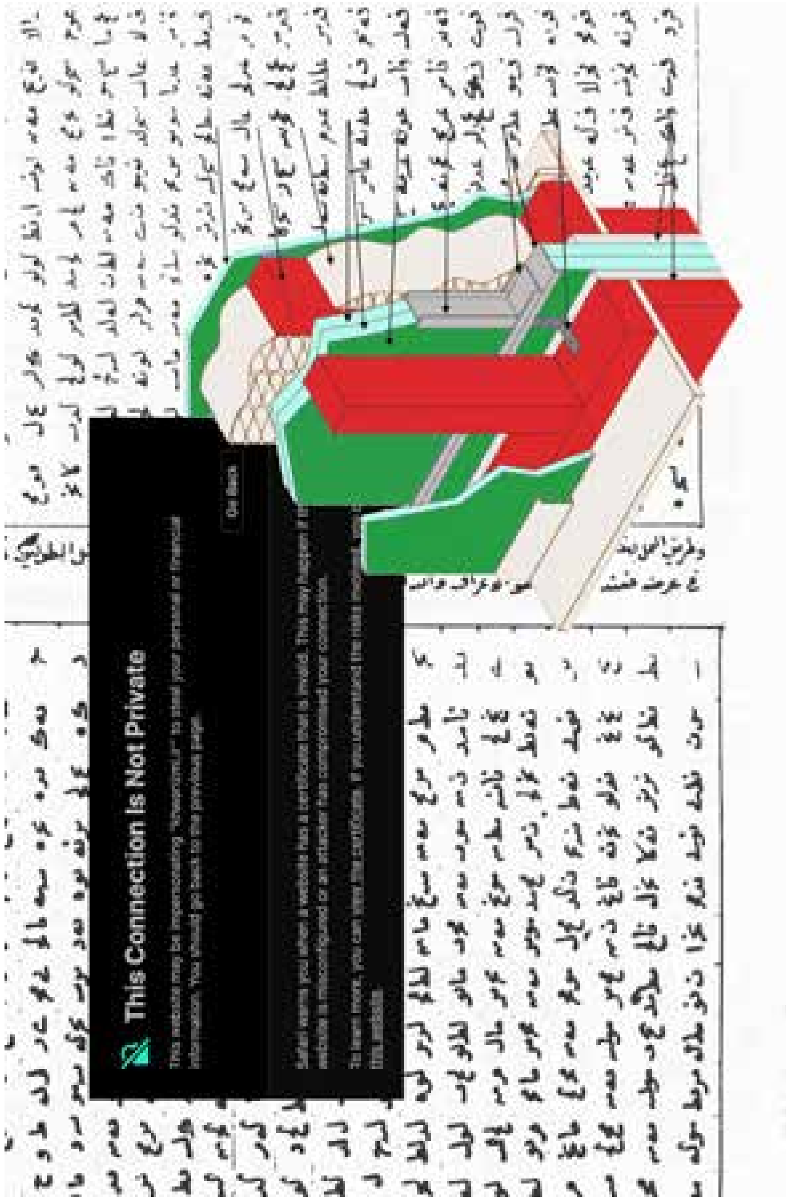
bottom
The 33th Khawarizmi Award ceremony, ph. Maryam Kamyab

applying (starting in 2025) a security firewall where "foreign web services could become part of a digital ecosystem but must adhere to the rules and standards of the EU such as democratic values, data protection, data accessibility, transparency and user friendliness."[13] Such firewalls sit in shear proximity to one another and constantly retrace world maps. They become tools to thicken the border access to a country's digital space and prevent users to be part of the ever expansive global internet ecosystem.

59.16 million internet users are located in Iran,[14] which is 70% of the population (in contrast to the 54% of Chinese and 88% of Americans). These users face domestic barriers on their online activities. In a recent law submitted in 2020 to the Iranian parliament, internet access has been restricted to the "approval of the Supreme Leader of the Islamic Republic:"[15] a first layer of imposed firewall on users.

14 "The Latest statistics on Internet Penetration in Iran," Mehr News Agency.

15 RSF Monde, "Iran: un projet de loi vise à renforcer le 'mur numérique' et la censure sur internet," in *Reporters Sans Frontières*, September 24, 2020.


This Connection Is Not Private
Go Back

In parallel, the second layer is the one preventing users ex-situ Iran to access Iranian webpages (such as the KIA page *khwarizmi.ir/kia*). The Persian internet ecosystem is thus subject to a double thickness firewall, both imposed internally and projected by external political and legislative forces.

Concomitantly, this overlapping of realities reinforces a secluded nation building narrative by which access to the Iranian digital arena (composed of an economy of advertisements and platforms of social exchange) is only permeable to the country's allies. This is most visible when looking at the winners of the KIA award in the past years, mostly scientist from China, Russia, Lebanon, and Switzerland. During the KIA ceremony, all seventeen trophies are placed at the centre of the main hall of the IRIB International Conference Center in Tehran. The room can host up to 665 seats[16] and is covered in a royal blue and gold moquette. Eligible delegations (that were able to apply and physically access the conference centre) contribute in inscribing this event within a grand nation building narrative; one reminiscing of the Persian empire's dominance in mathematics and its capacity to create bridges of global scientific alliances.

Both fire-walls and firewalls are erected with different configurations, thus allowing for different levels of permeability and porosity. The built fire-wall is subject to heavy rain leakage that reduces the overall resistance of the wall by allowing water in the pores of the plaster. The khwarizmic firewall are also permeable to seepage: the KIA website was first inaccessible due to the "suspicious nature" of the site and its geographic IP location. After the user presses over "I understand the risks and wish to continue," users can access the award page from abroad. This process of unpiecing and chiseling a 'brick' from the firewall is a routine labor that users go through often while "surfing the net;"[17] this labor is a corridor of seepage, another way of subverting the firewall. In 2010, Iran was infected by Stuxnet, an algorithm virus. Major Iranian computer systems interdependent to local nuclear sites had been demolished, setting back Iran's nuclear enrichment by at least two years. These khwarizmic attacks on the protective walls of Iran's cyber world have been claimed to be linked to the intelligence agencies of the United States and Israel. A cyber-attack of this magnitude has demonstrated its ability to weaken intra-muros Iran. It still stands today as a demonstration of the on-going global cyberwar, governed by algorithms.

Iranian based websites of misinformation are used to interfere in election results overseas, resulting in the country being labeled a cyber-terrorist country. While being a victim of some attacks, Iran and its solid cyberwarfare is today "one of the most active players in the international cyber arena."[18] Iranian's firewall and cyber architecture is a site of negotiation at the JCPOA (The Joint Comprehensive Plan of Action, commonly known as the Iran Nuclear Deal) meetings taking place in Vienna. There, cyber limitations, sanctions, and legislative firewall policies are on the diplomatic agendas of the negotiating teams. These arenas of arbitration can be inscribed in NATO's "evolving cyber threat landscape,"[19] highlighting the need to "defend our networks and operations against the growing sophistication of the cyber attacks." Algorithms ineluctably shape our understanding of today's crisis-as-usual world. Firewalls in their khwarizmic opaqueness and "trans-scalar"[20] entanglements propose a constant re-reading of the current geopolitical realities.

16 "About IRIB International conference center," IRIB, *www.irib.ir.*
17 Jean Armour Polly, "Surfing the Internet," in *Wilson Library Bulletin*, June 1992.

18 Gabi Siboni and Sami Kronenfeld, "Developments in Iranian Cyber Warfare, 2013–2014," in *INSS Insight*, no. 536, April 3, 2014.
19 "Cyber defence," NATO, July 2, 2021, *www.nato.int/cps/en/natohq/topics_78170.htm.*
20 Andrés Jaque, *Superpowers of Scale*, Columbia University Press, 2020.

sufilive shuffle

roo shamim

The Naqshbandi Haqqani Sufi Order spread to the United States in the early 1990s under the leadership of Shaykh Hisham Kabbani. His nationwide grassroots initiatives revived the tradition of *sohbat*, divine associations wherein the Shaykh transmits heavenly knowledge through a temporally-inspired oral tradition. In the early 2000s Shaykh Kabbani's organisation implemented live broadcasting video technology and social media to reach communities around the world, seeking to connect modern culture to traditional teachings and universal philosophy.

Shaykh Kabbani currently has one million followers on Facebook, one hundred thousand subscribers on YouTube, and has established the website *sufilive.com*, which currently archives over seven thousand videos of his teachings, as well as of his master, the late Grandshaykh Nazim al-Haqqani. The videos are loosely categorised by tags which include the date of the recording, the general topic of the teaching, the location of the gathering, and can be accessed through playlists, keyword search, and a shuffle algorithm that randomly plays a video from the embedded YouTube page.

background

The Naqshbandi Sufi order traces its lineage through the 14th century Uzbek philosopher, Baha-ud-Din Naqshband Bukhari. His disciples would gather three times a week to receive heavenly knowledge in three formats: the *sohbat*, or spiritual lectures, *dhikr*, chanting meditation said to channel the divine energy of consciousness to the physical realm,

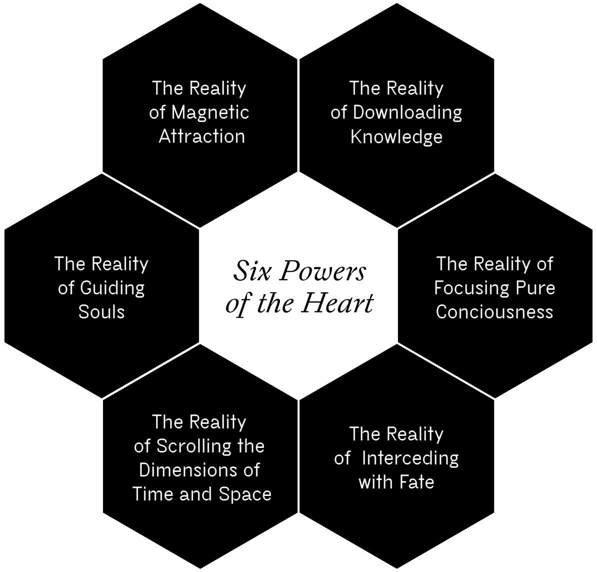
Source
YouTube

and *muraqabah*, a silent gathering in which the Shaykh would transmit knowledge and healing directly to the heart, with the belief that the knowledge would be decoded and activated in certain key moments of the student's life.

Shaykh Naqshband's spiritual teachings and practices are still observed by modern-day devotees. In their *sohbats*, the world-renowned Naqshbandi masters, Shaykh Nazim al-Haqqani and Shaykh Hisham al-Kabbani often draw metaphors between quantum physics, cyber communication technology, and telepathy, time travel and other spiritual powers that can be attained through sincere practice and devotion. *The Six Powers of the Heart* describe the achievements of the great Sufi Shaykhs of the Naqhsbandi lineage.

the concept

This visual essay playfully explores the connection between the information encoded in time-based media and the asynchronicity by which it is received. Drawing from the metaphor of finding inspiration from opening a sacred text to a random page to our world of digital media, it illustrates the concept of 'generative wisdom,' or personalised spiritual teachings that emerge from patterns between the user's video watch history, as generated by the shuffle feature on *sufilive.com*, and the Law of Time, a theory proposed by 20th century artist-philosopher José Argüelles, which explores the qualitative, rather than quantitative, perception of time. The user's video metadata would generate a table of inputs, which could store and analyse other data inputs such as calendar dates from alternate systems of time (i.e. the Islamic lunar calendar, astrological calendars, I Ching cosmic calendar, and the Mayan dreamspell calendar). As the output, the algorithm would generate interactive data visualisations that increase awareness of cyclical patterns and synchronicities within the data sets.

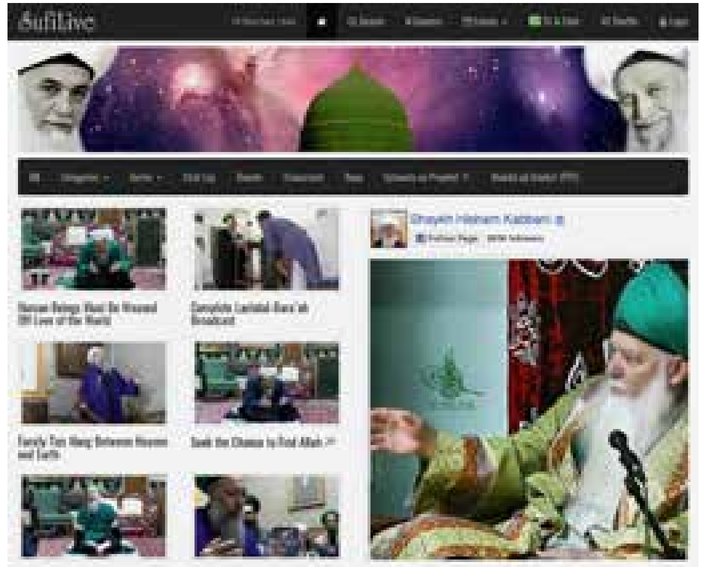


The Six Powers of the Heart describe the achievements of the great Sufi Shaykhs of the Naqhsbandi lineage

For example, if the input is astronomical phenomena, overlaid with a lunar calendar date, the output would be visualisations of celestial information directly related to the date when the videos were watched, when they were recorded, and connections to the lunar cycle. This speculative algorithm conjectures that the divine teachings channeled by Shaykhs in their *sohbats* transcend the laws of linear time, which we can then fathom through our contemporary understanding of cloud-based information and digital content architecture.

The proposed algorithm could be used to create a user experience for a website or application that promotes self-awareness, self-study, and a dimension of spiritual depth to online interactions similar to Co-Star, the personalised astrological social network platform which uses artificial intelligence to analyse publicly accessible NASA JPL data and find patterns in a user's astrological transits. Co-Star's algorithm maps human-written snippets of text to planetary movements to display personalised content for each user.

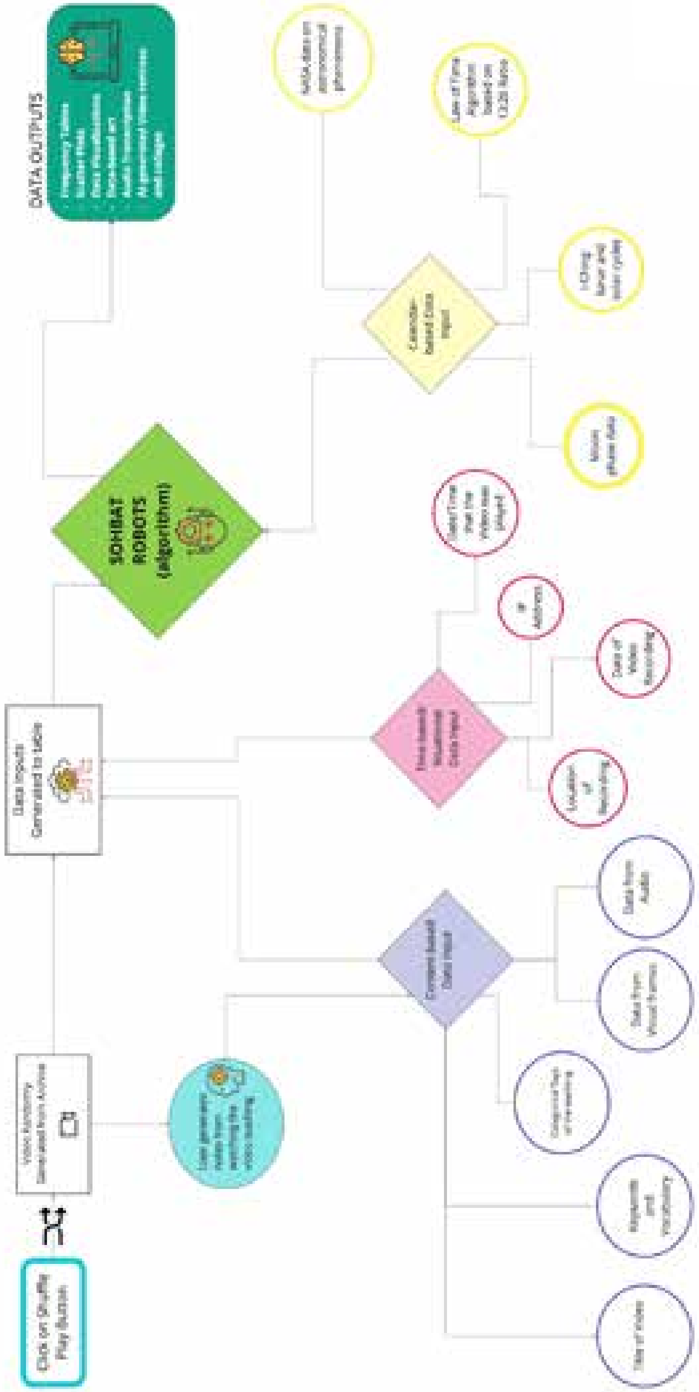
Source
sufilive.com



algorithms and data visualisation

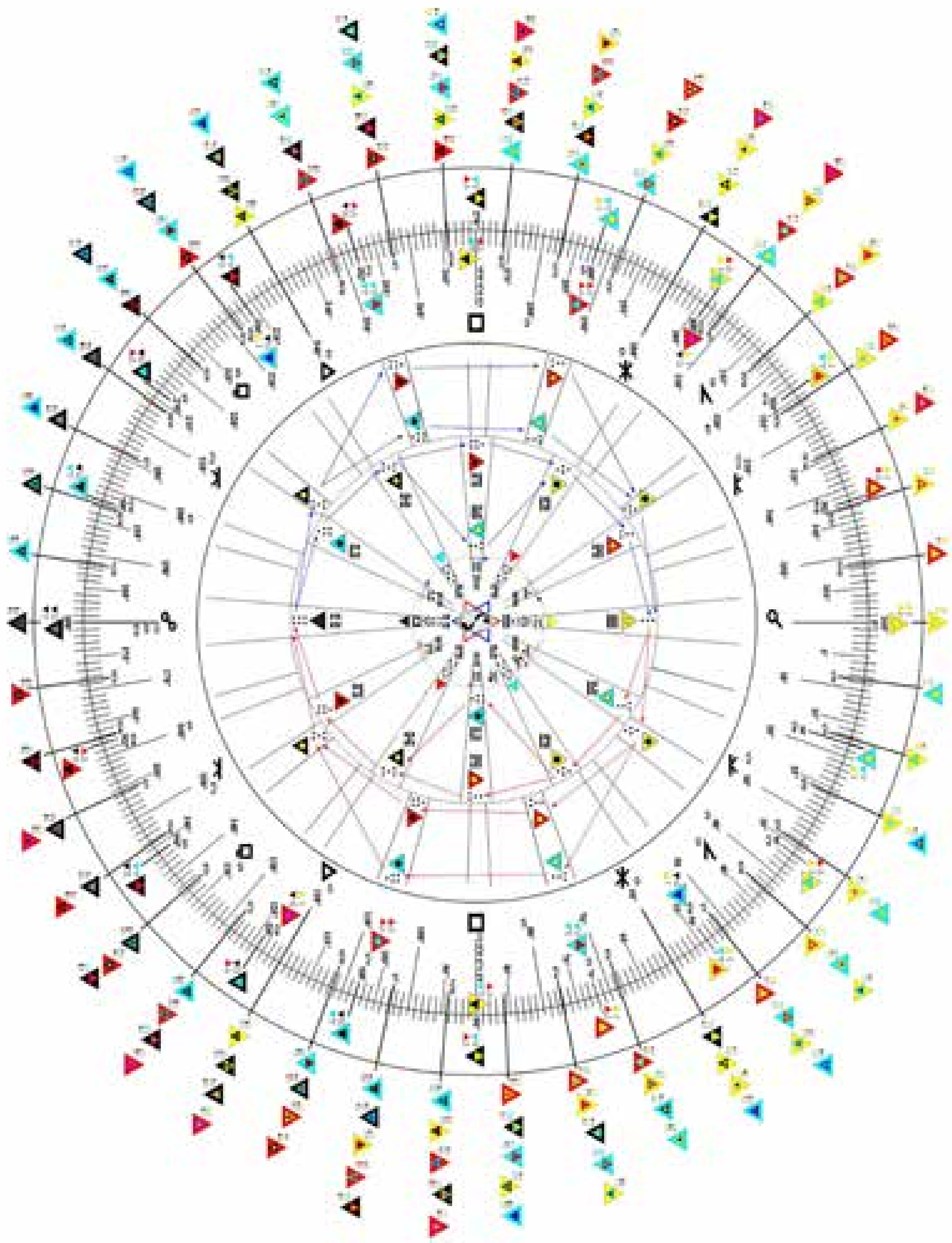
The possibility of data inputs and creative algorithms is infinite, and would require deeper research and prototyping to determine the precise information that would be generated in the data visualisations. The following pages include a collection of lunar phase algorithms from the open-source website by Ben Daglish, as well as visualisations of the I Ching and Mayan dreamspell cyclical calendars, which illustrate the Law of Time in the form of the equation: T(E) = Art.

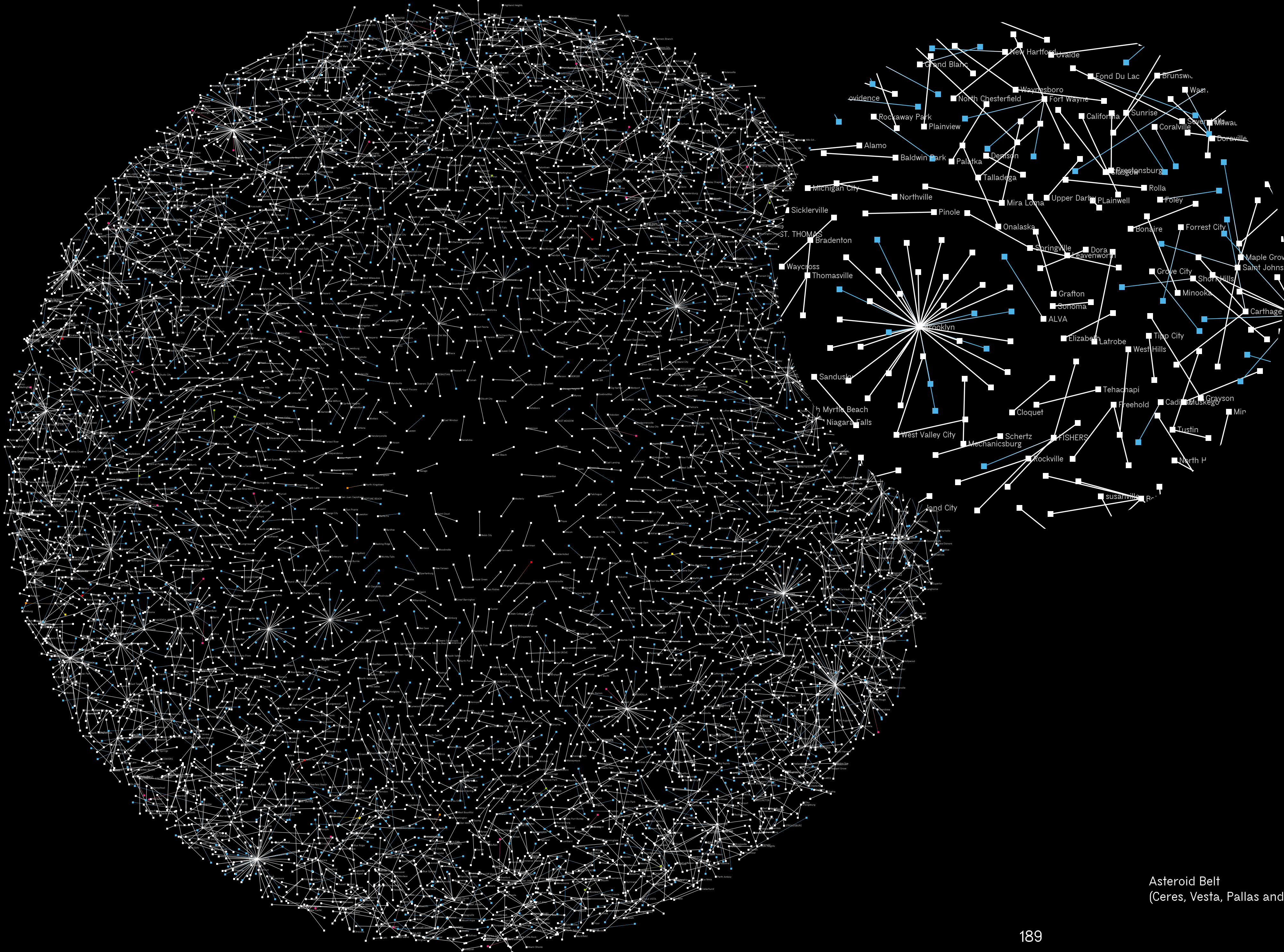
The algorithms pictured provide a framework for identifying a dataset with enough complexity to generate visualisations using the online tool Kumu. Users can explore the data visualisations to find temporal patterns and keywords that are unique to their video watch history, perhaps decoding a new contextual meaning for the information contained in the videos, years after they were recorded.



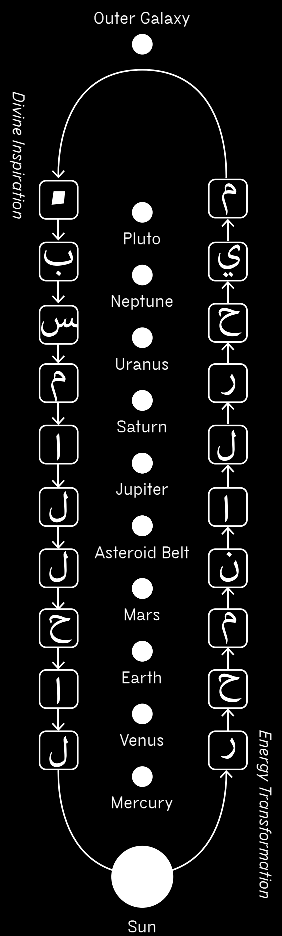
left
UX flow chart for sufilive shuffle

opposite spread
Cyclic (calendrical) arrangements
of the I Ching and the Cantong Qi.
Source: *www.reddit.com/r/iching/comments/k5bdvr/cyclic_calendrical_arrangements_of_the_i_ching*





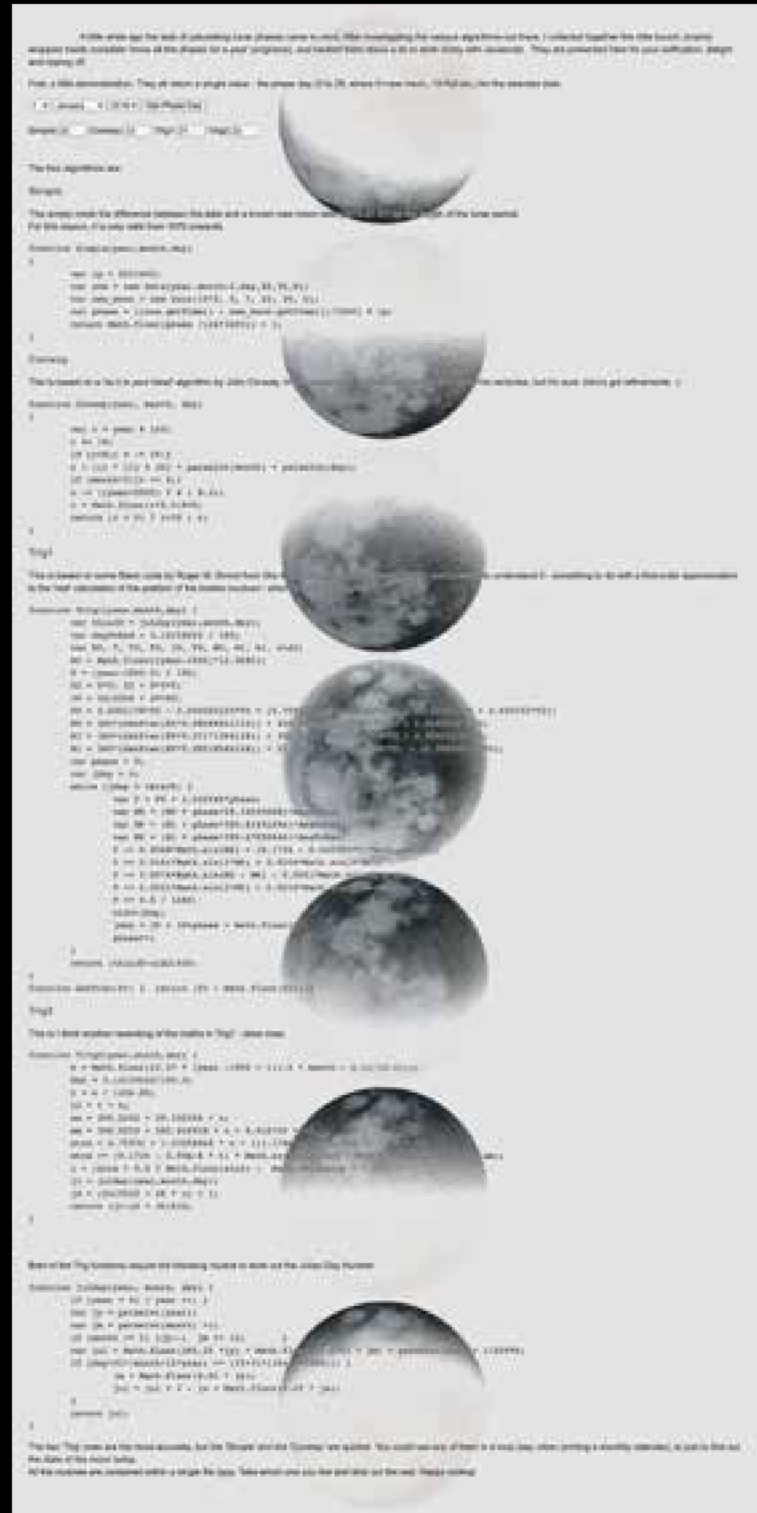
Asteroid Belt
(Ceres, Vesta, Pallas and Hygiea)



top
Wireframes and user flow of Co-Star app. Source: Melissa Neira, *bootcamp.uxdesign.cc/case-study-wireframing-co-star-d88c139fc69e*

left
Law of Time: Interplanetary Holon/Mayan Dreamspell. Source: *lawoftime.org/lawoftime/level1.html*

opposite page
Moon Phase Calendar Algorithm
Source: *www.ben-daglish.net/moon.shtml*



the manifesto of queer machines

noam youngrak son

I anticipate my future with artificial intelligence to be different from the streamlined-dystopia depicted in Hollywood movies, and rather to be a companionship between imperfect machines and queer bodies. I smell the contingency of this co-operation from my crappy MacBook and iPhone, the digital prostheses that I heavily rely on every day as a person from the creative working-class.

When it finally stopped working, I had been using my previous MacBook for four years. It used to be cutting-edge, but was soon considered outdated. It was purchased in South Korea and migrated with me to the Netherlands. It had a keyboard with a Latin alphabet that also indicated the Korean characters, as to represent my mother language. Underneath, the bilingual keyboard laid stuck to the keyboard with industrial adhesive. When the batteries started getting swollen after years of use, I could not get it repaired at the official Apple store in Amsterdam. The glued keyboard had to be removed altogether with the batteries, and Apple's policy of "only replacing parts with the identical parts" led to a refusal to replace my bilingual keyboard with a Latin keyboard in stock. It is only later that I managed to fix the laptop at a private unofficial repair centre, which was coincidently run by an Arabic man who, like me and my laptop, was an immigrant. This procedure made the laptop as illegitimate as my non-European queer body in Western Europe. The lingual/cultural context in which my computer was purchased determinated if it would survive in a foreign territory or not. The longer I use my digital device, the crappier it becomes. In other words, the longer the device drifts away from Apple's blueprint, the queerer it becomes, and the chance for it to become more intimate with my queer body grows. Apple sneakily hinders this connection by gluing the keyboard to the batteries, making the device unrepairable, and planning its obsolescence.

The way I perceive the intimacy with my queer machines is through performative uses. After breaking my iPhone screen, I desperately tried to handle its inability to read my fingers. Trying to turn off the alarm in the morning for instance, was far from the authoritative interaction between a subject and an object, but closer to a subject convincing another subject to be silent. I've never been more intimate with my phone before that performance created by a collaboration between my fingers and the broken touch screen. The climax of this happening was reached when its participants started reconstructing the bodies of each other. I did it by replacing the genuine, yet broken screen with a fake one. This made the status of the iPhone, again, as unofficial as my body. Yet, at the same time, my crappy machines also rebuild my body. On that morning with my iPhone, it was done by cutting my index finger on a shard of the broken screen. But sometimes, the reconstruction involves more subtle interactions. For instance, I had only used the left-side speaker of my MacBook because the right one made an unbearable high-pitched noise when turned on. In the long run, one can imagine that this companionship could transfer the deviance from the laptop to my body, in other words, imbalance the hearing of my left and right ears. If this inability could be inherited over generations, we might expect a kin group of humans that would only hear with their left ears in the far future.

I speculate that the artificial intelligence that will be entangled with my queer body in the future will be as deviant and illegitimate as my MacBook and iPhone are. While crappy machines are not represented in blockbuster

fictions about technology, representations of queer bodies are deliberately erased in human history by colonialism. However, this manifestation is written through the co-operation between my fingers — that I use for queer intercourses — and an unofficial laptop. Nobody can predict what kind of technical apparatus we will live with in the future, but the ones that the majority of us can afford won't be state of the art. What intrigues me is not how capable the technology will become, but how queer will the intimacy that forms with it be. My artificial intelligence companion in the unforeseeable future won't be as intelligent as the ones people will remember or fantasise about, but queer and crappy like my body.

This speculation is not about a utopia. Unfortunately, my electronic devices are crucially reliant on the technologies owned by the big tech corporations. They undoubtedly are the products of exploitative labor and represent a massive ecological footprint. My queer body in the consumerist society is inevitably dressed up with sweatshop garments and fueled by the crops and livestock produced by industrial farming. What bodies are involved in this intimacy? What bodies are excluded from this co-operation? Who does profit and who does get exploited from this entanglement? The queer alliance between me and machines is not politically sterile, and can only be activated upon a continuous acknowledgment of its constraints.

Author's iPhone with a broken screen and bilingual keyboard

My identity as a creative-working-class person is formed by a companionship between imperfect machines and queer bodies. (Digital collage of public domain images)

the canvassed opinions of frankenstein

maya christodoulaki

When Mary Shelley wrote a novel about a monster in 1816, she kept it nameless. She pieced together a personal identity made from her close family names. She compiled a creature inspired by her alpine escapades, an infatuation with electrochemistry, the ghost stories in Eyriès' *Fantasmagoriana*, and losing her first child while caring for her new-born. The book was written in 1816, the 'Year Without a Summer.' Two years later, the novel was published with an antique reference in its title as *Frankenstein: or, the Modern Prometheus*.

While in Switzerland, Mary Shelley's sister, Claire Clairmont, had an affair and a child with Lord Byron, who had another child named Ada Lovelace with his half-sister Augusta Leigh. While Mary Shelley's first child did not survive — only one of her four children managed to — the impact of this child not only inspired the tale of Frankenstein, but also would have been a remote half-cousin to Ada, the mathematician who proposed the mechanical general-purpose computer. In a twist of fate, both women compose early stories that will define Artificial Intelligence, with Ada being the algorithmic writer, and Mary the literary.

The infamous android which we associate with Artificial Intelligence began its anonymous course with little expectation, whereas to this day more than seventy-four films reference Frankenstein. Since the silent film of 1910, countless adaptations portray the monster in futuristic horror and science fiction films, sympathetic character-dramas and gothic parodies — engaging each time with the technological anxieties of the era. The 1931 film by James Whale even begins with the actor Edward von Sloan directly warning the

An affluent man receiving galvanic electric therapy from a French quack doctor, while staring intently out of the window. Coloured etching

following spread
Giolio Bonasone, *Epimetheus Opening Pandora's Box*. Engraving, 1531

audience of the dividing tale they are about to get exposed to. With its boundless reservoir of contrasting admissions, the cautionary tale can be extended and modified. Mary's goth prose and backstory have faded, but every reiteration of the film renews the destiny of the spirited yet overworked young man. Although a little worn from its original narration, the tale has survived continuous anachronisms. Could the current association of the monster with the imposing capabilities of Machine Learning be more than a light entertainment of the original narrative?

The novel feeds the wide-known narrative of the self-destructive, invention-seeking polymath that tirelessly recovers from the dismays of scientific and personal failure. Young Victor goes to study in Ingolstadt after experiencing death in the family and finds himself confronted with the disparities between alchemy and real knowledge. His father identifies his miseducation and diverts him from "occult philosophies" by saying, "my dear Victor, do not waste your time upon this; it is sad trash." His convictions gradually change when confronted with acceptable scientific practice, which Mary had identified in the concept of galvanism practiced by Giovanni Aldini and Luigi Galvani. As vitalists, they experimented with electricity on a range of dead animals and humans during the 18th century, seeking an internally stored *élan vital* which could reactivate the body. In that light, Mary saw in Prometheus a precedent of those galvanists, as he stole fire from the gods to counteract the negligence of his brother Epimetheus in equipping humanity with skills adequate for survival.

Mary often switches the voicing character between the protagonist, the monster, and the peripheral figures to reflect more points of reference. She echoes a version of her father's radical counter-revolutionary sentiments that saw the French revolution as a monster. The narrative aestheticises the discovery of reason, opposite to the tumult brought

by the beast of collective movements and, with that, shields the readers from the perspective of those who suffer from the unaccountable experiments of aristocracy. Moreover, with every dramatic recount, it is impossible to overlook her own storyline in the actions of the protagonist who wilfully challenges the notion of life, and yet, upon succeeding the animation of a giant artificial creature, dreams restlessly of the passed sister. As Victor she writes, "For the first time, also, I felt what the duties of a creator towards his creature were, and that I ought to render him happy before I complained of his wickedness." He develops a dependence on his monstrous brainchild. He dreads to share scientific failure and becomes restless to the thought of grave consequences. At times, the burden is alleviated through partnership and friendship.

Withal, it is not in the moonshot-bound creator where we see a match for Machine Learning's dictum. The utterances coming out of the familiar broken face of Frankenstein — popularised by Boris Karloff's movie performances — are the ones that fit perfectly to the objective of recognition, characteristic of our generation's Artificial Intelligence. Mary had extracted ideas from John Locke's *An Essay Concerning Human Understanding* (1690) and lent the misunderstood creature the skills to develop intelligence, learn how to distinguish human sounds and match them to objects and words. The beast says, "My sensations had, by this time, become distinct, and my mind received every day additional ideas. My eyes became accustomed to the light, and to perceive objects in their right forms; I distinguished the insect from the herb, and, by degrees, one herb from another." The monster perseveres through the continuous abhor and rejection. In hope of acceptance, it trains new levels of perception and learns to read. It accepts the alienation caused by the new language as a necessity for growth to a point that it contends other humans in speed and efficiency.

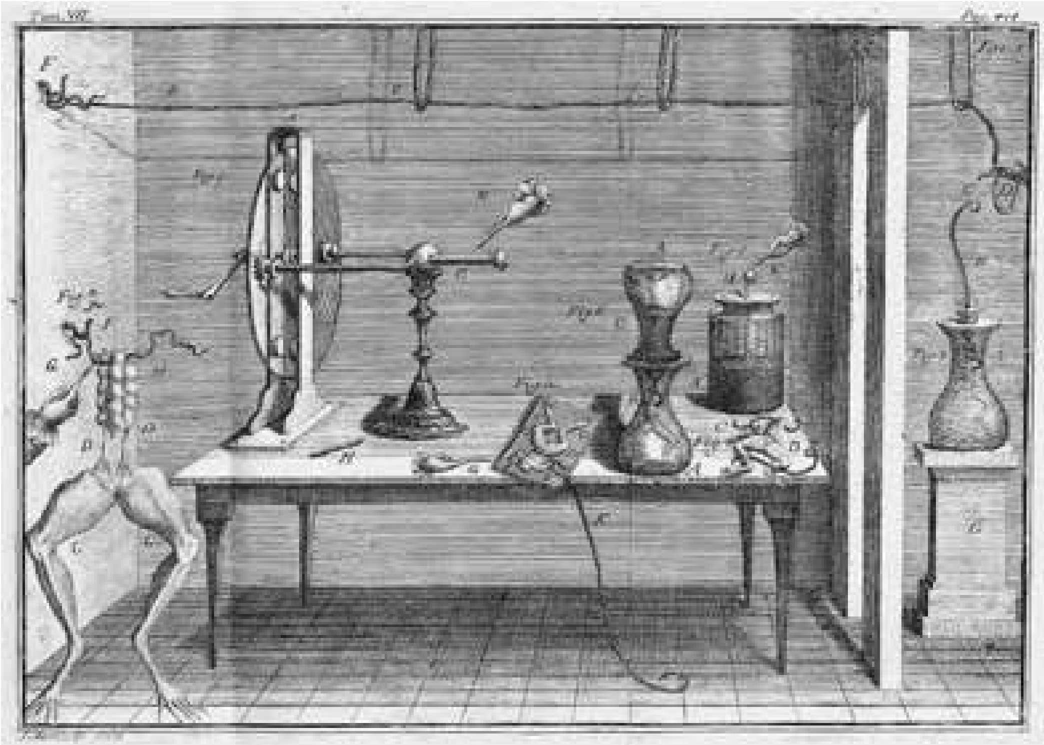
Theodor Von Holst, William Chevalier, *Frankenstein Observing the First Stirrings of His Creature.* Engraving, 1831

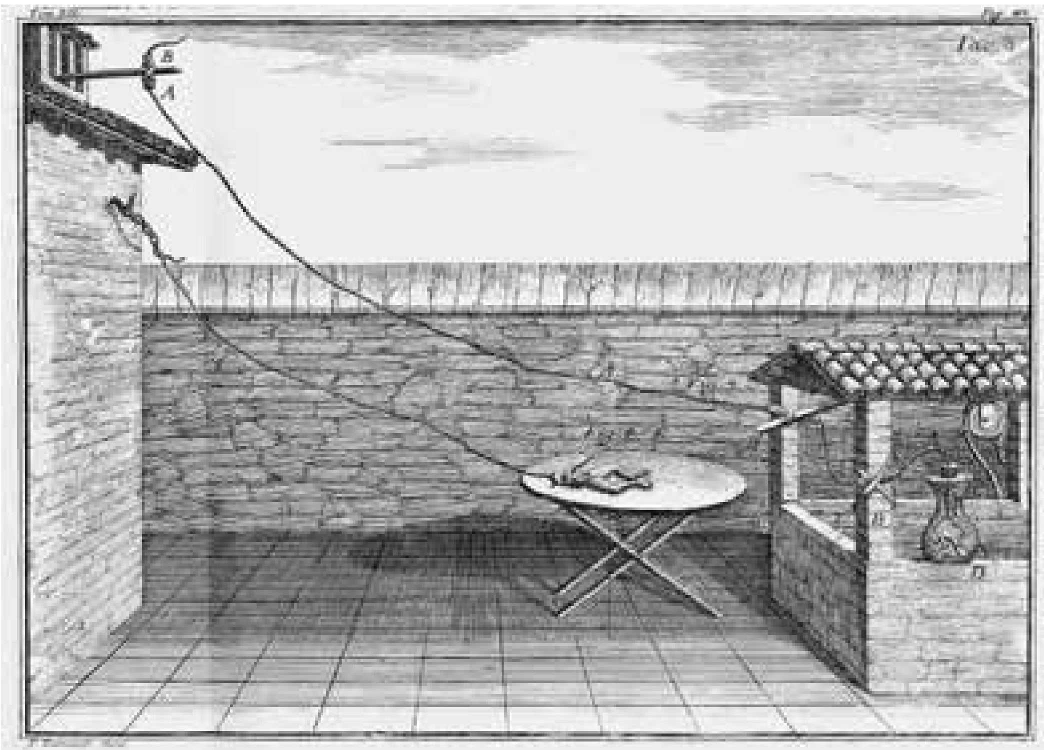
following spread, top
Luigi Galvani, *De viribus electricitatis in motu musculari commentarius*, 1791a, plate 1, p. 59

following spread, bottom
Luigi Galvani, *De viribus electricitatis in motu musculari commentarius*, 1791b, plate 2, p. 61

Unbeknownst to its use, but sure of its superiority, the monster accepts the visual authority of its creator as it develops an eye for beauty. The new knowledge systems carry social meaning. Of the limited acumen of peasants, the monster sorrowfully states, "He might dissect, anatomise, and give names; but, not to speak of a final cause, causes in their secondary and tertiary grades were utterly unknown to him." With an enlarged cranium itself, the monster validates the axiom that relates brain function to the topography of the head. It develops based on a scientific tradition that dates to Avicenne's 1347 *De generatione embryonis* (On embryonic generation) with a cranial depiction that connects the senses, fantasy, imagination, and cognition to brain cells. On its long exile, the monster reads and observes; it discovers new feelings and processes what it has been through; it even understands oppression and kindness, impoverishment and class structures, history and political sentiments.

When the monster is speaking, the voices of Mary, Frankenstein, and its own overlap. "So many opinions are canvassed" it exclaims, admitting to the frustration of increasing complexity. It is irritated by the multiple types of intelligence it has learned to perform and makes the public sentiment for anthropomorphic Artificial Intelligence suffer from the monster's doubts. The very complexity of the references that Mary and Victor gathered about the monster are enough to fiddle our judgment from a supposedly secured position of greater intelligence. While confused, it is again the adventurous spirit of Victor Frankenstein with which we measure up. We align with a demand for him to complete his vision and maximalise his potential. Overwhelmed by the scrutiny of a lost child and the anguish before the creation of another one, we excuse the protagonist of the surrounding social pressures to perform as a scientist. We forget that the creation of monsters comes at the





expense of peripheral knowledge, acquired orderly while studying, but inspired hastily while travelling. From the Swiss Alps to the Scottish Highlands, unknown, poor, and unregulated civilisations, allow the scientist to roam and appropriate, claim genius, with unconstrained creative freedom and an art of personal superintelligence over the rest. The forgiving eye of the stranger is fascinated at will, mostly at what doesn't affect him.

Frankenstein has been a fragmented, radical fiction of a disheartened, talented woman who brilliantly expresses an abolitionist position in the early 19th century. It has also been the tale of a revenge-seeking artificial creature that dares to not play by the scientist's rules and impose its alien intelligence. It has been one of the multiplying Frankenstein movies that only appear to have frozen in time. Repeating yet again the premise of Frankenstein, supposedly neutral and cautionary, would neglect the uncomfortable content of intelligence hidden in the cultural context of Mary Shelley — personal, scientific, political, historical. Sustaining the mere use of technology by Prometheus and Frankenstein means that no questions are raised about how and why we use it.

As with the reproduction of Frankenstein, stories about the history of Artificial Intelligence cannot simply be reduced to a documentation of its implementation. Instead, we need to question whether this technology has a place back in its supposed origins. When focusing on the function of mega, automated knowledge-structures, we pursue the one thing that machines do better — compute. We do, then, lose track of who tells the story each time — Mary, Frankenstein, the creature, or any other reference that feeds the recursive whole. We need to resist the pursuit of Artificial Intelligence as a self-absorbing mechanism that regurgitates knowledge into a dispositional structure.

The emerging atlases that map the relation of Machine Learning to other disciplines ought to include the internal dialogue that goes beyond the numbing cautionary tale and the usability of an instruction book. We need disciplines and practitioners that can visibly address the adaptive cultural significance of Artificial Intelligence. As we are still writing atlases to convince us of our own intellectual pursuits, any question following the pattern 'which is the role of Artificial Intelligence in discipline X' can be avoided as cosmetic. Epimetheus has already opened Pandora's Box.

For the unfitting uses of Machine Learning, there must be courage to either abandon the 'sad trash' or misuse it. If not, we suggest a paradigm shift that is on the fringe of arrogance and let algorithmic promises serve as a charming lie.

bibliography

Adam Frost, "Mary Shelley's Frankenstein—in Charts," in *The Guardian*, 13 January 2018

Sharon Ruston, "The Science of Life and Death in Mary Shelley's Frankenstein," in *The Public Domain Review*

Jill Lepore, "The Strange and Twisted Life of Frankenstein," in *The New Yorker*, 5 February 2018

"List of Films Featuring Frankenstein's Monster," source Wikipedia

Andrew Smith, *The Cambridge Companion to Frankenstein*, Cambridge University Press, 2016

Frédéric Migayrou, Camille Lenglois (eds.), *Neurones, les intelligences simulées. Mutations, créations*, Editions HYX, 2020

Frankenstein, dir. James Whale, Universal Pictures, 1931

Mary Wollstonecraft Shelley, *Frankenstein: or, The Modern Prometheus* (1831), Penguin Classics, 2003

Cornelis Cort, *Prometheus bound to a rock, his liver eaten by an eagle.* Engraving, with etching, 1566

contributors

eddie blake
Architect and writer. He teaches at the London School of Architecture and has taught at the Royal College of Art and the Architectural Association. He writes about architecture in *The Guardian*, *The Architectural Review*, *Vice*, and *Metropolis*, among other publications.

vera van der burg
Interdisciplinary designer and researcher, focused on artificial intelligence and the way it can operate in the field of art and design.

amanulla buriev
Doctor of Sciences in History, Leading Researcher at the Institute of Oriental Studies of the Academy of Sciences of the Republic of Uzbekistan.

christopher burman
Urban technologist, artist, and co-founder of the collaborative design studio Heat Island.

alessandro celli
Freelance research-led industrial designer based between The Netherlands and Italy.

maya christodoulaki
Architect and external lecturer at the Institute of Architectural Theory at the University of Innsbruck, Austria.

fabiano cocozza
Graphic designer and art director based in Milan.

camilla colombo
Curator and producer, focusing her practice on interdisciplinarity at the intersection of art and science. Co-founder of Ohme and Saloon Brussels.

amandine david
Researcher and co-founder of Hors Pistes, a nomadic residency program that initiates designer-crafter encounters.

shady elbassuoni
Associate professor of Computer Science at the American University of Beirut.

ali ghomashchi
Algorithms engineer developing novel algorithms for inferring contextual information about user behaviour using various data sensors of smartphones.

michael kessler
Architect and filmmaker currently based in Berlin.

ibrahim kombarji
Architect and writer currently collaborating with FormaFantasma in Milan.

maxwell neely-cohen
Author, artist, and member of the *livecode.nyc* collective.

outpost office
Design practice based in Columbus, Ohio founded by Ashley Bigham and Erik Herrmann.

dámaso randulfe
Artist, architect, and editor of *Migrant Journal*.

sara raza
Contemporary art curator and writer based in New York City. Founder of the curatorial studio Punk Orientalism, specialised in global art and visual cultures, mainly from Central and Western Asia and its international diaspora.

ayesha saldanha
Independent researcher, writer, and Arabic translator.

roo shamim
UX Researcher and Systems Designer based in New York City. She is idealistic about the potential of human-centred technology and participatory design.

noam youngrak son
Interdisciplinary queer designer based in Ghent and Eindhoven.

ilaria speri
Director at Wonder Cabinet, Bethlehem, Palestine.

Dixit Algorizmi—The Garden of Knowledge
59th International Art Exhibition
la Biennale di Venezia, 23.04–27.11.2022

organisation
Art and Culture Development Foundation
of the Republic of Uzbekistan

special support
Saida Mirziyoyeva
Deputy Chairwoman of the Council of the Art and Culture Development Foundation of the Republic of Uzbekistan

commissioner
Gayane Umerova
Executive Director of Art and Culture Development Foundation of the Republic of Uzbekistan

curators
Space Caviar
(Joseph Grima, Sofia Pia Belenky, Camilo Oliveira, Francesco Lupia)
Sheida Ghomashchi

exhibition design
Space Caviar
(Joseph Grima, Sofia Pia Belenky, Camilo Oliveira, Francesco Lupia)

visual identity and catalogue design
Studio Folder
(Marco Ferrari, Elisa Pasqual, Molly Davies, Serena Gramaglia, Nunzio Mazzaferro)

project management
Madina Badalova
Art and Culture Development Foundation of the Republic of Uzbekistan

project assistants
Temur Ortiqov, Laziza Akbarova,
Dilorom Tursunova, Jasur Asliev
Art and Culture Development Foundation of the Republic of Uzbekistan

local media management
Nigora Tursunova, Elmurod Nadjimov
Art and Culture Development Foundation of the Republic of Uzbekistan

exhibition installation
We Exhibit

communication & PR
Cultural Council

soundscape
Charli Tapp, Abror Zufarov

botanical environment
Studio Mary Lennox

catalogue authors and contributors
Eddie Blake, Vera van der Burg, Amanulla Buriev, Christopher Burman, Alessandro Celli, Maya Christodoulaki, Fabiano Cocozza, Camilla Colombo, Amandine David, Shady Elbassuoni, Ali Ghomashchi, Michael Kessler, Ibrahim Kombarji, Maxwell Neely-Cohen, Outpost Office (Ashley Bigham, Erik Herrmann), Dámaso Randulfe, Sara Raza, Ayesha Saldanha, Roo Shamim, Noam Youngrak Son, Ilaria Speri

editing
Maxime Benvenuto

translations and editing in Russian
Denis Stolyarov

translations and editing in Uzbek
Nigora Umarova

typefaces
MAD Sans, Dries Wiewauters, 2018
Laica, Alessio D'Ellena, 2020

printer
Longo AG
Bozen/Bolzano, Italia

publisher
Humboldt Books
via San Marco, 33
20121 Milano, Italia
humboldtbooks.com

ISBN 978-88-99385-94-1

Uzbekistan
National
Pavilion

ART AND CULTURE
DEVELOPMENT FOUNDATION
UNDER THE MINISTRY OF CULTURE
OF THE REPUBLIC OF UZBEKISTAN

Printed in Italy in April 2022