

# ORIENTATION: DATA SCIENCE AT THE END OF TIME

Applied math for data science (DSC 482/MTH 445) Fall 2022

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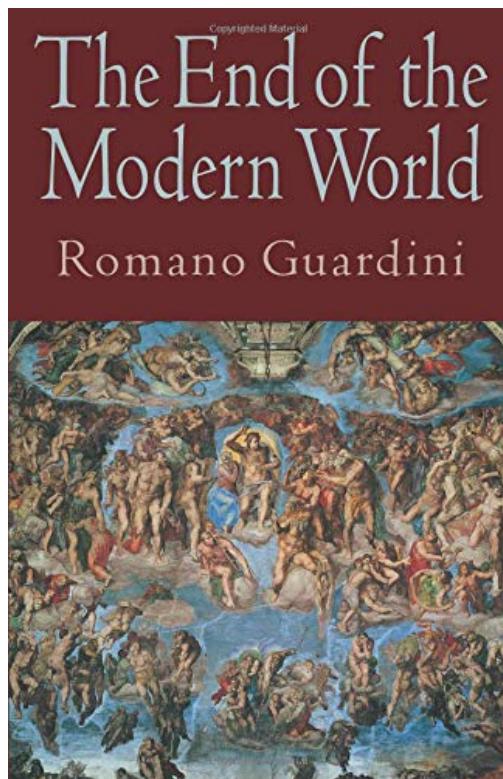


Figure 1: Cover of Guardini, The End of the Modern World (2001)

- How did people in antiquity experience and view the world?<sup>1</sup>
- How did people in the middle ages experience and view the world?
- How do we in the modern age experience and view the world?
- What does this have to do with statistics and probability?

The essay '[The End of the Modern World](#)' by Romano Guardini gave me the idea for this section. It was born out of the thought that probability as the foundation of statistics, is a profoundly **modern** concept, and I was wondering if a brief historical, non-technical, philosophical journey might help us orient ourselves towards it.

Guardini's book will appear pessimistic to non-faithful readers. It was however, written to help people in Germany right after WW II get a sense of purpose and orientation that they had lost after 12 years of life under the Nazis.

The book is strangely prophetic in many ways - probably because it was quite clear around the middle of the 20th century, what the essence of modernity was, and where the journey would lead us in the 21st century.

I'm offering this section to you because the DSC 482 classes should also have a "senior spirit" of discourse and critical discussion, which one cannot get from topical (in this case: statistics) textbooks alone.

## 1 ANTIQUITY - CLASSICAL MAN



Figure 2: Jacques-Louis David (1748-1825) - Death of Socrates

1. What historical time period are we talking about?
2. Do you know anyone from that time and what they said, wrote or did?
3. What were the world-views of people in antiquity?

Image: [Pergamonaltar, Berlin](#) (Βωμός τς Περγάμου), 2nd century BC. The base of this altar from a temple for Zeus is a relief showing the battle between the Giants and the Olympian gods ("Gigantomachy"). Excavated by the German engineer Carl Humann 1878-1886, this is at the heart of the Pergamon-Museum in Berlin. This altar stood in the ancient city of Troy (of Homer's [Iliad](#)).

## 2 SUMMARY



Figure 3: Jacques-Louis David - Death of Socrates (1787)

1. From Ancient Greece, ca. 400 BC to the End of Rome, ca. 476 AD
2. Socrates & Plato (philosophy), Aristotle (physics), Euclid (maths)
3. The world is a (closed) ball or sphere within which the Gods live with us; man must search for truth and experiment with hypotheses.

Image: *David, Death of Socrates (1787)*. The Greek philosopher and distinguished veteran of the Peloponnesian war, Socrates (469-399 BC), was convicted of impiety by the Athenian court. Instead of renouncing his beliefs, he died willingly, discoursing on the immortality of the soul before drinking poisonous hemlock.

Guardini: "Classical man never went beyond his world; his feeling for life, his imagination and his vision of existence were one with the limited world he knew. He never asked himself whether or not something might exist beyond his known world [...] because he lacked any relation which could transcend his world."

"Classical man *could not even conceive* of a desire to break the limits of his world. To do so those limits must have already been broken. This was simply not the case."<sup>2</sup>

This implies the impossibility of thinking up a concept like 'probability'. However, classical man had mathematics as defined by Wigner (1960): "*Mathematics is the science of skillful operations with concepts and rules invented just for this purpose.* Euclid's elements are an example, and his geometry was enough for Aristotle to explain many natural phenomena (though the classical concept of "nature" has got nothing to do with our modern idea of "nature")"<sup>3</sup>:

"Greek scientific thought was marked by flexibility and absence of dogmatism. The Greek mind was gripped by an endless quest for understanding of the ways of the world. Nothing however, had been decided conclusively; every question remained open, waiting to be answered further. Every philosophical reflection might contain the answer to life; therefore it could compete with any other possible supposition. Always, however, one had to remain within the limits laid down by the fundamental ethos of the Greek world. These limits could not be transgressed, and the trial of Socrates attest to the strength of this prohibition."

### 3 MIDDLE AGES - MEDIEVAL MAN



Figure 4: Annunciation of Cortona by Fran Angelico (1433)

1. What historical time period are we talking about?
2. Do you know anyone from that time and what they said, wrote or did?
3. What were the world-views of people in the middle ages?

Image: Annunciation of Cortona by Fra Angelico (1433). The scene depicts the annunciation of Mary by the Archangel Gabriel. The words in the painting can only be read upside-down to indicate that they are addressed to God, who would be in the proper position to read them.

[Cortona](#), my own favorite place in Italy, is a small medieval town in Tuscany - it was supposedly founded by one of Noah's sons, Crano, 273 years after the Great Flood. The city was already inhabited by Etruscans at least since the 7th century BC. Lake Trasimeno where Scipio the younger defeated Hannibal after he had crossed the Alps with elephants, can be seen from Cortona. Next to the town is a small convent, Le Celle, where St Francis of Assisi lived in a tiny cell.

## 4 SUMMARY



Figure 5: Richard of Wallingford, Abbot of St Albans

1. From the end of the Roman Empire (ca. 400 AD) to the 15th century
2. Benedict of Nursia, Charlemagne, St Stephen, Thomas Aquinas, Gengis Khan, Jean d'Arc, Dante, Leonardo da Vinci, Michelangelo.
3. Impatience with all limitations through Christian Faith; Germanic drive for transcendence; Truth through meditation

Image: [Richard of Wallingford](#), English mathematician, astronomer, horologist (the study of the measurement of time) and abbot of St Albans (1292-1336). Invented the most advanced clock of his time.

"The crucial truth for medieval man was the fact of Divine Revelation [...] set forth within the dogma of the Church [which] bound and limited man by its authority; [but also] made it possible to surmount this world. Revealed truth was conceptualized by means of a delicate logic which distinguished and then united all of reality. The theological system erected upon these foundations unfolded itself as a great synthesis. In the modern sense of the term, however, scientific explanation was almost unknown. The one point of departure for science in the medieval intellectual synthesis was authority, that of antiquity and especially the work of Aristotle" (384-322 BC), himself a disciple of Plato's. "The Middle Ages had established a relationship with antiquity which, although seemingly naive, was constructive."

"This drive for reconciliation [with antiquity] is crystallized in the *Summae*, which united theology and philosophy, sociology and morality. [...] Medieval man neither wished to explore the mysteries of the world empirically nor did he want to illuminate them by a rational methodology. He was interested in building his world out of the content of Revelation and upon the principles and insights of classical [Greek] philosophy. The *Summae* are that world as it was erected by the human mind. They can be compared with the medieval cathedral in which every form and artifact [...] were given a symbolic value which made possible a life and a sense of being integrally religious in nature."

"What medieval man lacked was any desire for exact, empirical knowledge of reality. [But] unless we free ourselves of the evaluations made by the minds of the Renaissance and the Enlightenment, we cannot really understand the Middle Ages. The judgements then leveled were made under the pressure of a polemic, which has succeeded in distorting the truth even to our own day. Equally distorted was the glorified Middle Ages of the Romantics."

"The Middle Ages were filled with a sense of religion, which was as deep as it was rich, as strong as it was delicate, as firm in its grasp of principles as it was original and fertile in their concrete expression. From cloister and monastery there shone a religious light whose strength cannot be overestimated. Medieval man thirsted for the truth. [...] This passion for understanding, however, had nothing in common with our modern enthusiasm for the techniques of scientific investigation. Medieval man was interested neither in pursuing nature and history empirically nor in mastering reality theoretically. He chose to plunge into truth by way of meditation."

## 5 MODERN WORLD - MODERN MAN

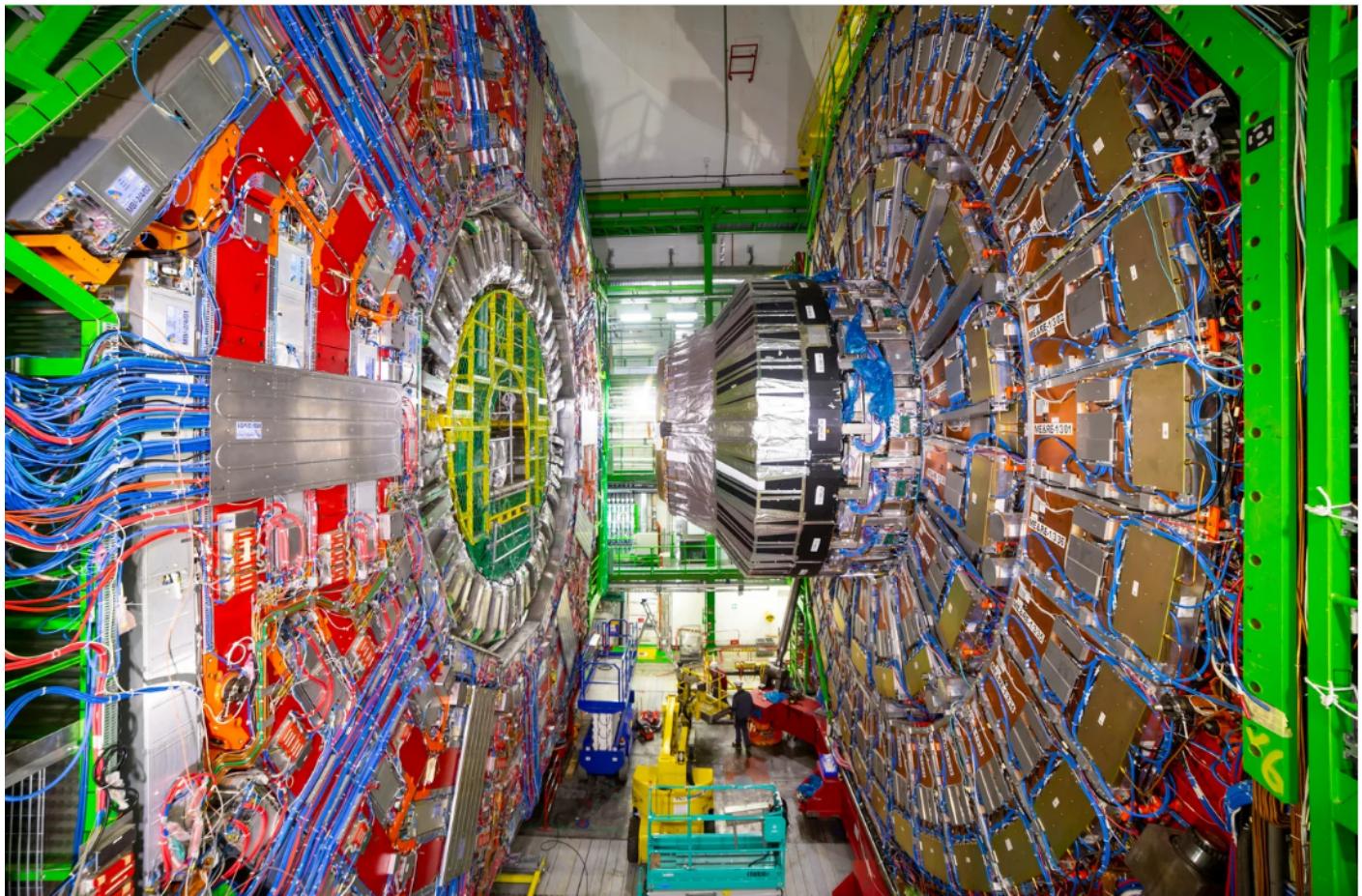


Figure 6: Cross-section of the Large Hadron Collider

1. What historical time period are we talking about?
2. Do you know anyone from that time and what they said, wrote or did?
3. What are the world-views of people in the modern era?
4. What is the importance of statistics and probability today?

*Image:* cross-section of the Large Hadron Collider (LHC) at CERN, Switzerland, where I spent a few good summers starting as a teenager, working with physicists on photo multipliers, to my own PhD many years later. I even met my wife there, at the first World-Wide Web conference! - Particle accelerators like the LHC, and the data processing surrounding a particle physics experiment are among the greatest "big data" events you can think of: ALICE, one of the detectors located in the cross-section shown above, has more than 12 billion sensors that create a data stream of more than 3.5 terabytes per second, or 300 petabytes per day, which is more than the estimated data created world-wide per day.

## 6 SUMMARY



Figure 7: Pablo Picasso, Guernica (1937), grayscale painting

1. Renaissance (1500s); Enlightenment (1700s); Modernism (1900s)
2. Galileo (method), Newton (laws of motion), Einstein (relativity)
3. Man vs. machine; Earth vs. universe; Nature/Science vs. God.
4. Probability vs. certainty. Statistics vs. experiment.

*Image:* The grayscale painting "Guernica" by Picasso (1937) depicts the bombing on the Spanish city of Guernica during the Spanish Civil War. It is also a typical cubist-surrealist painting where reality is dissolved in geometric patterns and symbols, distorted and disfigured to achieve a heightened effect.

"[In the modern age,] man's passion for knowledge began to lead him away from authority, pointing him directly toward real things. He chose to probe things with his own intelligence and to reach established judgements which were independent of any pattern first laid down by authority."

"Man begins to find his own individuality an absorbing object for study, for introspection and psychological analysis. [...] **Genius** became the most important measure of human value [and] the standard for all human judgements."

"Anxiety is the dizziness of freedom" (Kierkegaard, 1844): "Modern anxiety arises from man's deep-seated consciousness that he lacks either a 'real' or a symbolic place in reality. In spite of his actual position on Earth, he is a being without security. The very needs of man's senses are left unsatisfied, since he has ceased to experience a world which guarantees him a place in the total scheme of existence."

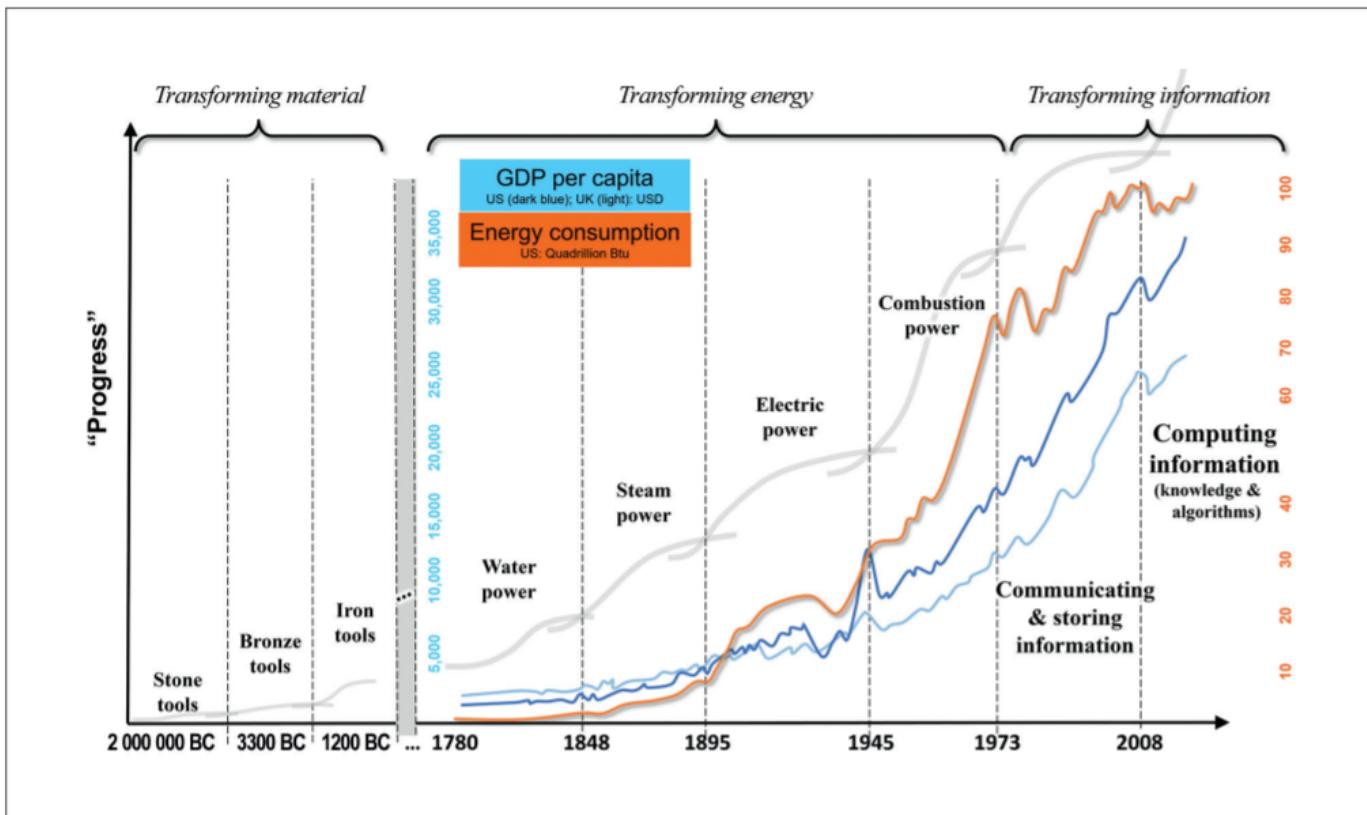
'Arkansas - the natural state': "Nature was all those things which existed in the world prior to anything man did to them; it was also the sum total of energy, matter, essences and natural laws [and] made a matter of value in itself. [Nature] became the norm which guided man in action and in reason toward whatever was right or healthful or perfect."

"Prior to the Renaissance, only the Work of God had an absolute meaning; after the Renaissance, the world ceased to be the Creation of God. It had become the work of Nature. Similarly the work of a man ceased to be an

act of obedience to God's ordained service; it became a 'creation' in itself. Previously a worshipper and a servant, man now took to himself the prerogatives of a 'creator'."

Science and technology as the new religion - Goethe: "Who possesses science and art, possesses religion as well." - "The three-sided vision [of 'nature', 'personality', and 'culture'] harmonized with the conceptions upon which modern science was being built. From modern science, technology has grown, and technology is a concentration of processes allowing man to posit ends in conformity with his own desires [...] and cut themselves away from an ethic which once had bound men universally."

## 7 DISSOLUTION OF THE MODERN WORLD



**Figure 1.** Schematic presentation of Schumpeterian long waves.  
GDP, gross domestic product

Source: Hilbert M Dialogues Clin Neurosci. 2020 Jun; 22(2): 189–194.

Figure 8: Schematic presentation of Schumpeterian long waves

*Image:* From 'The Ontology of Technology Beyond Anthropocentrism and Determinism: The Role of Technologies in the Constitution of the (post) Anthropocene World (Blok, 2022). [See here](#) for an attempt at analysing this visualization.)

- Uncertainty about the position of man in reality: "It is [now] taken increasingly for granted that man ought to be treated as an object. Man confronts this attitude in the range of authority exercised over him; he may merely meet it in countless statistics and tables or he may experience its culmination in an unspeakable rape of the individual, of the group, even of the whole nation." Guardini (1956)

- Unknown relationship between probability and reality: "Perhaps there are further metaphysical desiderata that we might impose on the interpretations. For example, there appear to be connections between probability and modality. Events with positive probability can happen, even if they don't. Some authors also insist on the converse condition that only events with positive probability can happen, although this is more controversial." (Hajek, 2019)
- Free will remains elusive as a concept: "Attempts have been made to link the existence of free will with the indeterminacy of quantum mechanics, but it is difficult to see how this feature of the theory makes free will more plausible. On the contrary, free will presumably implies rational thought and decision, whereas the essence of the indeterminism in quantum mechanics is that it is due to intrinsic randomness." (Britannica)
- The search for religion is alive and well among scientists, too: see e.g. "[Things a Computer Scientist Rarely Talks About](#)", by Don Knuth.

## 8 REFERENCES

- Encyclopedia Britannica (2022). Quantum Mechanics - Physics. [URL: britannica.com](#).
- Guardini, R (1956). The End of the Modern World - . Intercollegiate Studies Institute; REV ed. (April 1, 2001). ([Amazon](#))

[From an amazon.com review](#): "Written shortly after the end of World War II, The End of the Modern World is a bracing, sometimes bleak jeremiad against the dehumanizing dangers of what we now call postmodernism. Guardini is not a pessimist, but he is vitally concerned about the potential loss of human dignity and individual responsibility in a world culture dominated by technological utilitarianism."

- Hajek A (2019). Interpretations of Probability. In: Stanford Encyclopedia of Philosophy.
- Kierkegaard S (1844). The Concept of Anxiety.

Anxiety as both modern man's curse and saving grace: "I would say that learning to know anxiety is an adventure which every man has to affront if he would not go to perdition either by not having known anxiety or by sinking under it. He therefore who has learned rightly to be anxious has learned the most important thing."

- Knuth D (2001). Things a Computer Scientist Rarely Talks About. CSLI Lecture Notes 136. [URL: stanford.edu](#).

"After an introductory first session, the second lecture focuses on the interaction of randomization and religion, since randomization has become a key area of scientific interest during the past few decades. The third lecture considers questions of language translation, with many examples drawn from the author's experiments in which random verses of the Bible were analyzed in depth. The fourth one deals with art and aesthetics; it illustrates several ways in which beautiful presentations can greatly deepen our perception of difficult concepts. The fifth lecture discusses what the author learned from the "3:16 project," a personal exploration of Biblical literature which he regards as a turning point in his own life. The sixth and final lecture, "God and Computer Science," is largely independent of the other five. It deals with several new perspectives by which concepts of computer science help to shed light on many ancient and difficult questions previously addressed by scientists in other fields."

- Wigner E (1960). The Unreasonable Effectiveness of Mathematics in the Natural Sciences. Comm. Pure and Appl. Math. 13(1). ([PDF](#))

There is an extension of Wigner's thought by Turing Prize laureate [Richard Hamming \(1980\)](#). He observed: "When examining [Einstein's 1905] special theory of relativity paper one has the feeling that one is dealing with a scholastic philosopher's approach. He knew in advance what the theory should look

like, and he explored the theories with mathematical tools, not actual experiments. He was so confident of the rightness of the relativity theories that, when experiments were done to check them, he was not much interested in the outcomes, saying that they had to come out that way or else the experiments were wrong. And many people believe that the two relativity theories rest more on philosophical grounds than on actual experiments." As a modern man, Hamming claims "Mathematics has been made by man."

## Footnotes:

1 The German words for this are "Daseinsgefühl" (the feeling one has when existing), and "Weltbild" (a view of the whole world).

2 Counter arguments one might bring forward: what about astronomy and astrology of the ancient world? The answer: these (pseudo) sciences never left the sphere that bounded the world.

3 Wigner's 1960 paper is still worth reading. He writes about the "miracle of appropriateness of the language of mathematics for the formulation of the laws of physics," and admits that "we do not know why our theories work so well." This is a rather medieval, miracle-conscious, "unreasonable" way of thinking, for which Wigner (one of the greatest physicists, and a close friend of Einstein's) was heavily criticized.

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