Informatica per le Digital Humanities
Lecture 3
March 3 2025

Texts

Slides 2-3
Encoding is a process that maps items onto natural numbers, which digital computers can elaborate. Analog computers, like an abacus or Babbage's modified loom, do not work with digits in the way a digital computer does. There is no encoding with an analog computer, whereas encoding is needed if we want to work with a digital computer. This means that the fundamental role played by encoding in computer science is intrinsically connected with the digital nature of computers today.
However, we have to be aware of the fact that encoding is not necessary for computing (indeed, we don't need it when we do computing with our fingers or with an abacus). We live in an encoded world because we are surrounded by digital computers, and we have so many digital computers around us because things happened in the 20th century that ensured their enduring success.

Slides 4-13
The chain of events that led to the dominance of digital technology in computer science started in the 1950s, when these physicists discovered semiconductive materials (materials that allow or stop the flow of electricity depending on whether they are electrically stimulated or not), and built transistors with them. A transistor is a 3-legged device that, if electrically stimulated on leg B (base), allows for a current to flow from leg C (collector) to leg E (emitter). A transistor, thus, acts like a switch, because depending on how it is stimlated it makes electricity flow or it stops it. When electricity flows, the end of leg E is electrically charged, which we represent with a metaphor of a glass full of champagne. Instead, when the transistor does not allow the electrical flow, the glass is empty.

Slides 14-19
The notable technological innovation here is that this switch is not mechanical: there are no moving macroscopic parts. Instead, it is an electronic switch, where electricity flow in a part of the system (between C and E) is controlled by electricity in another part of the system (at B). This is why your electronic devices do stuff, but you do not hear sounds like with a mechanical watch or a combustion car engine.

Slides 20-32
In the same period when transistors were developed, a movie titled "Forbidden Planet" came out. Among many innovative characteristics, this movie features the concept of a computing machines that has "no instrumentalities". In the Italian translation "senza meccanismi", this machine could be seen as a computer that does not include material mechanisms, just like an electronic computer, in which there are no macroscopic moving parts. Probably, in the writers' ideas, the computer in the movie (which is the main antagonist of the protagonists) is so evolved it doesn't even have transistors in it.

Slides 33-46
There is a gap that needs to be filled: the one between "electronics" and "digital". How can an electronic system made of transistor be a digital system? Where are the digits inside an electronic circuit? Here is the fundamental encoding that underlies all digital systems that are

built in the form of electronic circuits: we map the empty glass, that is, the state in which the E leg of a transistor does not see any electricity flow to a "0", and we map the full glass, that is, the state in which the electricy flows to a "1".
Under the light of this interpretation, when we observe the state of an electronic circuit, we physically observe electrons moving around, but it is *as if* we saw 0s and 1s.

Slides 47-54
There is another gap to fill: the digits we know go from "0" to "9", whereas in the fundamental encoding we only have two, "0" and "1". The fact that these two were enough to express all the numerical quantities was known since the times of German philosopher Leibniz.

Slides 55-60
The binary numerical system (with only two digits) is based on the same mechanism as the decimal system (with ten digits) that we are used to. The only difference is that, instead of having powers of 10 that add up (10^0 for units, 10^1 for tens, 10^2 for hundreds, etc.) we have powers of 2 that add up to form numbers (2^0 for units, 2^1 for pairs, 2^2 for sets of 4, 2^3 for sets of 8, and so on). To indicate which system you are using, you should put an index at the bottom right corner of the number: if there is a 2, that number was built in the binary system; if there is a 10, the traditional decimal system was used.

Slides 61-67
To express a number in the binary system, we have to express it in the form of a sum of powers of 2. Let's take 237 as an example. In the decimal system, it is made of 2 hundreds, 3 tens, and 7 units, that is, 2×10^2, 3×10^1, 7×10^0. We have to express the same total quantity, but with powers of 2 (2^0, 2^1, 2^2, 2^3, 2^4, 2^5, 2^6, 2^7, 2^8…correposnding to 1, 2, 4, 8, 16, 32, 64, 128, 256…). We know we don't need 256 because it is bigger 237, so it cannot be a part of it. In the end, we find out that 237 = 128 + 64 + 32 + 8 + 4 + 1. If you express the components that form 237 in terms of powers of 2, we have that $237 = 2^7 + 2^6 + 2^5 + 2^3 + 2^2 + 2^0$. Use the exponents of the powers as indicators of the position where you have to write a "1", and write a "0" in the other positions. The exponent "0" corresponds to the position of the first digit to the right, and then you proceed towards the left: 11101101. This means $237_{10} = 11101101_2$, that is, the quantity that is known to you as "two-hundred-thirty-seven" is expressed as "11101101" in the binary system.

Slides 68-69
This technique works for any numerical quantity, and this is why we can build computers with electronic circuitries that feature only two electrical states: we interpret those states as "0"s and "1"s and we introduce the binary system to express quantities with those binary digits. We can imagine building electronic systems in which there are more electrical states (maybe 10 different ones, each for each digit in our traditional decimal systems), but they would be far more complex to build, more prone to errors, and more energy consuming; hence, engineering criteria have shaped the electronics of modern computers to be binary.