



2⁵ Things I Learned in Computer Science

University of Basel, Dept of Mathematics and Computer Science

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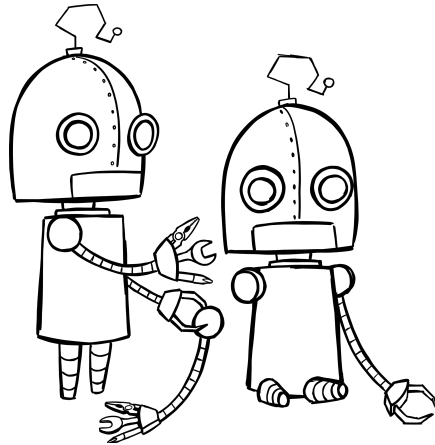
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The fixpoint of describing yourself

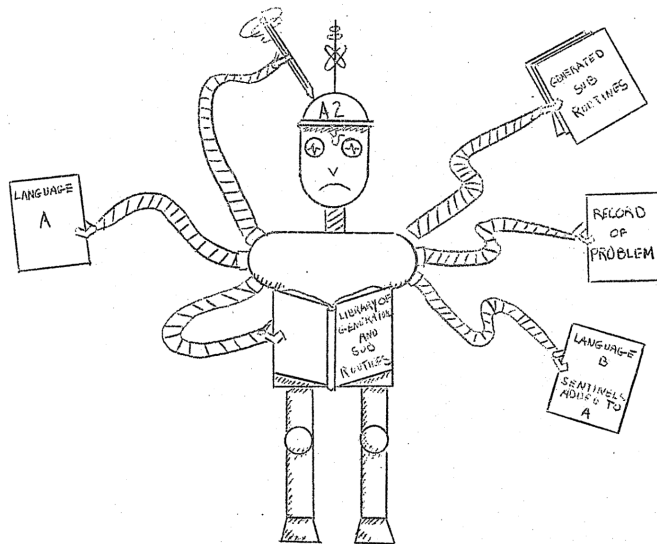
What could be easier than to write a program that produces it's own code as output? It's not that easy – even a versed programmer will spend some hours to figure out the trick (which can be different for each programming language).

One trick is that the program must contain a description of itself, inside its own code. And because outputting that self-description also needs code, this self-description must be somehow compressed.

But once written, such a program (also called a "Quine") reproduces itself each time it is run, and this in turn is called a fixpoint. One could call this the fixpoint of life, because any lifeform must master this trick, including robots if they wanted to build themselves and become a lifeform.



To some dedication goes here



Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Author's Note

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We have Machines within Machines

In 1954, computers just computed numbers. Grace Hopper, a famous female programmer around then, had a hard time to convince her colleagues that these machines can do more.

The picture is hers and shows how a computer program can translate one computer program into another one. She even coined the term that is still use today: a **compiler**.

Nowadays we have many more of these translation and transformation machines, with names as funny as the picture: *cross-compilers*, *transpilers* and *compiler-compilers* (cocos). Their mission is to translate from one computer language to another, for example to “compile” a human-written program to machine code, or to “transpile” from a new version of a programming language to the old one.

12

Acknowledgements

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Counting to more than ten with two hands

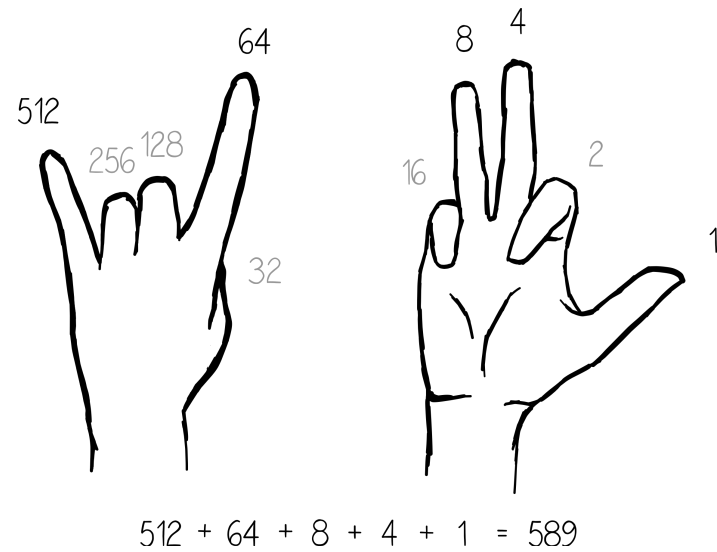
Normally you count with your fingers by stretching them out one after another. You don't care about which ones are stretched out, but only about the amount of them. Each of them is as significant as the other.

By changing the significance in the way that the right thumb has significance 1 and the left neighbor neighbor is always twice as significant we can get 1024 different numbers:

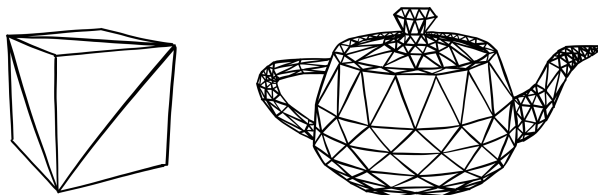
$$1+2+4+8+16+32+64+128+256+512=1023, \text{ and } 0$$

This is called binary counting and exactly the way a computer counts but with zeros and ones instead of bent and stretched fingers.

11



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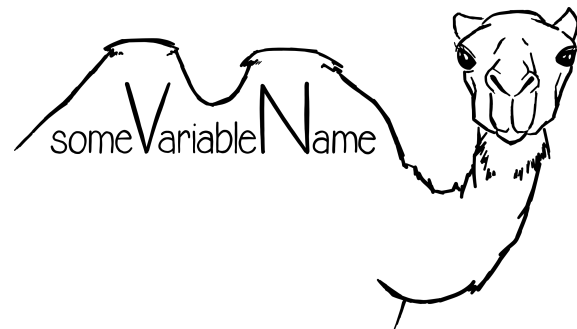
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CamelCase, or why coding conventions matter

One problem that often arises when writing code is the naming of variables. Often multi-word names are used for variables but in most programming languages it is not possible to use spaces in a variable name.

One programming style that tries to structure this is called CamelCase. It is the practice of writing each word in the middle of a phrase with a Capital letter. This greatly improves readability.

```
thisGreatlyImprovesReadabilityComparedTo  
whenwewouldusenocapitalizationatall
```

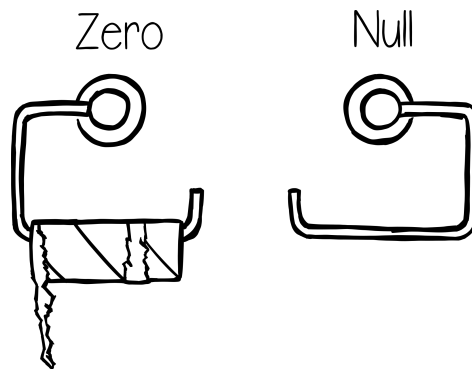


World of triangles

The 3D pictures seen in computer animated films or computer games consist of many small triangles. The shape of a figure in such an image comprises many points. To visualize a surface, a set of those points is connected by lines. The mathematical figure which emerges through this process is called polygon. The smallest polygon possible is the triangle, where only three points are connected. Furthermore, a triangle guarantees that all the points of the polygon are on the same plane.

The more triangles are used, the more detailed a surface is. Whereas a simple object with flat surfaces like a cube can be modeled by using only a few triangles, a more complex structure like a teapot requires many more triangles for representing its round shape.

10



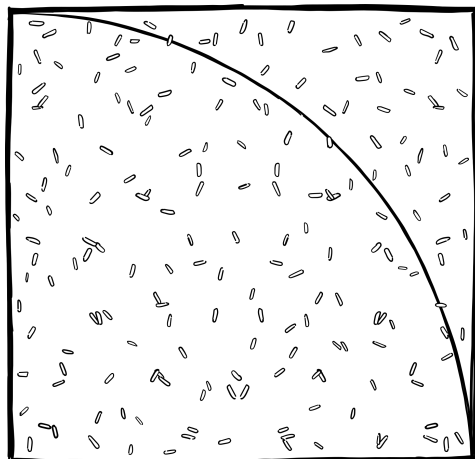
How to calculate Pi with rice

Draw a square and a quatercircle in it on a paper and throw a hand full of rice on it. Done!

Well almost done. Now you count how many grains of rice landed inside the square and how many landed inside the quatercircle. The ratio of these two numbers is an approximation of the ratio of the two areas $\pi \cdot r^2 / 2 = \pi / 4$. Multiply the ratio by 4 and you get Pi, well an approximation. If you are not happy with the accuracy just use more rice.

This is one example for the Monte Carlo method. Key is to avoid computing a complicated formula by using random samples in a clever way.

9

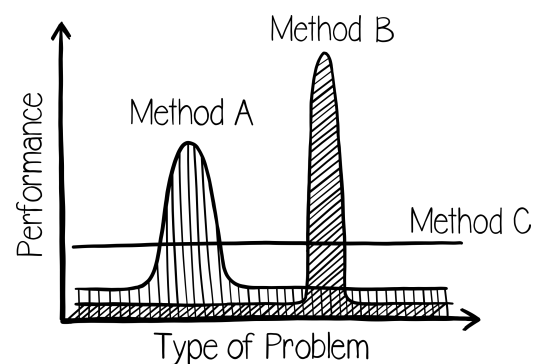


1

Zero is not null

The `null` value has a special meaning in computer science. It is used to declare that a value is not yet defined or known.

The speciality of `null` is that although it shows us that a value is missing, it is itself a value. So it is possible to compare two non existing values. Suppose we have data about a patient; it does make a difference if the patient has no disease (0) or is not yet diagnosed (`null`).



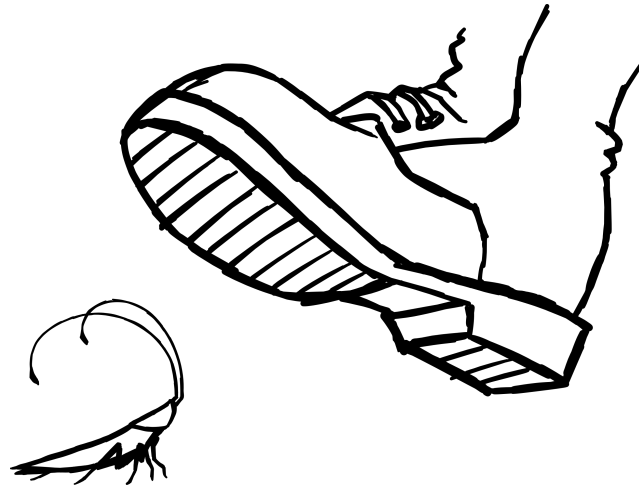
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We all hate Bugs

Bugs creep into your house without notice, there they eat your food and clog your sink. They hide in corners and behind large furniture and are most of the times hard to find. If you find a bug that was bothering you for a long time the feeling of success is rewarding.

A bug in software is very similar. It's usually a behavior of the software which is not intended. It is often very hard to find bugs in software and can sometimes be attributed to one single character that was wrongly placed.

The act of finding bugs is called Debugging. Like pest control, the code is searched and cleaned from every bug that influences the behavior negatively. Unfortunately, while fixing software bugs the programmer accidentally adds other bugs. The cycle is endless.

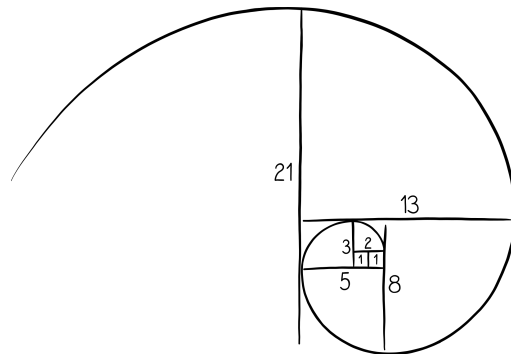


There is no such thing as a free lunch

8

In Computer Science we have a wide range of very different problems and accordingly many approaches to tackle them. We might for example try to find some 'optimal' solution for a search problem, but it is unclear which specific algorithm one should use. So it is only natural to think about algorithms that always provide us the best solution, regardless of the problems subtleties.

However, the 'No Free Lunch' theorems state, that no single method works better than any other for all possible problems. Instead, it is necessary to select the method based on the problem (or data) at hand. That is, there is always a cost associated with selecting a method and unfortunately there is no such thing as a free lunch.



10th Fibonacci Number: $13 + 21 = \underline{\underline{34}}$

Being lazy is a good thing

7

A lazy person is always searching for ways to make things faster and more efficient.

Instead of doing the same thing over and over again, a good computer scientist tries to automate the task. This not only improves the reliability, but also saves time in the long run. Furthermore, a good computer scientist is also lazy when it comes to writing code. Rather than solving a specific problem, a good programmer develops a generic solution that can be reused for similar problems.

Good programmers are diligent in order to be lazy. Or with other words: They are strategically lazy. And that's a good thing.

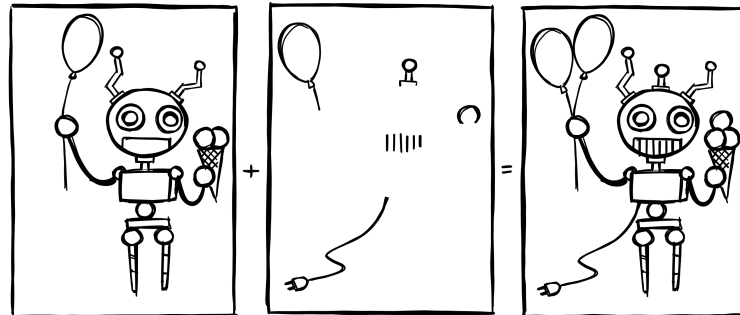


Sometimes a problem can be solved by solving the same problem, but smaller

3

Imagine a problem that you can only solve if you know the solution to smaller instances of the same problem. Computing, for example, the 10th element from the famous *Fibonacci sequence*, will require you to sum up the 9th and 8th Fibonacci number. But if you don't know the 10th number, you will most certainly not know the 9th and 8th either. So you'll have to go deeper: In order to obtain the 9th number, you need to add the 8th and 7th element. Knowing the 8th will require the 7th and 6th. And so on. Doing this is called *Recursion*.

But when to stop? Recursion only works if there are certain smallest problems for which you *know* the solution, otherwise you'll keep fragmenting forever. Continuing with the approach above will eventually lead you to computing the 1st and 2nd Fibonacci number, which are defined to be 0 and 1, respectively. Knowing these will allow you to hand the results all the way to the top and finally obtain the desired 10th Fibonacci number.

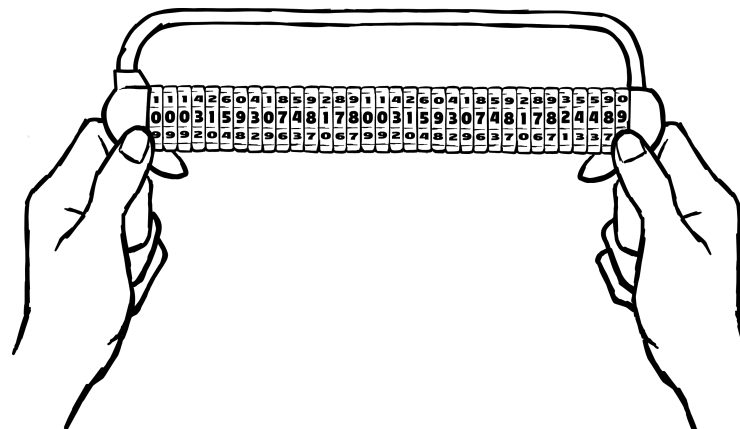


"Brute Force" means you are weak

4

For some problems in Computer Science, it can be proven that there are no "efficient" ways of solving them. In this case, the only resort is **brute force**. Brute force means that you let the computer try out every possible—and we really mean *every* single, possible and potential—value that solves the problem, until you succeed.

Several cryptographic algorithms are based on such problems where the secret key can only be guessed or found by exhaustively trying out all possible values during a few billion years. Confronted with such time scales, attackers find themselves in a very weak position.



6

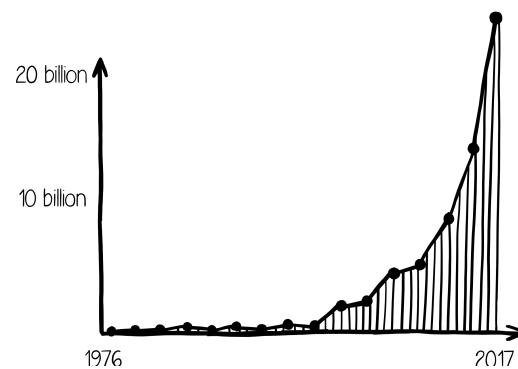
Why Patching is like Picture Puzzles

If you have a buggy version of a program and a corrected one: why send the whole program instead of just the small differences?

This is how updates for your smartphone work: you will receive the set of differences –a so called *patch*– that your smartphone applies to the old and buggy program.

Now go and find the differences: Did we spot them all?

Transistors



5

Moore's Law

In 1965, the technological progress lead Gordon E. Moore to formulate his rule of thumb that became famous under the name "Moore's Law". It states that the production costs of microchips used in electronic circuits would fall, leading to smaller and more powerful microchips at a lower overall cost. He estimated that the number of components on a single chip to double roughly every 12 months.

This law has been updated several times over the following decades. First the increase in the number of transistors used in a single chip was the driving force behind the exponential progress. Since the mid-1990s, and until the early 2000s, the continuation of the trend was mostly due to the downscaling of the components themselves. Today, as the manufacturing process is hitting physical limits, there is a development towards integrating functions, that until now were provided by separate components, into a single chip.