The Thinking Thing

***You can write a brief sub title here***

By

Fabricio Tosi

**Title of Your Book**

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# Foreword

I'll talk about life and intelligence. These two topics will be the focus of the story.

The concept of intelligence could be interpreted in different ways. I won't talk about human intelligence, but rather intelligence as the ability to solve problems, overcome obstacles, adapt, learn, and in general, what we can qualify as an intelligent response to a specific situation.

A few days ago, someone told me that intelligence was related to the consciousness of one's own existence. No, I'm not talking about that kind of intelligence.

A machine can solve problems, its response is intelligent, but it's not conscious of its own existence. An anthill can solve problems that an individual ant couldn't solve on its own, the system is intelligent, the anthill finds the way, but this system is not conscious of its own existence.

In the following chapters, we'll develop an intelligent system that will solve problems, somewhat in the line of artificial intelligence. We'll talk about computer science.

The story is suitable for all people, and no prior knowledge is necessary to understand it.

And I said I'd talk about life. Life as a single entity and the relationship that could exist between life and intelligence. We'll think of life as a single thing.

Normally, when we look at the world, at reality, we see creatures, individuals. And I mean individual in the sense of an exemplar of a species, not talking about humans, but about individuals of any species. I said that we see individuals, a fish, an ant, and colonies of individuals.

In this story, we'll observe life from a higher level. Let's say that all living creatures are made up of cells. Life builds cellular structures, where the cell is the building block.

Now let's imagine individuals as cells of a larger tissue. And all of life, as a single individual. Where all individuals of all species are the cells that form it.

It requires a little imagination. Keep in mind that although we believe that the individual is independent of the rest of the environment, in reality, no individual will survive outside the ecosystem. It's like leaving a goat on the moon.

This is in terms of life as a single entity, as a single organism. I also said I'd talk about the relationship that could exist between life and intelligence. We'll see that this relationship is also close. We'll see it by developing a machine that will automatically solve logical problems. To develop this computational system, we'll use observable characteristics in life. The system will be something like a life simulator. And by simulating life, we get a computer.

Seeing it in action, I think it could help us understand a little better what happens with life.

I say this because, at least for me, life has always been quite mysterious. Why am I here? What is my mission? Why do I have to die? Why is there so much variety of living beings? Are animals more important than plants? Does all this have any purpose? Is there an intelligence that designs all living beings?

The questions I personally have about life seem to have no end.

So, let's get started. We'll create life with the sole purpose of solving logical problems. We'll do this by creating a new species of living beings tailored to the problem we want to solve. The species will evolve and give us the answer we're looking for. It'll be easy. This is possible because life has plenty of intelligence.

We'll see it step by step.

We'll start by seeing what we need to solve problems or how to process information.

The Thinking Thing

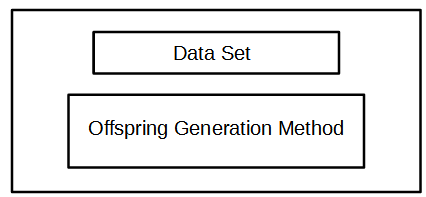
Chapter 1

# How to process information?

In chapter 3, we will conduct an experiment where we will process information using a mathematical abstraction that we will create based on certain characteristics that we can observe in living creatures.

The abstraction we will use will be an object that we will call "Individual," and the computer will be made up of a collection of individuals, like a family or a species. The machine we will build will consist of individuals only, where the individual is the building block and the only component of the system. It will be something like simulating a colony of living creatures.

The "Individual" object is very simple, far from the complexity of real living beings. But it will serve as a conceptual model, and we will be able to see how life could be processing information.

To build this "Individual" object, we will use only two characteristics of life: the data that defines the individual and the ability to reproduce. All living creatures reproduce, and all living creatures have a set of data that defines the individual, something like the construction plans of the individual. Schematically, for us, an individual will be something like the drawing number XX.

(Insert drawing here)

But before we dive into the experiment, we will take a moment to analyze in detail the basic ideas on which this model is based. We will see below what we call information processing, how this process is carried out, and why a family of living creatures might be suitable for performing this task.

## How to process information

Computers process information to solve problems. The process starts with the declaration of a set of data that defines the context of the problem. Operations will be performed on this data, and this will provide new information that will be included, in turn, in the set of known data.

As we add new information to the data set, the context changes state. And with each new operation, we get more information, we know more, and we are closer to finding the solution. Trivial problems could be solved immediately, in a single step, but more complex problems will require a sequence of steps to find the solution. We can call the sequence of steps that must be taken to find the solution a "method," "algorithm," or "program."

And it's not just computers that solve problems in this way; we do it too.

If I ask, how far will a projectile travel when launched? It will not be possible to answer without knowing the context (information about the projectile, launch information, and environment information).

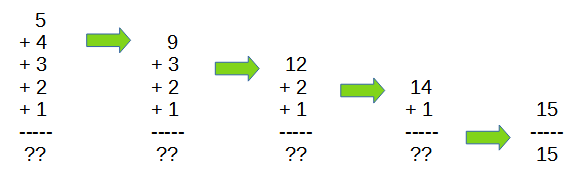
If I ask, how much have we spent in total? It will not be possible to answer without knowing the list of expenses. We need to have certain information to carry out the calculation.

In both problems, the initial set of information is different. And in both problems, the operations and the steps we will follow to find the answer are different. Both the data set and the method are closely related to the problem.

As an example, let's take a closer look at how we add a list of numbers.

Context data: the initial data set will be the list of numbers we want to add.

Method: The first step will be to add the first number in the list to the second. This will give us a new data point, a partial result. The next step will be to add this partial result to the next number in the list. And we will repeat this procedure with all the numbers in the list to get the final result.



Different problems will have different solutions. We cannot solve adding a list of numbers, calculating the distance a thrown stone travels, or sorting a deck of cards in the same way. These are different problems with different methods of finding a solution.

However, when it comes to processing information, viewed generically, there are some basic elements common to all problems. These are

* a set of data that describes the context, and
* a method that describes the necessary steps to find a solution.

Now, our intention is to build a machine that automatically processes information. Therefore, it will be necessary for the machine to be able to store information about the context and execute the appropriate method on the data.

The electronic computers we use daily have a memory device where they keep the information they are working on, and they also have other devices, including the processor, that allow them to execute a program.

Regarding memory devices, we will consider two different types.

* The "read and write" memory, like the ones in electronic devices we use daily (PC-SMARTPHONE), where information can be written, read, and erased, and it will be especially the possibility of modifying the information that interests us in these memories. On the other hand,
* the “read-only” memory, in which once the information is recorded, it cannot be modified. Examples of read-only memory are CDs or old vinyl records, where it is impossible to modify the recorded information.

We have talked about how to process information and have seen what the main elements on which this procedure is based. Let us now see how life could provide these resources, and how a family of living creatures could be suitable for performing this task.

## DNA and reproduction

A characteristic of all living beings is that they all have a giant molecule that stores the information necessary to build an individual. In this story, we will use the idea that it is a large and complex molecular structure in the form of a chain that we call DNA. This DNA is different in all individuals. Two individuals of the same species will have many traits in common but will differ in details that make them different. Similarly, the DNA will be different in details.

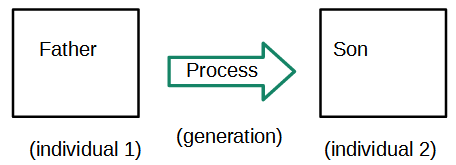
The objective of this story is not to describe DNA precisely. We will only use a very general idea; we will think that all individuals carry the information that defines them inside, and we will call this DNA for the purposes of this story. That's all. The idea is that if DNA contains the information necessary to build an individual, then it is functioning as a support of information or memory. And this is the usefulness that DNA will have for us, to function as the system's memory. DNA has the ability to store a large amount of information. Furthermore, we will think of DNA as a read-only memory. In this way, the information that describes the individual will remain constant throughout the individual's life, and thus, the individual will always be the same, with the same fingerprints, with the same characteristics that differentiate them from other individuals, throughout their life.

I have mentioned that when we process information, the context will change state as we perform operations on the data. The new information we obtain must be included in the context, modifying the state. If we are going to use the individual's DNA as the system memory, the data set cannot be modified because it is a read-only memory. Let's see how we can overcome this obstacle.

Let's see what happens with

## Reproduction

When an individual reproduces, their offspring will not be exact copies of the parent. The children will be very similar but not identical to the parent. This is because no two individuals are the same. In reproduction, the information contained in the father's DNA will be modified to create the child. The child will be a new version of the father.

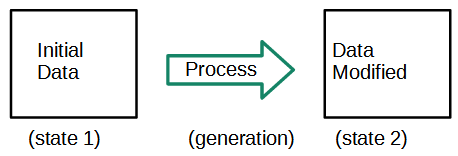


The mechanism of reproduction modifies the information, processes it in some way to produce a new individual, an individual different from all those that have existed until now, an improved individual. It is therefore not a random modification, it is a carefully calculated modification.

We can say that it is a programmed modification since some "method" or function has been applied to the father's data to achieve a specific result. Reproduction will then be the mechanism we use to process information.

Therefore, the information contained in the father cannot be modified because it is a read-only memory. However, the information can be read, the information can be extracted during the process of reproduction, it can be modified by applying the method, and the result can be recorded in a new read-only memory, the child.

In this way, we can make the context change from generation to generation.



And with this, the machine we wanted to build already exists. Life provides all the necessary resources, and nothing needed to be modified. Life is a natural computer.

The function of an individual in this model is to maintain a set of data. If we consider that information is processed during reproduction, this will be a single, simple step in the process. The difference between the father and the child will be the minimum of all possible differences.

I have commented that, in general, solving a problem will require a series of steps, usually more than one. So, the father will not find the solution to the problem, nor will the child. It will be the work of the entire family or the entire species. The problem-solving process will advance step by step, slowly, generation after generation. One step at a time.



In the next chapters, we will create a computer based on living creatures, or rather, on families or species of living beings where the species has been tailored to the problem. The new species is the computer, and this computer is only useful for solving a specific problem and no other, where an individual represents the state of the calculation at a particular point in time.

Note that an individual is not a computer but only represents a state in the calculation process. The calculating machine will be formed by all individuals of the species.

But let's take a closer look, step by step. I have said that an individual represents a "state" of the calculation. Let's see what we will call "process states."

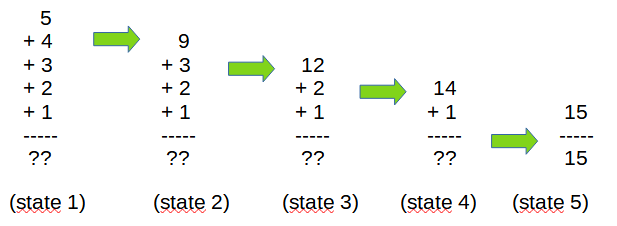
Chapter 2

# States of a Process

Let's review again the sum of a list of numbers that we used as an example in the previous chapter.

Initially, the list contains 5 numbers, and that is all the information we have about the problem at that time. We will call the set of data the "context" of the problem.

We have found the solution after performing 4 addition operations between 2 numbers. There have been 4 steps.



Note that, at each step, after each sum, the set of data has changed.

Every time we perform an operation on the data, the context changes state.

And among the possible states of a process, we will distinguish:

* an "initial state",
* a "final state", and
* a set of "intermediate states".

We start the sum with the list of numbers we want to add, this is the "initial state".

The goal is to obtain the total result of the sum of all the numbers in the list, which is the "final state".

In the case of a game of chess,

The "initial state" is when the pieces are placed in the starting position before any moves have been made.

The "final state" is when checkmate has been given, the game ends, and this is the state we want to reach. And between the initial state and the final state, the game will change state each time a player makes a move, these will be the "intermediate states".

Now, imagine that in the middle of a game of chess, we wanted to stop playing for today, and continue tomorrow from the same point where we left off.

To be able to continue tomorrow from the same point, it will be necessary to remember the state in which the game was left.

To remember the state of the game, we could write down on a list the position of the pieces on the board, so we could reconstruct the game to continue from the same point.

In this case, the information of the state will be the position of the pieces, and this is the set of data that defines the context in this case.

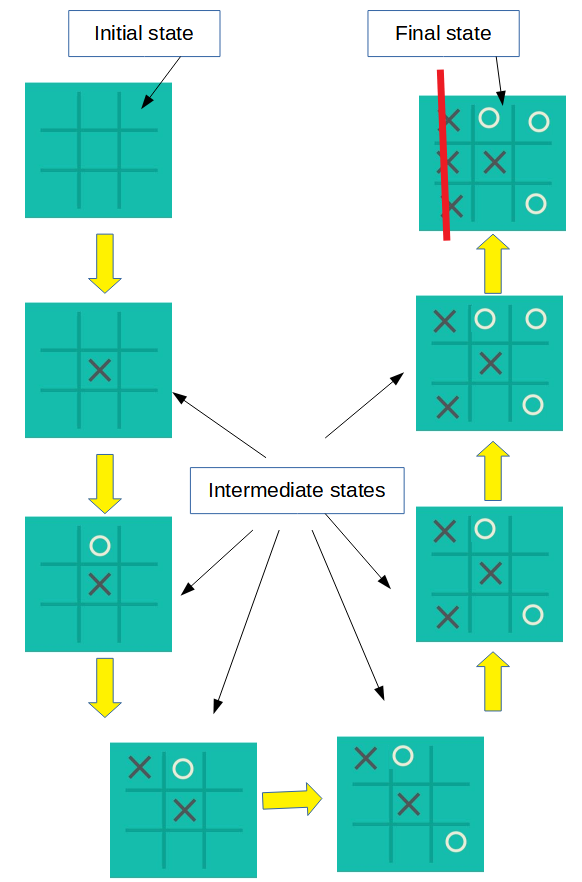
We will use the idea of states of the process to solve the problem, looking for a path that takes us from the initial state to the final state through intermediate states.

There could be a large number of possible states, but we want to know which of all the possible ones form the path that goes from the initial state to the final state.

The game of chess is of great complexity, and if we wanted to generate all possible states, we would find ourselves with a high number of different states, something like 10 to the power of 120.

To visualize it graphically, let's use a simpler example.

Tic-Tac-Toe (3 in a row)

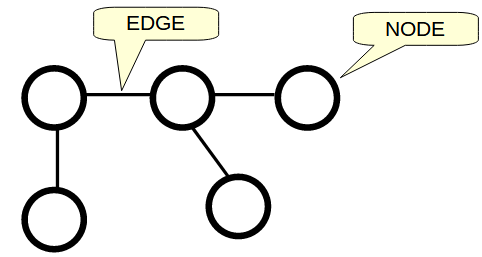


The drawing shows in the game of 3 in a row, the path through different states that goes from the initial state to one of the possible final states.

To solve problems, we will use the concept of "states", along with a structure called a

"graph".

In mathematics and computer science, a "graph" is an abstract structure that represents relationships between objects. A graph consists of a set of nodes and a set of edges that connect pairs of nodes.

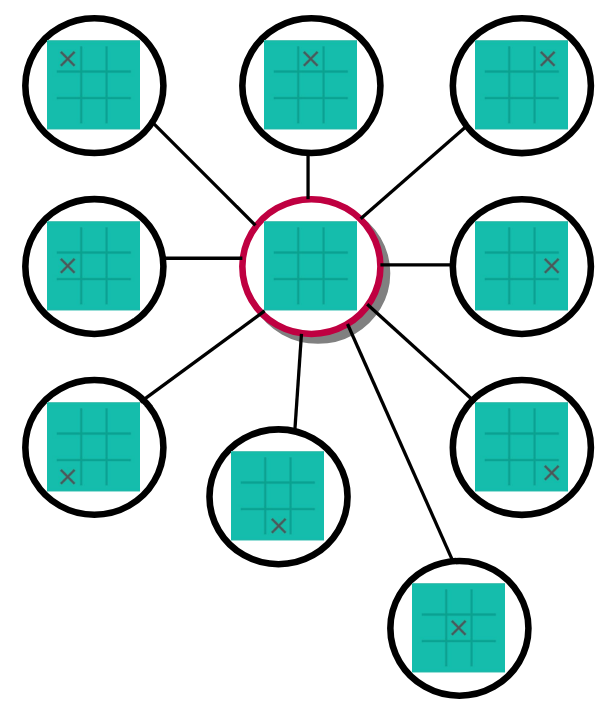


Graphs are used in different ways for the analysis of different types of problems, but we will construct a graph in the following way.

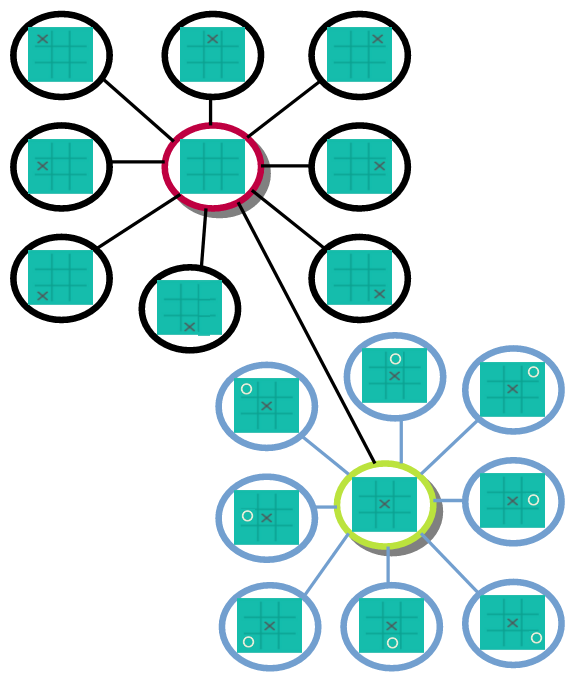
Within the nodes, we will place a state of the process, and the edges that connect the nodes will show us the relationship between parents and children.

For example, let's see how we would start building a graph with the states of a Tic-Tac-Toe game.

We will start by placing the initial state within a node. The children of the initial state will show all possible moves. In this case, the board is empty and a token can be placed in any square, so there are nine possible moves. We will create the nine children of the initial state and connect them to the parent with edges.



From these new states, valid moves can also be made. In all of these boards, there are eight empty squares and a token can be placed in any of them. We will generate all the children of these states, place them within a new node, and connect the parent to the child through an edge. I will show it for just one of the children.



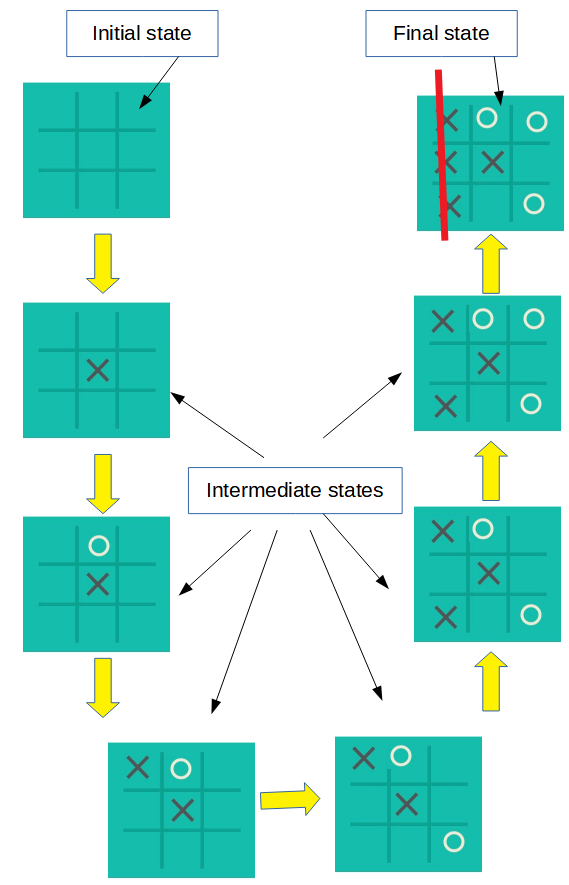
The graph begins to transform into a large network of nodes and edges.

If we continue with this process of generating children for each valid move from each node, the final network will be large and complex.

In the case of this game, there are

9 \* 8 \* 7 \* 6 \* 5 \* 4 \* 3 \* 2 = 362,880 possible states. This means that the graph will have 362,880 nodes.

Once all possible states are generated, we can see among them which are the final states, and we can see the path between states that lead from the initial state to a final state. As in the previous example.



In summary, we have discussed

* what we call states of a process,
* what a graph is, and
* how it is possible to find, among all possibilities, the "paths" that lead us to the solution of a problem.

With these ideas, we are now ready to start the experiment.

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Chapter 3

# Third Chapter Title

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