Robot’s Cognition Architecture: Unconsciousness

ABSTRACT

The intelligent agents are programmed to perform a certain goal; they always use a decision as a function of an input from a sensor or perception; also, always use a conversion between the input data and a policy or a code. By capturing soccer ball and saying: it is a "ball", we are associating perceptive signals as “human” codes.

In this architecture the goal is to satisfy the self body of the robot ("hungry", "thirst" and avoid the "pain"). Against all the AI community, in which the meaning of information and decision is from the input to the output, here, we use the opposite direction, such as radar, that is: from the output to the input. So, we have something different that does not require conversion code tables. We do not teach what a “ball” is in advance, but later.

We use a learning methodology like the supervised and reversed as it works from the output to the input like the reinforcement learning. Calling it, “Out-Wait-In".

As we will see in this article, is something that goes as the Ockham’s razor. This architecture does not use traditional search, nether message forwarding, and nether message content. We do not have codes of predefined data. With this, we do have not to search for codes nor have not knowledge in binary decision trees. We do, however, avoided "pain" and we do have to teaching it how to satisfy the "hunger" and "thirst". However it lacks a consciousness of what is it is making. But with great potential to future upgrades.

1. INTRODUCTION

1.1 Addresses and Forwarding

If we consider all the communication systems, in terms of having or not message’s address and messages forwarding, there will be 4 types of defined systems. One does not make sense: a system with no addresses but with forwarding. Because the message to be forwarding, it should had at least one address. But the other 3 types of systems are possible and exist in reality.

Let’s begin with the system with the two techniques: addresses and forwarding. Included in this system are: the mail, the Internet and the phone. We have, in all of them, the need of an address and a way of message forwarding. As in the mail, the letter goes through post offices to the address indicated, in the Internet, the message goes through the various routers until the recipient computer, and finally, in the phone, the call goes through several telephones central exchanges ending in the destination phone. In this type of system, you must have a conversion table between addresses and forwarding directions.

The memory of the brain may be in the neurons links (dendrites and axons) and not in the cell body, although it is assumed that it is not in the links, because it would be physically impossible to set up a connection between two distant neurons in just a moment. In fact, we can associate two events at one time and remember them immediately.

Just as should not exist conversion tables and forwarding messages in the brain, of this type of system does not help us to find out how is it that a cognitive system should be.

So we change to a system with no messages forwarding but with message address, includes: The Ethernet and the teacher who’s checking the attendance of the students. In this type of system, each user must first know the address but does not need to forward anything, because it is intended to all addressable or those who’s belonging to the system. In the Ethernet a computer with the address of the recipient sends the message to the line, which is where all the other computers are connected. Likewise, the teacher calls the student and everyone listens. Then who is interested answer, which means the recipient who is answers.

In these two previous types of systems every user has a list, sometimes a large list of recipients. That requires a lot of prior knowledge. Starting from the principle that lies in the brain system, in each neuron that communicates with the other lacks such addresses list, these types of systems do not serve us.

It remains us one type of system, which is one without messages addresses or messages forwarding, well known among us as the newspapers, radio, television, radar, books, magazines... In this type of system, the message is addressed to all. But only some find it interesting or helpful. This type of system can be useful to us. And it is. As we show afterwards.

The holistic memory of neural networks results in spite of losing prior information. These networks do not serve for more than establishing associations between inputs and one output codes.

1.2 Searching

If you ask us to search for a book about "Ferraris" in a library, we do a search in a book index by location, by subject ("cars") and then to a summary by sub-themes ("Ferrari") and we found it. However, there had to be an early work in building such an index and summary. And now… if no such index or summary exists, and the books are all arranged in order of arrival, for example! There is no other possibility, then to search one by one until you find a copy of "Ferraris". Don’t you think?

Well, we had said that, in this architecture, there are no search for codes nether codes itself. So, now, imagine that the books had a "life" by them self. Then when we apply the last type of system without no message addresses nether messages forwarding we could arrive to a library and scream "Ferrari" and the book or books about "Ferraris" answer: "I'm here". The response is almost immediate, since the distance would be like a message to all (broadcast) and all, in parallel, "hear" the entry in the library. Finally the interested book acts.

We will therefore use a simple architecture, to represent what was found. In Figure 1 we have a blue rectangle that represents all neurons or nodes of a graph in parallel that "hear" the entry, and then the output response is feedback to the entry.

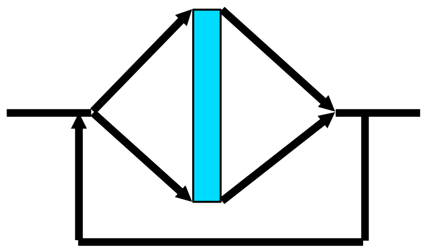

Figure 1. Simple architecture.

It is a versatile model, since it allows us to represent any graph with no traditional search. The search is no longer the responsibility of an agent and becomes the responsibility of the search space. This architecture can have weights as in neural networks. In which the credit of the information is given by the recipient and not by the source. And as we will see, we have no data standard codes.

We can imagine, this system, as a states machine with feedback.

1.3 Learning “Out-Wait-In”

In a classical system, the outputs are in function of the inputs. For other hand in genetic algorithms, inputs are generated which produce outputs, then picking the best inputs, produce new outputs.

It's a step up because as we are going to see they generate random inputs, but the output remains dependent on the input.

In the famous method of the black box, we introduce data in the inputs of the box in a measured way, and with the results obtained at the outputs of the box, we attempt to uncover how the box worked. Being that the goal, it is used precisely this method by the brain to figure out how the world work. I do not know how to address my arm to move it. In the past I have moved my arm and became aware of how to move it now.

First, the brain generates movements to the body and from this last one to the real world. Those are the inputs of the black box. The black box is the real world and the body together. Then by the proprioceptive sense (sense of itself) of the body, and the five senses senses the movement in the real world, we obtain the result of sensory experience in the six senses. Those are the outputs of the black box. Only after that short delay, between the inputs of the black box and is outputs, is when we can conclude anything. Only then can you learn.

For example, first one output node, shown in Figure 2 as red, triggers the sound "A" and stays in standby, because it was triggered. That sound travels through the real world and reaches the "ears" of the system at input node (green).

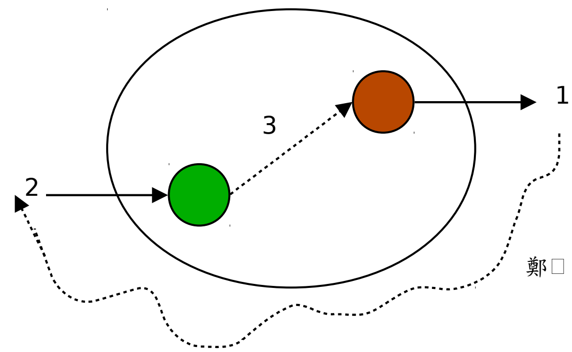

Figure 2. Learning “Out-Wait-In”.

Finally, the red node that was waiting "hearing" the input nodes, "hears" the green node "Screaming", "green". Now the red node remembers the "green" identity, and began sensitive to "green" node. The next time the system "hears" the sound "A" from another agent, recognizes the sound, imitating him. Since green node fired, followed up by the red node, because it is sensitive to "green" and then the output of the sound "A" comes out.

It learns by repetition, not by copy. The learning is a supervised learning because we can educate the system after the same starts running. The system performs a certain output, and learns from the input. Therefore, it is reversed, from output to the input and not from input to the output, as usually.

1.4 The Past Memory

Many scientists use structures of knowledge and decision in a tree-shaped. Like directories in computers discs. They have a serious problem; they cannot know if an event occurred before or after another, in other words, the structure loses the time factor. As we known, the body produces all the movements in a continuous and temporal way. So if we lose the time factor, we lose whole essence and relevance of the information.

What is proposed here is a line shape structure with accordance with a timeline and opposite to tree structures. With this, the memory is in the nodes of a graph in line shape.

The neuroscience principle of Dale [4], who says that "a single neuron can contain several different neurotransmitters, but releases the same neurotransmitters in all its synapses" (William A. MacKay) suggests the possibility that each neuron has a distinct identity of one other, enabling us to establish that each neuron records (with certain plasticity), in their dendrites, the input signals and outputs a unique identity... as a natural number, for instance. A “ball” is a collection of past memories.

There are about 10 billion neurons in the brain. If we have a life expectancy of 80 years we can spend about 40 neurons per second. That's enough to be able to save the 25 frames per second (each image is retained in each neuron cell dendrites and represents an image with a factor of identity with a certain percentage of similarity).

The need to communicate correctly with the extremities of the body, at the speed of a neuron (100km/h) implies that, to travel about the two meters of the body and return, corresponds to spend about 7 neurons per second, the maximum. We, therefore, have enough neurons to build a temporal memory. The elephant has more neurons than human but they also live longer.

We can also consider the hypothesis if our brain has a "past time window" in which we only remember what's in that window, unless we have remembered from a previous event and had been moved between generations of windows. For example, the fishes have 10 seconds past time window, only remembering what happened back in 10 seconds or by remembering what those are the more needed memories in the 10 seconds and transitioning to the present. Nevertheless, the fish can remember an event that occurred 2 minutes ago, just have to constantly remember or reliving that earlier event.

Since the best memories will transition to the present, at the end of the time line memory we could come back to the beginning and have virtually unlimited memory. "Eternal" Life!? (For robots)

With the graph in line shape, building up a past, represents our firmware which, together with the genetic hardware and the environment software, decides our behavior. We do not decide our behavior by the genetic or environment only variables.

1.5 Decision

When we want to know where we parked the car, we not decide by a probability. Otherwise, we faced up always the most usual place. We usually not decide in function of a search for the car, or on inputs from the senses. We decided rather in function of time, in other words, the thought of our car take us to the most recent episode in which we parked it, when we remember the time we parked the car.

That decision method is used here; the most recent recall that maximizes the senses of the moment and the senses in the past memory, allows us to obtain a moment in the past memory.

Then we execute the next time step in past memory that is the proprioceptive sense saved in that point in past that is associated to the correspondent action. We tend to do what we did in last in the past. Like this, we are going to update the past memory with the most recent events, actualizing it. And if the robot "eat" and "drink" in the past will be able to repeat it in the present, when it became with “hunger" or "thirst". This is a basic instinctive or unconscious behavior.

1.6 Cerebellum

From the output to the input, we begin by generating an action: it could be an action randomly, a genetic instinct or an action induced by something external to the system. We start by generating random actions (such as when the baby moves his or her arms almost randomly), which cause movement in the body and in the real world. Then the signals returning by the internal body movements (proprioceptive sense) and the 5 external senses are recorded in the robot present.

This line of information from the output to the input is the feedback line in Figure 1. At the same time, in the output neurons at the cerebellum, the neuron that fired or acted is on hold listening to the proprioceptive sense, in order to establish a correspondence between the action signals and proprioceptive signals.

The noise in proprioceptive signals that no corresponds at that action are avoided by repeating the same action. The signals remaining in the proprioceptive sense are associated with the action. The other occasional signals are disassociated from that action. Is like astronomers doing sky photographs of long exposure and processed by computer. The lights that remain in the sky all the time of exposure are stars. The others temporary reflections are eliminated from the photograph. They assume that during the “short” time of the exposure, neither a star born nor a star dies.

With this, it allows a person to elevate a robot by the arms and later the robot starts to stand up alone. Because we have induced only proprioceptive signals on the robot and no action was taken by the robot (when lifted by the arms). It was an induced learning performed by an external agent (person).

1.7 Architecture

The cognitive system overall architecture is shown in Figure 3. Here, we distinguish inputs from senses (vision, hearing, touch, smell, taste and proprioceptive, or others). Those inputs goes to temporal past, in green.

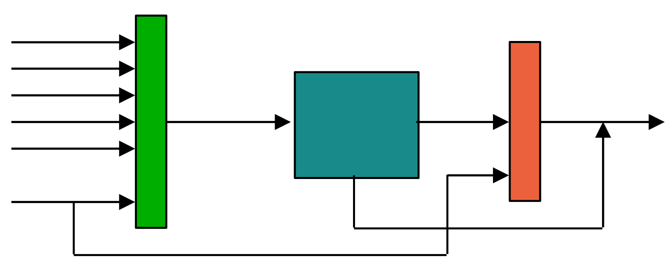

Figure 3. Robot’s cognition architecture.

Next, the recalled past events goes to the central unit, in blue. In this unit, the decision act is made, the emotions are detected and random actions also leave the central unit to the output directly. The act and the emotional expression then pass into the cerebellum, in red. This one, in its turn, receives information of proprioceptive sense.

Finally we have the robot’s actions executed trough the body to the world, feeding again the robot senses. The feedback line shown in Figure 1 is not shown in Figure 3.

This architecture is independent of robot body, and it is biologically viable. I believe that all animals with brain have the same architecture. What varies in itch animal is is body (not the organs), the culture of the animal and it environment.

1.8 Pain and Motivations

1.8.1 Pain

Whenever the robot feels "pain" executes the opposite action of the last action performed. If robot is walking forward will, in pain (detected by touch), walk backwards. A reflex.

1.8.2 Motivations

The motivations enter in the proprioceptive sense as an internal signal of the body like "thirst" or "hungry". So the actions performed by the robot with “hungry” (low battery) are going to be almost the same, depending of the environment, when the robot fells “hungry” again. Because of the decision method chosen here.

1.9 Random

Random actions are generated up early in the system startup (living in "womb”). Thereby we build up a random start for the past. The random actions also help the cerebellum nodes to eliminate the noise. We need to guaranteed, however, that the random action executes all the possible actions or that missing action is never going to be executed. These random actions can have genetic origin, acting by stages.

After the random stage, it is no longer need a random action. The random stage should disappear so the robot does not unlearn an "habit". And then, can be allowed and induced behavior in the robot.

1.10 Dynamic

The system works like this: a group of senses inputs recalls some episodes in the past memory, by broadcasting the present group to all past memory. And if the group with enough proximity (percentage) within each group in the past memory then the time in past memory inputs to the central unit. Here, the most recent of all is chosen.

Then the next step in time of the chosen time is going to the cerebellum. In fact what goes to the cerebellum are the proprioceptive signals of that moment. Those signals are broadcasted to all action nodes and the ones sensitive to those signals acts. The robot moves. Simultaneously the present group of senses is being recorded in the past memory at the present time equivalent point.

The action produced by the system generates new perceptions, yielding a step in the dynamics of the system, and need to allocate new memory to save the present group of senses inputs. The cycle begins again for a new step. Note that an action at one step in time originates some proprioceptive signals that are going to be recorded at the next step in time.

1.11 Emotions

Emotions are particularities of the brain architecture. They serve to establish communication with the elements of the same species and recognize the "Good" and "Bad" in the other, something essential in a consciousness that lacks in this work.

Emotions features are detected in the central unit and genetically expressed in cerebellum. This emotional expression returns proprioceptive signals which are recorded in the past memory. That's why, when we simulate the "laughter", reminds us humor situations, especially the last one.

In this system, we have the happiness, sadness, novelty and pain emotions. For example the novelty is not recall anything associated with particular perception; is a novelty. Happiness is, for example, when eating or drinking when hungry or thirsty.

2. TEST

The simulation (in Java) has been performed in 3x3 houses labyrinth in shape of "T". One end of the "T" has water, another food and at the latter there is nothing at all.

The "robot" has 302 neurons for a sense (302 threads), 5 senses; Feels "thirsty", "hungry" and feels "pain" when collides with the walls. Moves forward, left and right. Drink and eat. Five actions are possible (5 more threads). It "sees" and "smells" the houses on the maze. It has "taste" for food and water. And it "feels" the walls. Four senses more the proprioceptive one does the 5 senses.

The test is to see if the "robot" goes to drink water and does the same for the food avoiding bumping into the walls.

3. CONCLUSIONS

After about 150 steps (3 seconds per step, 50 steps per cycle of thirst) and with just a little help to drink the first time, the "robot" now "drinks" when he feels "thirsty". The same went for the food (250 steps, 100 steps of hunger cycle). The "robot" learned at first and did forget.

Only with random actions (20 steps) the “robot” does not learn much; besides, the "robot" may have an obsessive and repetitive behavior, especially at first, if there is constancy in perceptions?

This architecture is body independent, but once inserted in a certain body is engaged with in it; adapts to the body, integrating it. So, now this architecture cannot be transferred in any way, to a different body or an equal one but differently connected. The only chance is to change it to another body exactly the same way.

The 3 robotic rules (suggested by Isaac Asimov) that say, in general, a robot cannot in any way harm the man. This cannot be applied in such architecture. The "robot" has a self motivation (and attention, no free will). So the only way to prevent a "robot" to harms humans (besides its "good" education, since they do not born good or bad) will be via a remote control which allows us to power down the "robot". Even if the "robot" is on the other side of the planet it should be possible to turn it off, at the touch of a button or by a verbal command.

3.1 "Work to be done"

I have the notion of being implanting some instinctive behavior of a "being" into a robot. Hence the lack of "awareness", where the robot analyzes self behaviors, depending on values of "Good" and "Bad". There are many possibilities of an implementation over this architecture. We could use the information from the input to the output, not yet used here. The system is digital with analog inputs. Those may influence the decision.

I am also implementing the same architecture and program in the robot from LEGO; NXT MindStorm; and in the robot Finch with good results.

In those cases, it is not necessary to simulate the world or the robot's body, and has therefore more realism.

Adding to the sense of hearing to the robot, we can teach voice commands to it, after they learned like Pavlov's dogs.

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