A Brief of Software Design - Fall 2017

Gopika Sreedhara Pai
Arizona State University
gspai@asu.edu

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Abstract

In this article I will be discussing about what I learnt, researched and the topics that were discussed in the class this semester. I will be focusing on the behaviors and the physical gestures of a social robot, We will also be having a sneak peek in the evolution of a social robot, a brief of neural networks, and the working of the social robot made as a part of the curriculum. I have also included the challenges that I faced while making the robot.

Acknowledgement

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1 Introduction

Ever since the increasing demand of technology, mankind has evolved in creating marvels, from the basic calculators to computers, and now the social robots or the humanoids. These incredible technologies has changed ones life in a vast manner.

A Social robot has the ability to perform the basic functions like humans. Their physical appearance and gestures are very much similar to human beings. A robot could be categorized as a social robot when it interacts and communicates with humans or any other physical things which expects a response, by following social behaviors and the set of rules attached to its role.The word robot comes from a Czech Slavic word Robota, Which meant that a work that a medieval peasant was obliged to do for his medieval lord without any payment. Robots are the machines which use their programming

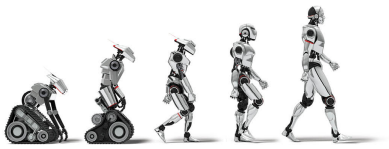

Figure 1: Robot Evolution

to make decisions. For E.g. A human found a coin on the ground, there are three main things that you have to go through. First, your eyes need to see the coin, then the eyes send that information to the brain, and your brain processes that input and recollects the previous experiences to make a decision to pick it up or not.

Robots undergo a similar decision making process, they have sensors for input, control-system for decision making, and end effectors for output. Sensors are expected to be able to detect images, sound movements accurately. Effectors has to be fast enough for what we expect them to do. The control system acts like the nervous system of the human body, they are important to make the sensors and effectors to work together. This is the basics of a simple robot.

2 History of Robot

The concept of robots has evolved since the medieval era. We can talk about when the concept came into existence and now the are in every possible industry and even in the military. Industry is the fist place to start as thats where the robots first became useful.

Since factory work is repetitive and involves lifting heavy weights, the world's first ever robot Unimate was installed on General Motors production in New Jersey in 1961. It was a heavy weight robot, which was programmed on a huge magnetic drum, which instructed the robot to stack and weld hot pieces. But since the robot was in its initial stage, the arms were not flexible, and they were often powered by clunky hydraulics, and they were difficult to program.

Figure 2: First Industrial Robot - Unimate

In 1974, robotic arm IRB-6 came along, which was a break through. This was the first electric industrial robot which was controlled my a microcomputer. It had a 16KB RAM, it was programmable and could show 4 digits using its LEDs.

Meanwhile, when the programming was becoming easier, there was another issue that came up. Since the robot could not see, it was not perfect in making decisions and that is when the engineers had developed new algorithm that allowed the cameras to recognize edges and shapes by using visual cues like highlights and shadows. It was in the year 1981, when the industry got its first robot with a good vision.

Ever-since the emergence of Artificial Intelligence the robotic advancement has increased to an extent that it is no wonder if the industry installs its complete production lines handled by robots. Humans have advanced so much in the field that the current aim is to achieve a fully functional human

like robot aka humanoid.

3 Generation of Robots

Dexterity — Mobility — Autonomy — Communication — Interaction

1. Dexterity: this is the basic function that was performed initially, where the robot performs making gestures.
2. Mobility: this is the next level function that was performed as the next stage, where the robot is able to navigate in different environments.
3. Autonomy: here the robots are able to perform tasks with a high degree of autonomy.
4. Communication: It is a subset of Interaction. Here since there is a good communication, the information flows feasibly.
5. Interaction: This is the next level of communication. The robots will be able to interact with humans, take input and give output.

4 Neural Networks

4.1 What is Neural Networks?

Neural networks is also called as artificial neural network when it comes to information technology. Here the software is patterned in the form of neurons of the human brain. These technologies generally focus on solving complex signal processing or patter recognition problems.

4.1.1 Functioning

A neural network generally involves a large number of processors which are operating in parallel. These processors are fixed in different levels, where in the first level, it receives raw information and each successive level receives an input which is the output of the level preceding it.

There are several nodes, which has a small sphere of knowledge of its own, the knowledge is what it has previously seen or experienced. It collects the information and traverses through the data to find a similar match. The

levels are highly interconnected, that mean, for each node in level n will be connected to all the nodes in level n-1 and to all the nodes in level n+1.

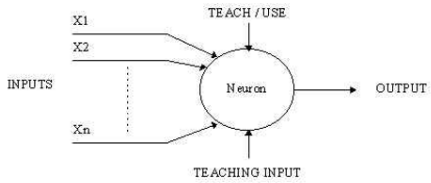

Figure 3: A simple neuron

4.2 Backpropagation Algorithm

Back propagation algorithm searches for the weights which minimizes the total error of the network over a training examples.This algorithm consists of two passes namely, forward pass and the backward pass. In the forward pass the network is activated on one step and the error of the output layer is computed. In the backward pass network error is used to update the weights. Since we know that all the neurons are tightly packed and connected, at the output layer an error is propagated backwards through the network.

4.3 Learning Process of Neurons

There are two general ways in which neurons can learn, Associative mapping and Regularity detection. Associative mapping is a type of neural network where the network learns to produce patterns the way the inputs are received.Whereas Regularity detection the units learn to respond to certain properties of the input patterns.Here each response has a different meaning.

Learning process an be classified into two categories:

1. Supervised Learning: This type of learning incorporates an external teacher. Each output unit is told what it is supposed to do and how it is supposed to react to certain situations

2. Unsupervised Learning: This is where the machine is not been told as what to do when, it learn on its own. Based on the data it collected so far, it analyzes and responds.

5 Paper: How much the eye gaze and head orientation is important

5.1 Eye gaze and Head Orientation.

Eye is a very important part to conveying any type emotion, may it be anger, sadness or happiness. Looking at a persons eye you can instantly understand what the person is going through. For example in a conversation you are having with a friend, and if the person is not looking at you while speaking you might get insulted or find it extremely weired.

Similarly, when it come to a robot, if a robot hat looks like a machine and claims like one, does not do the basic gestures then it would be either considered a rude robot or improperly programmed machine.

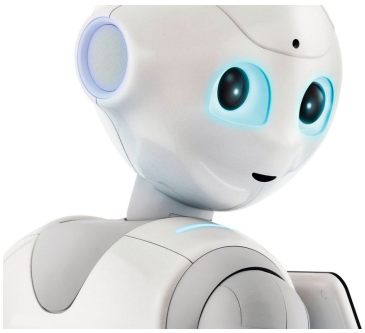

Figure 4: A humanoid turning to looking at you

Humans are people who are highly dependent on emotions and gestures based on the situations. Humans expect their close one to reciprocate the same feeling as they do. So is eye gaze suffice in a conversation? What if a person is talking to you and you turn your head in a different angle and your eye oriented towards that person. It will be awkward. Similarly, If the person talking to you is looking somewhere else while his head oriented towards you, would mean that the person is not interested in having a conversation.

5.2 Interference Effects

There were three experiments conducted, where the aim was to understand how important eye gaze and head orientation is in a humanoids behavior. The experiment conducted of people who were asked to click any of the four

buttons pointed in four directions (north, south, east and west). There would be a face shown and the eyes pointed to one direction, the head would be directed in a direction and people should recognize the direction where the head is pointed to. Second, The eye pointed to one direction and face to other, where as the the people should point out the direction to which eye is pointing. Lastly, eye and head directed in the same direction but people are supposed to point out the direction which is orally told and not visually seen. In the first experiment and the second experiment 80 percent of the

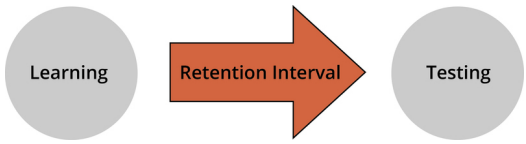

Figure 5:

people got the direction right in the time span of 10 ms to 50 ms. Where as in the third experiment people took more than 100ms to come to the right decision or even more.

What happens in this scenarios is that, human brain is functioned in a manner that it recollects the previous experiences and acts upon. When the synchronization get wrong with wrong information been passed, the brain gets confused and takes more time than normal to come up with a solution.

Here we can understand how important the eye and head orientation are, when it comes to making a humanoid. It is interesting to know that a nearly as perfect robot "Sophia" happens to be the first robot to get the citizenship of a country.

When we created a robot as a part of the curriculum, this was in our mind. To meticulously checked every part to its perfection. Next section will describe my learnings in the project.

6 Mr. Pyaare Mohan - The Indian Robot

We had to get the parts of the robot 3D printed. There are a set of semi spheres which act like eyeballs. Four Semi concave structures which act like eyelids. A frame that holds the eyebrows. A base that can hold the motors for the eyes and a rod that moves the eyelids. The head is joint to the neck using a joint with a ball bearing, that helps the head to move in all

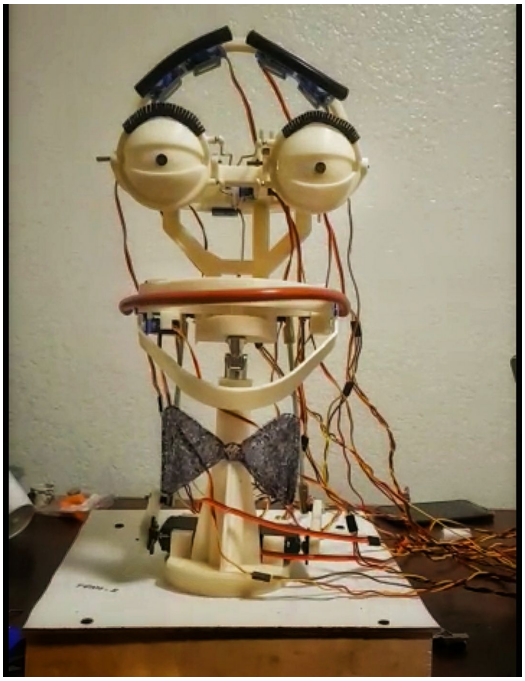

Figure 6: Mr. Pyaare Mohan

possible directions. The body is attached to the board that had another motor attached to it leading to which the whole body to move.

We have focused on creating the basic facial expression on the robot. The robot has two eye brows which is attached to 4 motors. The motor pairs are attached to the tips of the black tubes which acts as the eyebrows. These motors are set in such an angle where if the robot it sad the motors turn up, bending the black tube which clearly indicates the bot is sad, visa versa.

The eyes have two inner joints inside the semi-spherical structure which gives the eyeballs to move in all possible direction, these joints increase the degree of freedom of the eyeballs. Since the eyeballs as semi spherical structures, So as for the eyelids to move the eyelids has to slide in front and then close. For this reason we have a rod which is attached to a motor that slides front and back and gives a seamless flow to the eyelids to close.

The lips part of the robot is attached to three motors which helps the two triangular shapes to go in the opposite directions when the mouth is open and join together when it is closed.

The whole head is attached to the base using two rods which are attached

Figure 7: Materials for the robot assembly

to the motors. When those motors rotate, the rods pull the based leading to which the head moves.

6.1 Challenges Faced and Knowledge Gained

While working on the project, we initially started of with assembling the structure and attaching the wired and blocks together. Since the job on the hardware part was entirely a new work for me, that is something I truly enjoyed. Working on assembling the robot gave me a huge idea about the structure and the connections of the robot. While assembling the robot, I framed a blue print in my head, which indeed helped me a long way through while working on the software part.

We used PSoC creator 4.1 to work on our robot. Where we linked the software to the hardware using the Pulse Width Modulation Layout. here the issue I faced was when we had to separate the modules according to pairs since there were only two input links available in each model. And for every model we used we had to assign a clock. Whereas the PSoC limits the clock usage to 8 numbers. That is when we came up with the idea of including two modules together and reducing it to 8 clocks.

Then in the linking part of the module we linked all to their respective pin numbers.

While coding we initially made sure that all the angles are intact and then we started to work on the emotions. My Idea behind keeping all the angles in the same position initially was to get a better idea of the numbers that we need to record in the code. And yes this idea made our work way

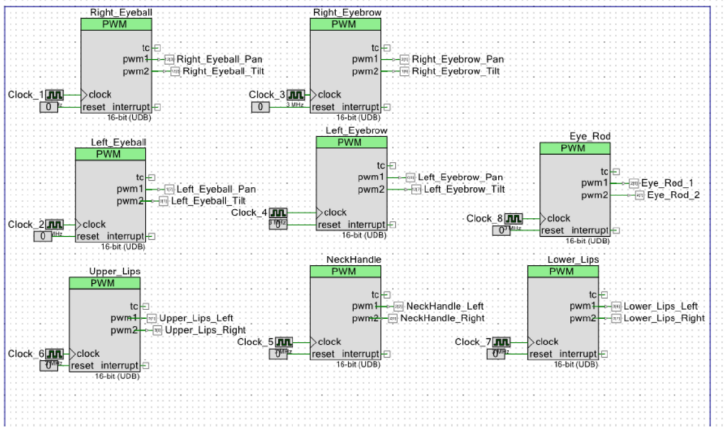

Figure 8: Materials for the robot assembly

more easier.

Finally, We created several emotions apart from the basic emotions happiness and sadness, Such as, Yawn, Indian Head Nod, Talking gestures, Astonishment and Restlessness.