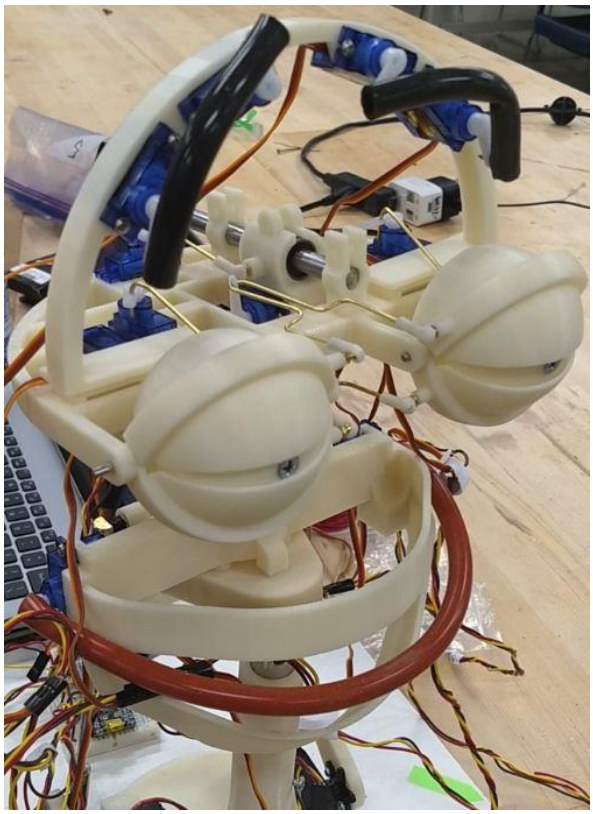

TECHNICAL MANUAL

Social Robot

Abstract

This manual, documents our team experience in the building of a social robot. Created in fulfilment of final project.

Team 5

Software Design 564

Team Members

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Contents

2. Abstract

Humans have always strived to build machines and technologies that simulate human behavior. These innovations started with a need to improve human lifestyle, and build machine substitutes that could handle tedious, time consuming and exhaustive work for us. So, most innovations began as a necessity.

The human affair with innovation is almost as old as mankind. For example, in 1485, Da Vinci had developed the design for a flying machine. Of course, he was born far ahead of his time and such an invention couldn't come to pass. But slowly and steadily, humans have reached the pinnacle of technology. At this point of time, humans have the money, mind and technology needed to conduct research even into topics considered fanciful. Who would have thought humans would one day reach Mars? We often we end up surprising the naysayers.

It is only in the last few decades that humans have started to use technology to make human life luxurious. Building things we would enjoy and not necessary things we need. This of course means a good thing for humankind- as there is no limit to human imagination. Finally, technology has caught up with us and we can build most things we envision.

The world is consequently moving into a world of automation and robotics. A significant part of research nowadays is into building robots that are anthropomorphic and human-like, so that they can do the work of humans more convincingly. These robots are expected to be able to interact with human beings in a natural manner. We call them social robots.

We build a basic version of a social robot. Instead of focusing on the mobility of the robot, we focus on the facial features of the robot- trying to build a robot that form human-like gestures. This type of research would in future lead to robots that are able to interact with humans in a more human-like manner.

3. Introduction

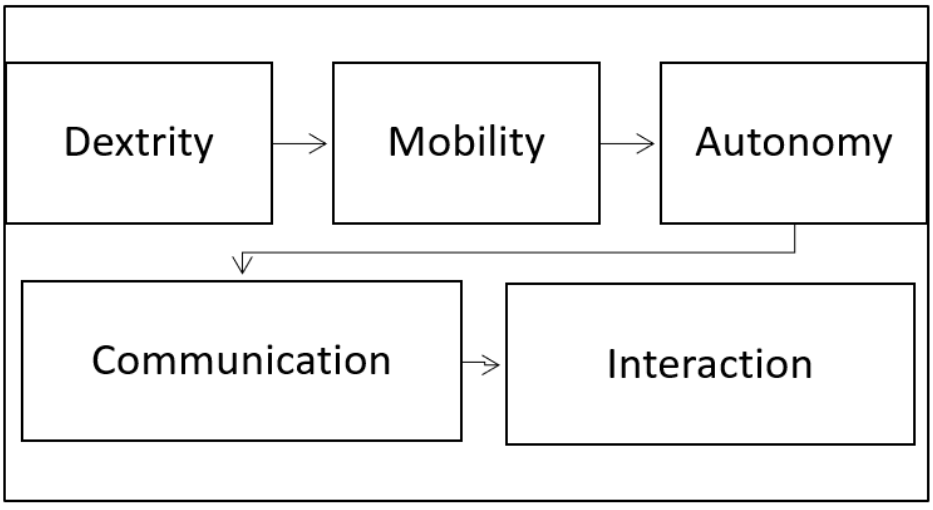
A robot is a machine designed to execute one or more tasks with speed and precision. Robots can be guided by an external control device or the control may be embedded within. Robots can look like a human being but they don't need to be sometimes they are just created to perform specific tasks.

An example of a simple robot would be a dishwasher. It is a machine which is programmed to do a specific task- clean dishes. So, it fits the definition of a robot, albeit it is a primitive robot. Normally, people wouldn't think of a dishwasher or a coffee machine as a robot, but they are.

Another example would be Roomba vacuum. They are created to vacuum the floors. For this type of robot, its efficiency in cleaning the floors is the major thing. They don't need to look human-like. Hence, they were designed to aid their movement. Roomba vacuums are mobile, and able to move around obstacles, which makes them an evolved form of a robot (compared to a dishwasher.)

On the other hand, in some situations we would want a humanoid robot something which resembles human beings. For example, if a family wants a robot robotic butler, they would require a humanoid robot. Similarly, in situations where the robot is expected to nurse a patient or similar service role jobs, a humanoid robot would be required.

3.2 Generations of robot



1. Dexterity: Robot should be able to make movements this involves gestures.
2. Mobility: The robot should be able to navigate in different environments.

3. Autonomy: These robots perform tasks with a high degree of autonomy.
4. Communication: It is a subset of interaction. Communication involves information flow.
5. Interaction: Robot should be able to interact with humans.

In this study, we are building a human-like robot. We are focusing on building the face of the robot, so that the robot can do gestures that simulate a human's emotions. Thus, the robot has limited movement (but not mobility as it is just a face). Hence, we can say that our robot belongs to the generation, 'Dexterity'.

3.3 Human Robot Interaction

Human-Robot interaction (HRI) is the study of interactions between humans and robots. In this field, we study the design of robots. We also study the interactions between humans and robots. This interaction can be remote (example with the mars rover) or proximity based (service robots.)

3.4 Social Robot

A simple definition of robots calls them "a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer." In a way, robots are essentially machines with varying levels of 'intelligence' which enables them to do tasks. Some robots have artificial intelligence and can perform tasks with intelligence. However, there are different types of aspects to intelligence- IQ is just one part of the equation. Humans are also expected to have social and emotional intelligence. Without these, it is impossible to work effectively in the human world as we are social creatures. To this effect, humans endeavor to build robots that are socially aware, and capable of emulating human social norms. Bruce Edmonds argues that "social intelligence is not merely intelligence plus interaction, but should allow for individual relationships to develop between agents". Currently, social robots are built with an idea of them eventually working for old age homes, and terminal patients. Keeping this in mind, this quote makes even more sense. For example, humans expect empathy and care from nurses. It is an important part of robotics to research this issue in our quest to build a humanoid robot.

3.5 Objective of project

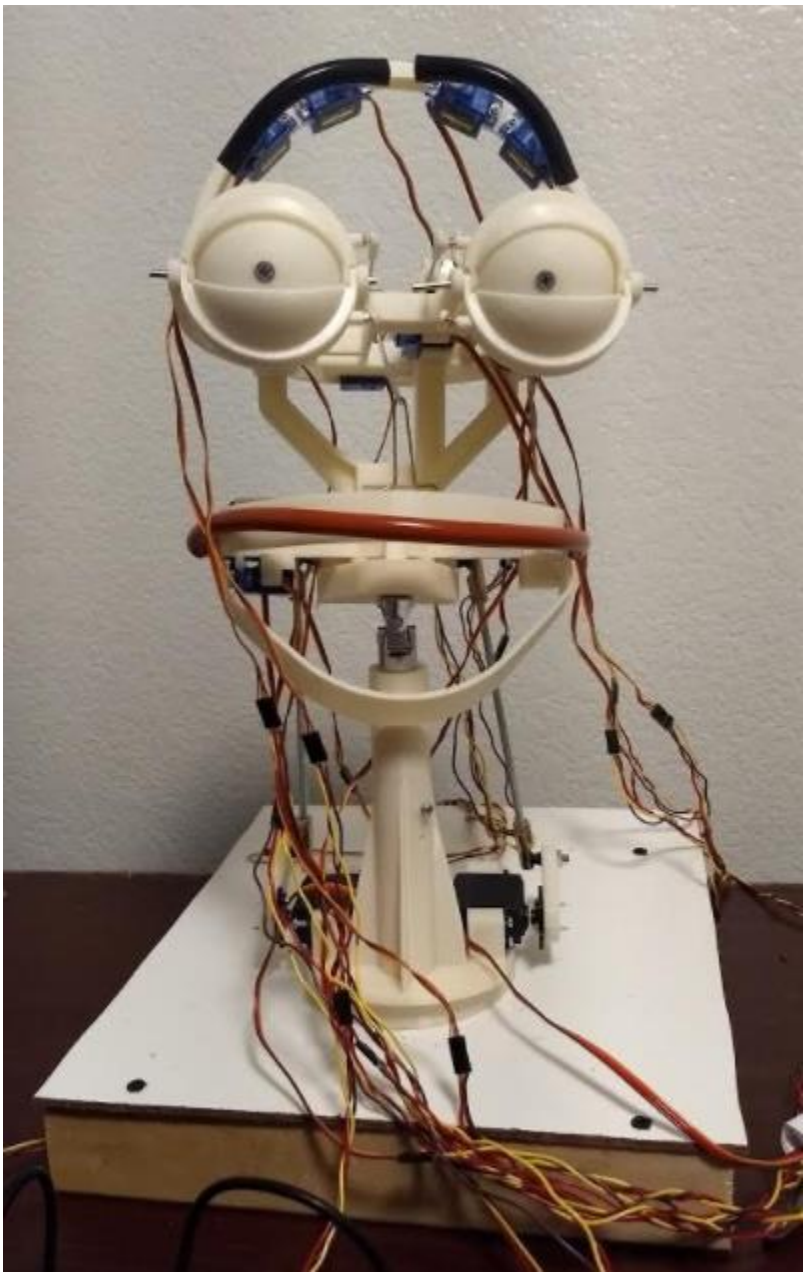
The main objective of this class project is to build a social robot. To achieve this objective, we are building a robot with a human like face, and programming it to achieve several gestures on the human face. Through these gestures, the robot can interact with a human. For example, through programmed commands, the robot can move its eyebrows or head.

We built the robot from scratch, with the design provided. This allows us unlimited degrees of freedom, which isn't possible with a bought robot. So, we are only limited by our coding and

imagination in how many gestures the robot can perform. Therefore, our objective is to make our robot as expressive as possible, using a lot of gestures.

To achieve this goal, we have used PSoC to do the programming for our robot.

Our Robot.



4. Technical Manual

4.1 Components

Eye brows : These are controlled by 4 motors and produces several shapes through which we can understand a lot about the emotion of the robot.

Eyes: There are a pair of semi spheres and 4 parts of semi concave figure that acts as eye lids. These are attached to neurons which is basically molded copper rods of 1mm diameter.

(An expression which he gives when he is in shocked and at the same time anxious, Yes we know he has a lot of emotions, don't we?)

Lips: The lips consist of two plastic parts and a pipe wrapped around them, to simulate the upper and lower lip.

Neck: The neck here is a long, straight plastic part, which is connected to the upper body through a joint. This enables the robot's face to stay upright.

Neck joins the upper body

4.2 Robot construction

This section describes the steps involved in creating our robot from scratch.

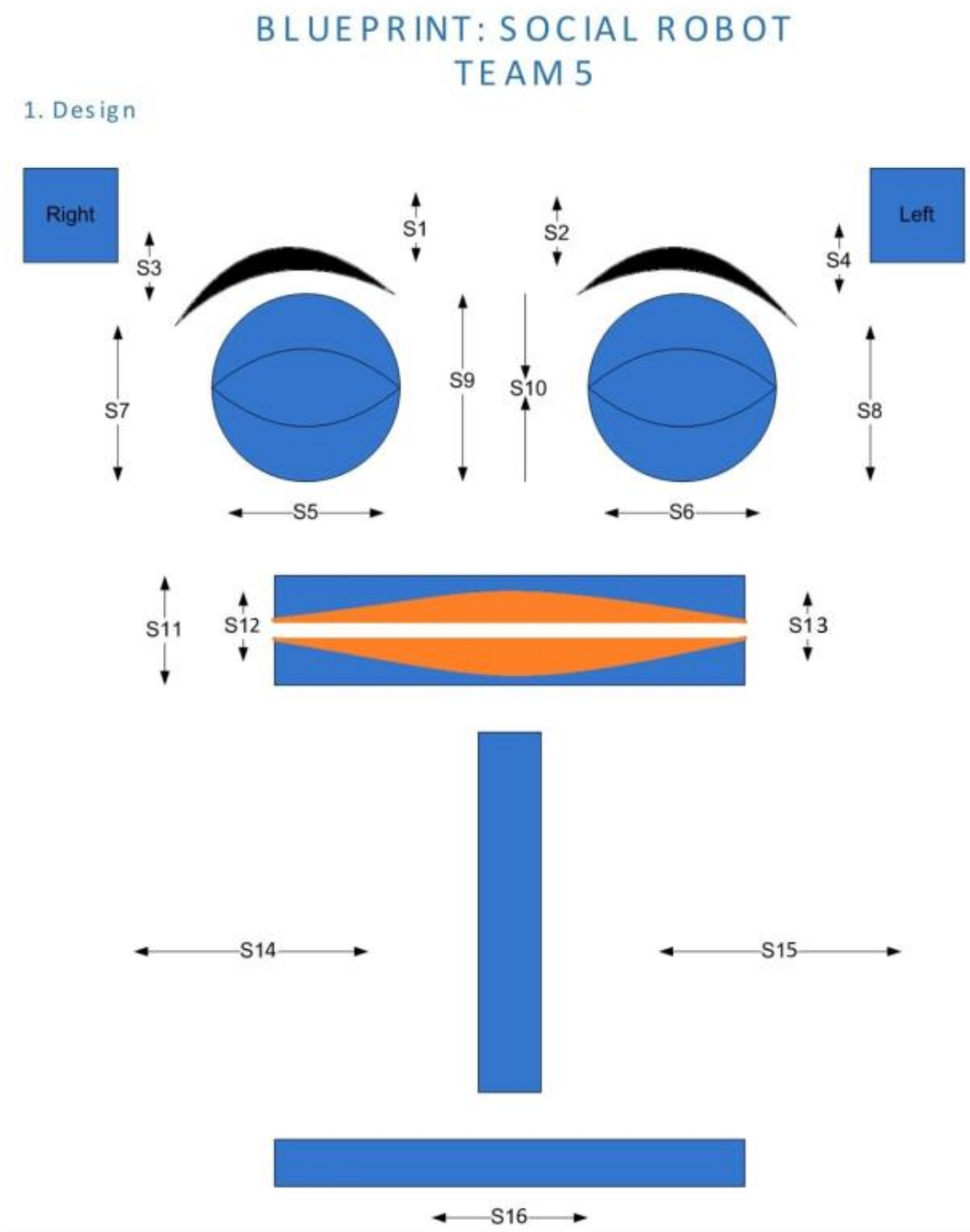
- **3D Printing preparation:** Get .stl file designs for 3D printing the robot from the professor
- **3D printing:** Book the lab, request an order for printing the parts for the robot.
- **Verify parts:** Make sure no part is missing, and all the parts are sturdy and in good shape. At this stage, we made the necessary changes to the printed parts. Drilling holes where the needed, removing the clogging and cleaning the parts, etc.
- **Assembling:** Put together each 'organ' of the robot individually, in a bottom up approach. We build the lips, eyes, bottom, and neck separately in this step.
- **Build the robot:** connect all the parts/organs together as per the expected design
- **Wiring:** Attach wires to all the motors. There will be three wires for each motor.
- **Program:** This is the final step. For each movement of the robot, you have to connect the wires to the microcontroller.

4.3 Gestures

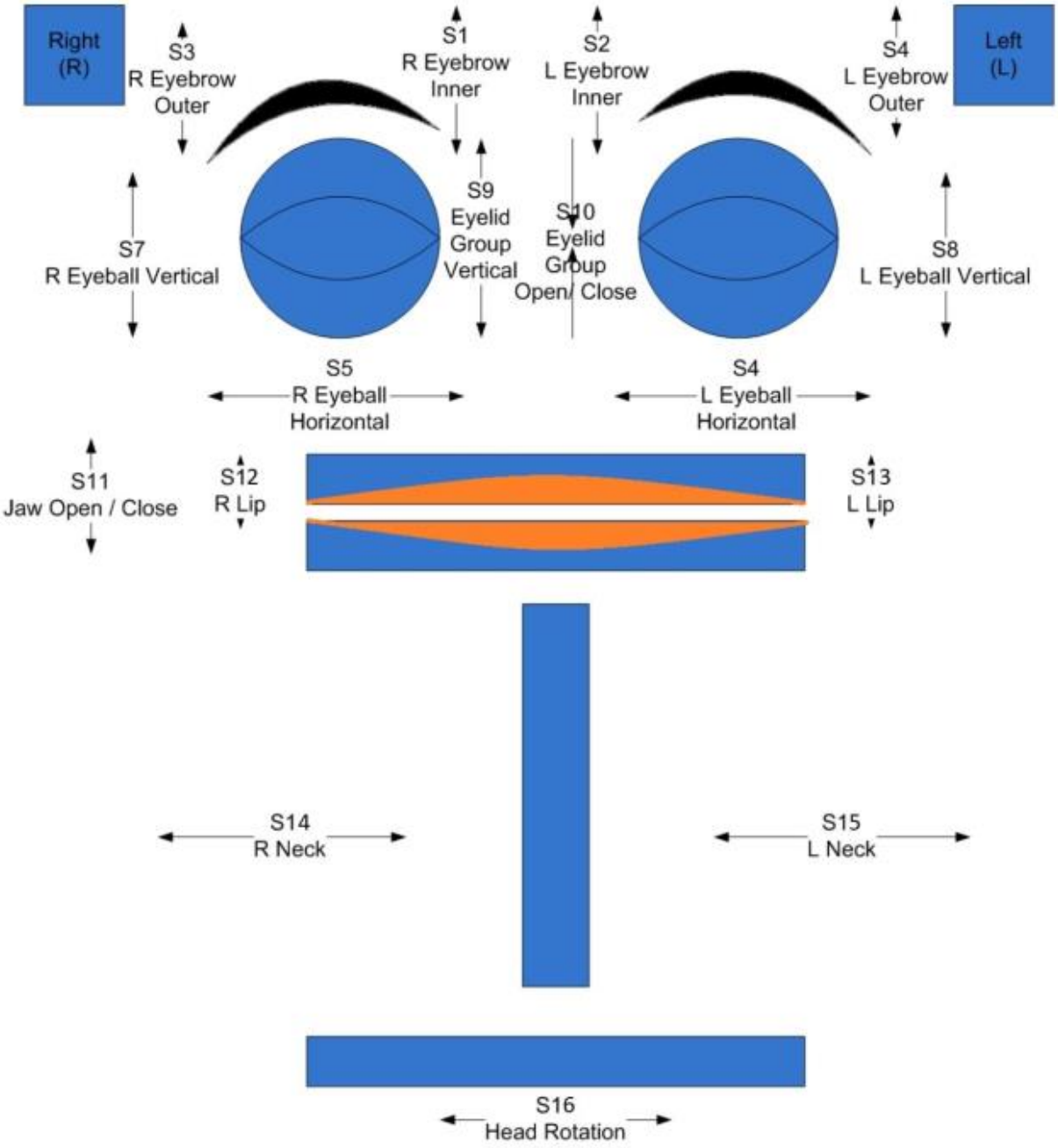
- **Yawn:** The robot's lips fall and then lift slowly to simulate a human yawn-like gesture.
- **Indian head nod:** The robot moves from side to side to copy the Indian head nod gesture
- **Talking:** The robot's mouth moves up and down in quick movements. It looks like the robot is speaking.
- **Astonishment:** The robot's eyebrows are raised, and the mouth is open is an open mouthed surprised gesture.
- **Thinking:** The robot's one eyebrow move up as if it is confused.
- **Happiness:** The robot's eyes are open, and the eyebrows are in normal position.
- **Restlessness:** When the robot is feeling anxious or confused, It shakes its eyes rigorously, giving us an idea that something is wrong.

4.4 Blueprint

4.4.1 Design



4.4.2 Movements



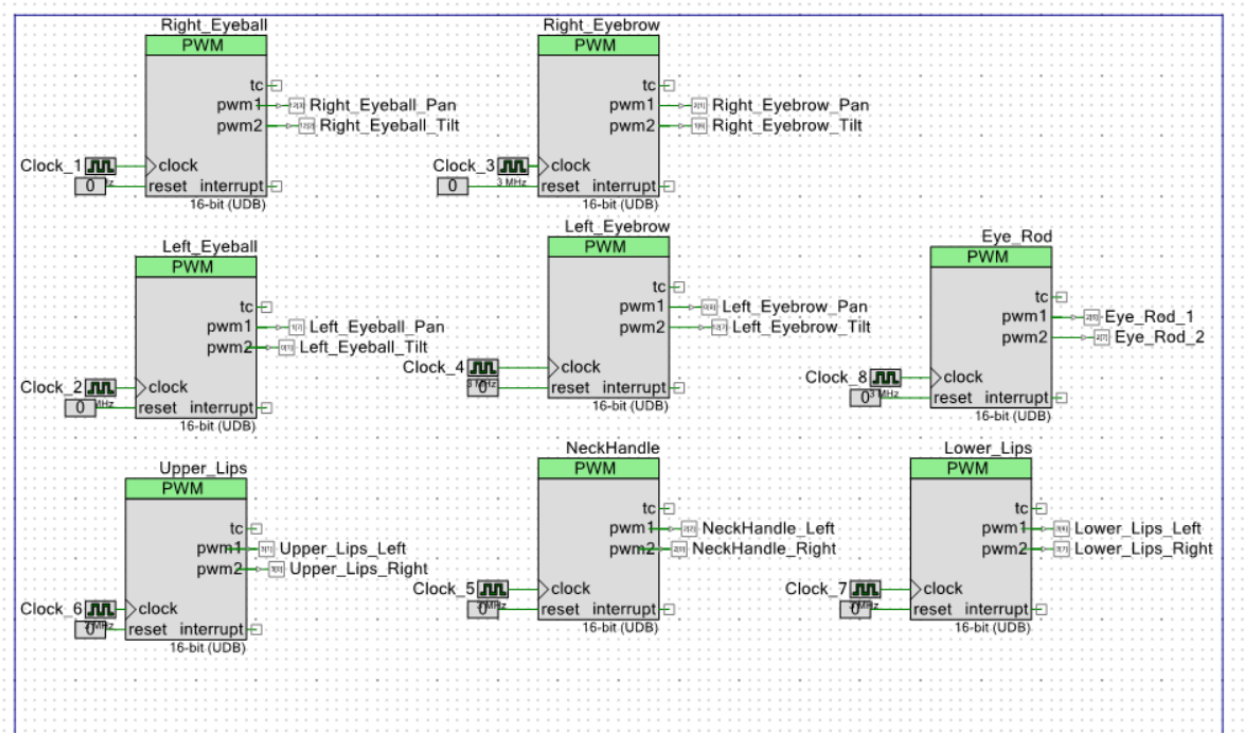
4.4.3 Servo Motors and Wires Nomenclature

↓Wires (Brown, Red, Yellow)	Servo Motors →															
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
B	1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46
R	2	5	8	11	14	17	20	23	26	29	32	35	38	41	44	47
Y	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48

Servo Motor Description AND Mapping of Servo Motors

Description	Servo Motor Number	Port
Right Eyebrow Inner	S1	0.0
Left Eyebrow Inner	S2	0.2
Right Eyebrow Outer	S3	0.1
Left Eyebrow Outer	S4	0.3
Right Eye Ball Horizontal	S5	0.4
Left Eye Ball Horizontal	S6	0.5
Right Eye Ball Vertical	S7	0.6
Left Eye Ball Vertical	S8	0.7
Eyelid Group Vertical	S9	1.2
Eyelid Group Open Close	S10	1.4
Jaw Open Close	S11	1.5
Right Lip	S12	1.6
Left Lip	S13	1.7
Right Neck	S14	2.0
Left Neck	S15	2.1
Base – Head Rotation	S16	2.2

3.4.4 Pulse Width Modulation (PMW) Layout (with their Unified Names)



4.5 PSoC Implementation

For the implementation of PSoC, we downloaded the PSoC 4.1, Which is available for free online. Then using the installation guide installed the software on the computer. Next step was to create project, where you have to design the software and attach a clock and frequency to it. Similarly, we can have as many as 8 clock in the design but it can't hold more than 8 clocks.

Next we need to link the pins to the socket. This is a link between the Micro-Chip and the software. PSoC enables easy linking between both. Once the linking is accomplished, we can write the code for the robot to work. When it is a process of dealing with the motors and their movements, we need to first figure out the exact angles and the values of those motors. The task needs to be completed using a trial and error method.

5. Team Experience

5.1 Team Class Experience

Robotics is a field of engineering that is related to design and design. It is a confluence of the fields of mechanical, electrical, and software engineering. As a result, it is only natural to study this subject in a course for Software Design. We took the class Software Design because we were interested in learning about the way a software can be framed such that you get a wonderful output s desired more like a magic that drags ones attention towards this field. To this effect, this class was an amazing success.

In the initial couple of weeks of classes, we went through a history of robotics- learning about the types of robots developed over time. We learned to separate the robots in different generations based on their abilities. It was inspiring to see how far we have come from the earlier primitive robots to the social robots that are being developed currently. We learned about the subtle difference between communication and interaction generations of laptops.

Later, our class focused on social robots and the research done in this field. It was a great experience to read the research papers and learn about the effort that goes into creating new technology. It was a more of a “learn by experience” type of class in that way, because we studied these papers and then the students themselves presented the learnings from the papers. This way, we grasped the concepts of innovation better because we were forced into the mindset of researchers who had done the research themselves, and learned presentation skills as well.

One important thing about this course for our team was the interactive class experience when the professor took the class. It was a very unique experience, not something we had seen before. We enjoyed the back and forth between the students and the professor, where we would bring up new technologies we had studied and then we would discuss them in detail. For example, we frequently discussed robotic innovation in Japan, automated vehicles. We discussed how innovative Apple iPhone had been when they first came into the market, and we also discussed Sophia, the first robot to gain citizenship of a country.

Lastly, each team had the opportunity to present their learnings about the papers they had been assigned. The best part of this experience was learning how to improve our presentation skills. It was a great experience to be in a class where the professor encouraged us to be more proactive and improve by observing the presentations of the other teams in the class.

We learned about how many things go into building a social robot- for example, how a robot recognizes if a human being is talking to them, how a robot is able to physically navigate itself in different environments. We also learned about the fascinating ‘Uncanny Valley’ effect and

discussed how we can mitigate its effect on humans. We discussed several studies focused on care-robots and how they can be made to be appealing to old people and patients they would ultimately serve. We also discussed how social norms change in different countries, and what effect this would have on a robot. This was also discussed through examples for example, in certain countries the norms for personal space would be different. The robots would have to be adapted, as needed.

5.2 Bringing the robot to life

A major part of this course was the hands on experience of building a robot from scratch. To this goal, we worked in the innovation lab and built our robot and later programmed it.

First the professor provided us with the design of the robot which saved us considerable time. These files were used to 3D print each team's robot. The material used for our printing our robot was PLA plastic, and while not as good as Nylon, the parts were sturdy enough that we were able to work with them, without any of them breaking.

Once we got the parts, we met in the labs to build our robot. It was a great learning experience to assemble it- because we learned the nuances involved in robot making. We used a drill machine for the first time, and other tools. Even for those who had experience using these tools before, this was a more thorough experience because of the number of steps involved in building it.

One of the best results of this course was team rapport. All of us of team five worked together to build the project. Later, we took the robot to our home and collaborated on it together, splitting the work among each team member. It taught us patience and team work. For example, while one person worked on assembling the parts of the robot, another worked on cutting the wires in their proper shape. One person worked on building the eye structure and another worked on the lips.

Not just within our own team, other teams also cooperated with us. As the professor said, this class was not about competition because innovation can't succeed if people hide what they have achieved, knowledge has be shared. This was clearly followed by all the teams in the lab. Other team members shared how they had built a particular part, and we all worked together.

Not only knowledge sharing, we also cooperated and bought the items together. For example, one team ordered the wires for three teams, and another team ordered the motors for two teams, etc. This way we were able to reduce our shipping costs, and it actually built a sort of bond between all the teams. It was a very unique learning experience as we all worked together on a common goal.

5.3 Challenges and resolution

While the experience as a whole was very nice, there were a few hiccups. For example, the holes in the eye structure of our 3D printed parts were a little large. The difference was minute to the eyes, but it meant that the joints we were using to attach the eyelashes, eyeballs to the eye structure kept falling off. Because of this, it was a challenge to code the eye part. As we needed mobility and degree of freedom in the tiny cylindrical metal joint, we couldn't use gum to solve the issue. We ended up spending a considerable amount of time in trying to fix this.

Another thing while not an issue, it really taught us responsibility- it was keeping track of the small parts. Since one team ordered parts, we had to go and collect the parts. Sometimes, there was a miscommunication and the team had forgotten to order an additional part. In those situations, we had to quickly order parts, or get the parts from other teams. But as everybody was working together and collaborating so well, ultimately everybody got the parts.

Apart from this, due to some reason, the threads we received were multi-threaded and not solid wires. We found this when we started doing the wiring, and it was too late to ask for a refund and replacement for our order, so we managed using these wires only. It was a little difficult to put those wires in the microprocessor, but we made it work by threading the wires together. This reduced their girth and allowed us to do the coding.

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