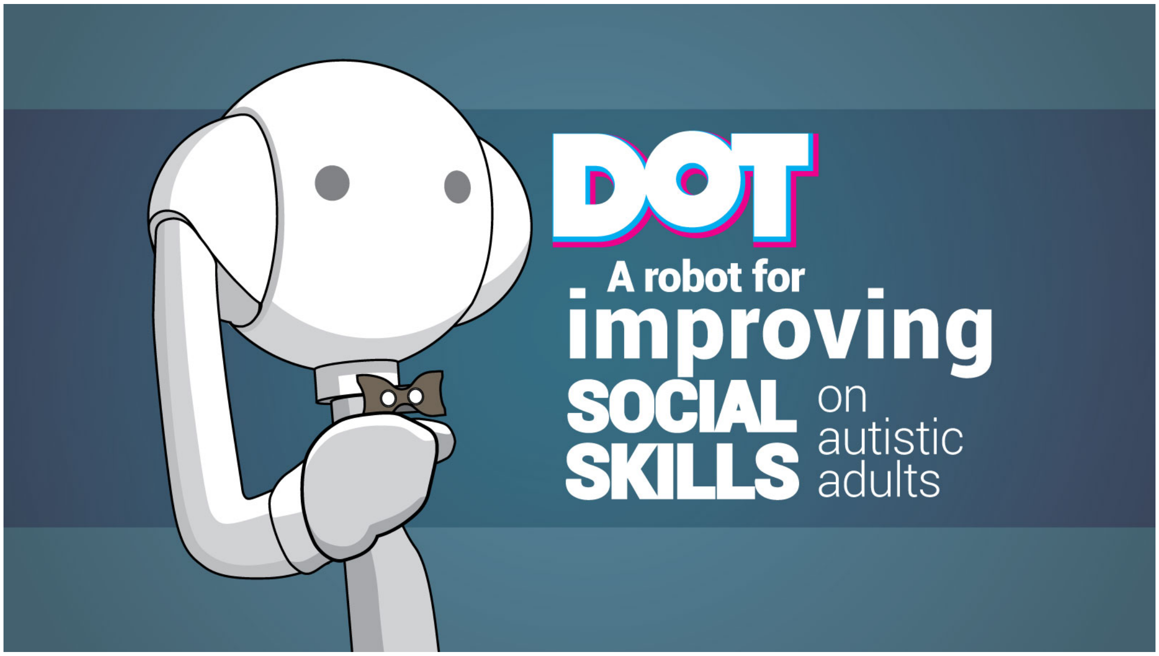

Group3:
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Abstract

The purpose of our robot companion is to interact with autistic adults in order to aid their therapy. The main interaction is a handshake followed by the robot either escaping from the situation, if the handshake is too violent, or staying and complimenting the users skills in interacting, if the handshake is good. The robot uses movement and audio consisting of pre-recorded messages to communicate the mood of the robot.

Description

The first problem we had while facing the task was to better understand what autism is, what adults affected by this disease need and how interacting with a robot can actually help them.
During this first phase of research we noticed that there are very few studies on adults with respect to autistic children so we had some difficulties in choosing what kind of robot to build.
Luckily we found a very useful study where a new kind of therapy was described: the patients were taught, by working in groups of people both with and without autism, the social behaviors they find difficult to understand and perform. Those behaviors range

from what to do when a person is sad or scared to how and when to perform a socially accepted handshake.

Since autistic adults often have difficulties in interacting with people mainly because of the unpredictability of their reactions, we thought that the patients could better appreciate this kind of teaching if they had to interact with a robot. For these reason we focused on an interaction with a clear and predictable reaction from the robot, which is a simplification of the reaction of a human being.

The interaction we chose to simulate and help to understand is that of a handshake.

The main idea is to teach the user how to perform this interaction in a suitable way as well as what the reaction of a person will be if the interaction is performed poorly.

As we want to make the reaction of the robot clear to the patient and we are simplifying what really happens in reality, the robot response during the interaction is aimed at underlying what is going wrong through vocal messages that in reality would never be used by adults.

Once the robot is turned on he will start looking for people in the room driven by its desire of making new friends. It is important to notice that the patient does not need to propose himself to the robot, it is the robot that, in a completely autonomous way, will go around looking for the patient.

Our robot has an arm and a hand to fulfill the task, in order to not scare and accidentally harm the patient it will keep the arm close to the body during the search phase.

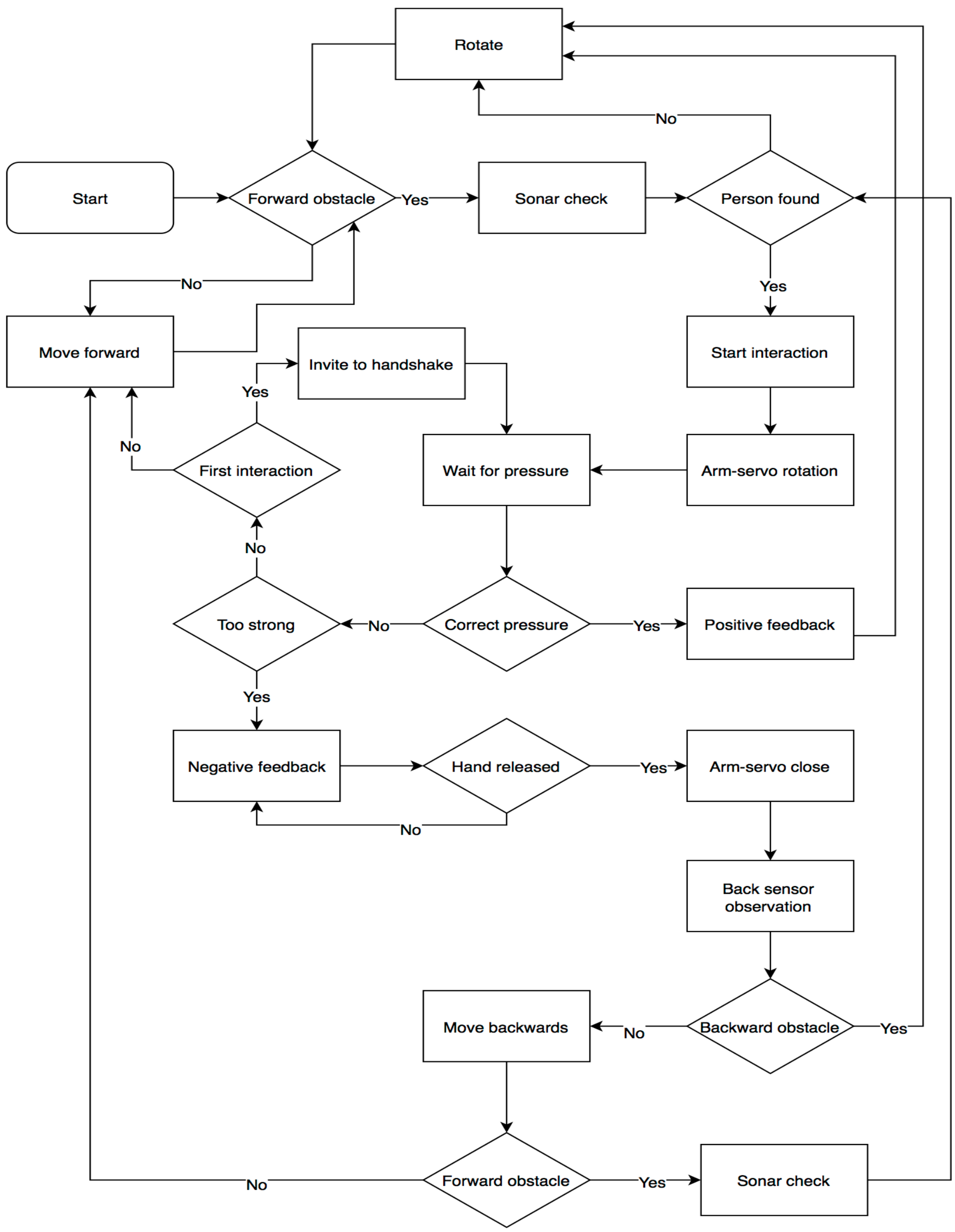
In the very moment it finds a person it will introduce itself presenting its arm to the person, who will be challenged to answer the greeting by shaking the hand.

At this point three possible scenarios can happen:

1) The patient does not shake the hand of the robot. If this happens the robot will ask the patient to repeat the task another time, if it still doesn't receive any answer it will close the arm and start looking around again. If this happens more than once, it may be helpful to show the patient how to interact with the robot to stimulate his attention and avoid this situation in the future.

2) The patient does shake the hand of the robot using too much strength. The violence of the handshake is measured by examining how long the shake goes on. If the duration of the handshake lasts more than the socially accepted time, that we estimated being 3 seconds, the shake is considered too violent. In this case the robot will ask the patient to let go of its hand and will escape from him because it is hurt. Once it is safe and has put some distance between itself and the patient it will ask the patient to try to interact with it again.

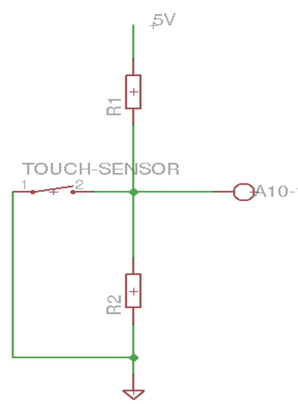
3) The patient completes the task in a successful way. Here no corrections are to be done to the patient behavior and the robot will show happiness by congratulating the patient and claiming that it now has a new friend.



After the first phase of research we had decided what kind of robot to build and entered phase two: prototyping.
We use the Arduino Mega platform instead of the Arduino Uno because the complexity of our robot requires the larger amount of I/O-pins and memory of the Mega.
We also thought about the components we needed to buy for our product: we had to implement the obstacle avoidance, the recognition of a human being and the sensor to put on the hand to complete the interaction.
In order to have a complete obstacle avoidance we decided to use four infrared sensors (Infrared Proximity Sensor – Sharp GP2Y0A21YK), three are used for detecting the

obstacles in front of the robot and one is used for backwards obstacle avoidance. We decided to have only one sensor in the back because the robot mainly moves forward, for this reason we have a sensor aimed to detect obstacles on the front right of the robot, a sensor for obstacles in front center of the robot and a third for obstacles on the front left of the robot.
To recognize people we use a sonar sensor (Ultrasonic Module HC – SR04 Distance Sensor). Our recognition algorithm works as follows: once one of the three IR sensors detects an obstacle in front of the robot the sonar activates and measures changes in the distance of what it has in front of it performing a 120°rotation and acquiring data every 100ms. If it sees that there are at least two peaks in the derivative of the distance, one positive and the other negative, within the range of 15 acquisitions which is what we estimated being the maximum size of a person, it realizes that what it is analyzing is a person and the robot can start interacting with him.

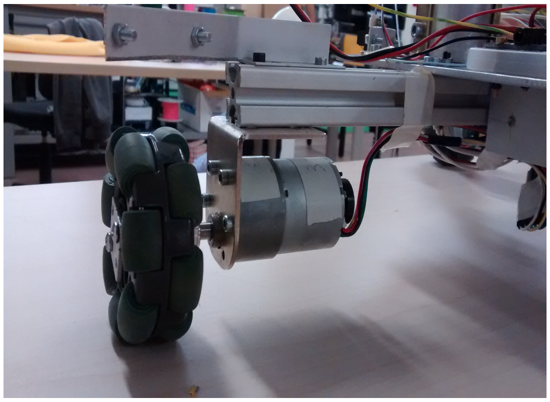
The touch sensor in the hand is made of two layers of fabric with conductive thread sewed on them, divided by a thin layer of foam.
The handshake makes the two conductive layers touch each other, bypassing a resistor and changing the output voltage of the system.



As far as the movement of the robot is concerned we are using three OmniWheels, a setup that enables the robot to move in any direction. Each wheel is connected to a motor (Pololu 30:1 Metal Gearmotor 37Dx52L mm with 64 CPR Encoder) with the Encoders already integrated in them in order to control the movement and the rotations of the motors. Two DC motor drivers (MR Microrobot DC Dual Motor Driver 30V 4A V2) complete the circuit providing the motors the appropriate power, as these drivers has two entry points each we were able to use only two of them, linking two motors together to one of them and the other alone to the second.
The last movements we needed to implement were the opening of the arm and the rotation of the sonar. For these movements we use two analog servo motors (PowerHD analog servo – 3001 HB), which, with their rotation, get the arm and the sonar to rotate.

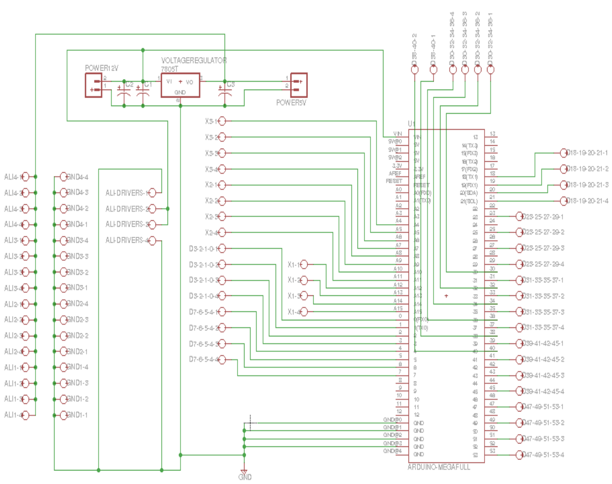
In order to provide the right power to all the components we bought a Lipo-battery providing 8000mAh at 12V, as we have some components requiring 5V instead of 12V we also bought a BEC voltage regulator that provides the right voltage to the right components.

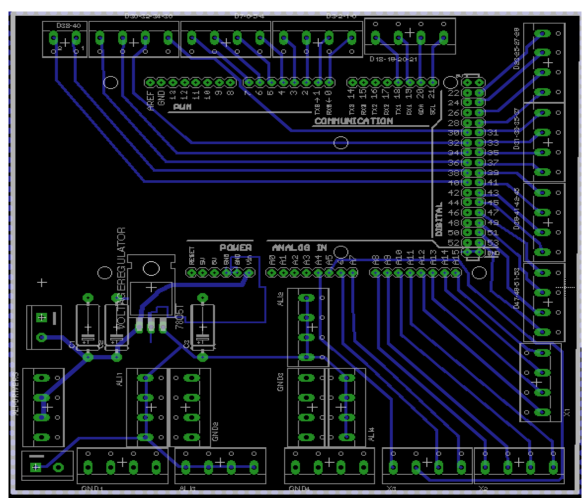
During this phase we also built the first structure of the robot by using a tripod as the body of the robot and a plastic tube for the arm. The critical part of all the structure is the shoulder as it has to allow two kind of movements: a horizontal rotation, which is linked to servo motor, aimed at opening the arm and presenting it to the person interacting with it, and a vertical rotation, completely free, allowing the arm to be shaken. For both types the shoulder should be designed in order to avoid the servo motor to sustain all the weight of the arm and not be in danger when the person is shaking the hand. To do that we tried more than once to
build the right joint, and in the end we arrived at the right combination of metal and ITEM parts.



Another problematic part for us was the connection of the motors to the wheels as, by screwing the motor to the metal piece linking the two parts, we broke the metal gear inside the three motors because, as we found out later, we were using too long screws. Since we didn't want to buy new motors, mainly because of the estimated shipping time that would have caused us to lose a week of work on the project, we decided to open them and fix them. Luckily we succeeded by replacing the gears with some other plastic gears that we were able to buy from a Milan based company named LIP.

In the first stage of the electronic development we used a breadboard to connect the components to the Arduino board, in order to fastly change the configuration of the devices.
When the electronic scheme was clearly designed, we removed the breadboard and we built a Printed Circuit Board, which guarantees robustness of the connections and the freedom to remove the Arduino board.
The PCB was designed using the software EAGLE, and then built using the Press 'n Peel technique. This method allowed us to make the board using only a copper base, a laser printer, an iron, hydrochoric acid and nail polisher.





In the first stages of the development, we didn't have the Battery Elimination Circuit, so the PCB is prearranged to house a voltage regulator.

After having built it we decided that it was the time to start with the final product.
All the electronic and mechanical materials that we have described so far are all still used in the final robot as we saw that everything was working correctly.
The last thing we added was the audio feedback: we use the Grove serial MP3 player attached to a couple of speakers, powered by USB port, to reproduce prerecorded messages that it reads from a MicroSD card that has to have a capacity of less than or equal to 2Gb.
What we had to modify the most was the structure and the front-end.
First we removed the tripod and we modeled a metal tube to be the main bone of the body, it's a bent pipe of aluminum in order to bring the gravity center within the boundaries of the base, Then we attached two PVC plastic tubes to it: one to be the upper part of the torso, where the shoulder is linked, and the other to be the arm.
We bent the plastic tube for the arm 90° in the place where we wanted the elbow to be.
To create the head of the robot we used four polystyrene semi spheres, two having 15cm of diameter and two having 30cm of diameter. Our head is not a human head, that's the reason why the shoulder is directly linked to it. In fact, the smaller semi spheres are used as starting points for the shoulders.
While the bigger ones are used to create the shape that most resemble the human head.
Our initial idea was to place the speakers inside the head, but than we realized that they

were too big to fit and so we placed them more or less at the medium height of the robot. In order to cover the sonar and make it look a little more familiar we bought a wood papillon.

Regarding the design process, we focused on keeping the simplicity as main parameter, in order to communicate just exactly what we need to the autistic adult, considering that the more elements we add (such as colors, sounds, shapes…) the more likely the patient is going to feel overwhelmed during the interaction. It is worth mentioning that a continuous testing process with the patients would be required in order to understand how the shape should more properly follow the function. The functional model we present, differs from the ideal prototype due to technical reasons, and the preference to have something that we can test with. Ideally we would build a plastic case instead of having a textile skin, and we would definitely define a production model that can be replicated. Our final functional model is the following:

As far as the firmware is concerned we decided to structure it in order to have the main functions ordered in libraries, each library describing a functionality of the robot. In this way the main sketch is cleaner and more readable as it is pretty short. This solution also makes it easy to build many different versions of the firmware and setup tests in a little time without having to copy a lot of code.

Our hope is that this robot could really help in improving the social skill of autistic adults in order to improve their life in society, we know that this is only a starting point but we are also aware of the fact that this robot can be improved, for example by enlarging its firmware to teach it more than one behavior and make it even more useful.

The mechanical configuration of the root should be extended, in the first place more degrees of freedom need to be added to the arm of the robot: the current configuration only has two degrees of freedom, both at the shoulder, while a real human arm has at least six.

The current electronic system based on the Arduino board is a simple solution, but it can't afford much more complexity, both on the electronic and on the software sides.
If the system is going to be extended significantly, the Arduino board should be removed and changed with a real computer or more powerful bords. The Arduino firmware will then have to be converted into a ROS system with dedicated nodes.