SydeKick

Team 64 -
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ECE 445 Project Proposal - Spring 2019
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Introduction

Objective

According to the Centers for Disease Control and Prevention (CDC) rates of autism have increased from 1 in 150 newborns being diagnosed with autism in 2000 to 1 in 59 in the year 2018[1]. Yale University conducted a study August of 2018 where they witnessed significant improvements in the social skills of children with autism after a month of working with robots[2]. Our motivation for this project is to build a therapeutic “Sydekick” for those who have have autism.

Our intention with “SydeKick” is to create a robot that is a partial humanoid; this means it will have a torso, head, and two arm-like appendages that operate on one rotational axis. Sydekick will have a set of wheels to govern its translation and rotational motion and make its easier for the child to interact. The robot will contain a set of games built-in for the child to interact with. The benefit of “SydeKick” will be the low cost production of this product while containing similar features and functionality. Through “SydeKick” our team hopes to create a solution cost-effective solution for children with autism to have daily therapeutic sessions with minimal guidance.

Background

There are a few solutions currently out in the market that try to help children with autism through robotics. The prime example on the market as of right now is a product called Milo. Milo is a humanoid designed by RoboKind, a Texas-based robotics company[3]. Milo currently costs $5000 to purchase. The goal of Sydekick is to build an economically feasible partial humanoid that can effectively keep a child with autism occupied and act as a therapeutic tool. The competitor research into this area shows that there are not many cost-effective applications that are currently in the market. Most robotic scientists that are looking to tackle a similar problem have not productionized their products and the ones that have, like Milo, have a steep price. RoboKind, the company that designed Milo, found that it causes anywhere from $17,000 to $22,000 yearly to educate a child with autism[4]. This price plus another add-on for an expensive robot becomes very infeasible for most families. Through our initial findings we are motivated to build “SydeKick” in the most economically feasible way possible and compare our price points once it has been executed[5].

High-Level Requirements List

- “Sydekick” should be able to effectively play a game of Simon Says with the child for at least two minutes.
- “SydeKick” should maintain interaction with the child by moving with and facing the child and keeping a minimum distance of 1 foot away .
- “SydeKick” will not be able to drive past a certain speed (undecided based on data) and will not lift arms over shoulder length. .

Design and Requirement

Figure 1: “Sydekick” Block Diagram

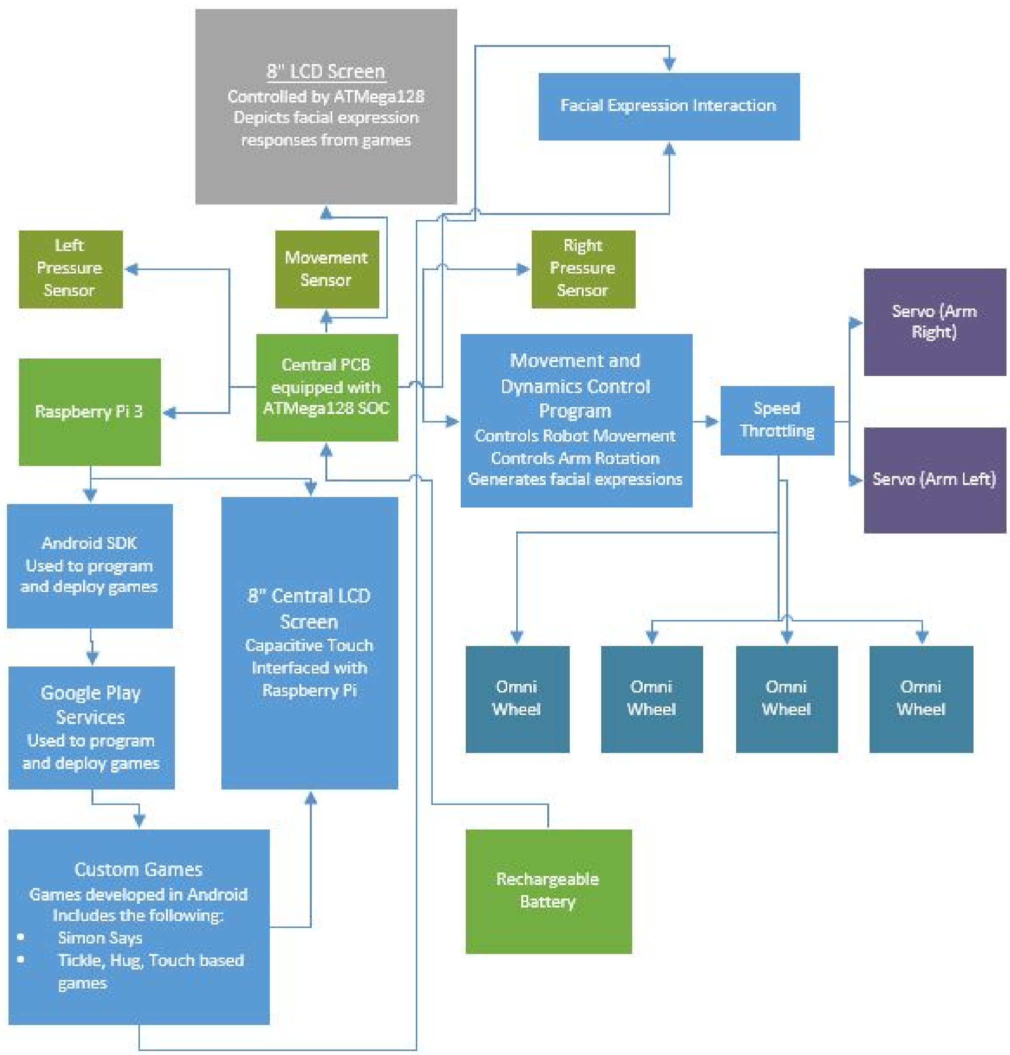
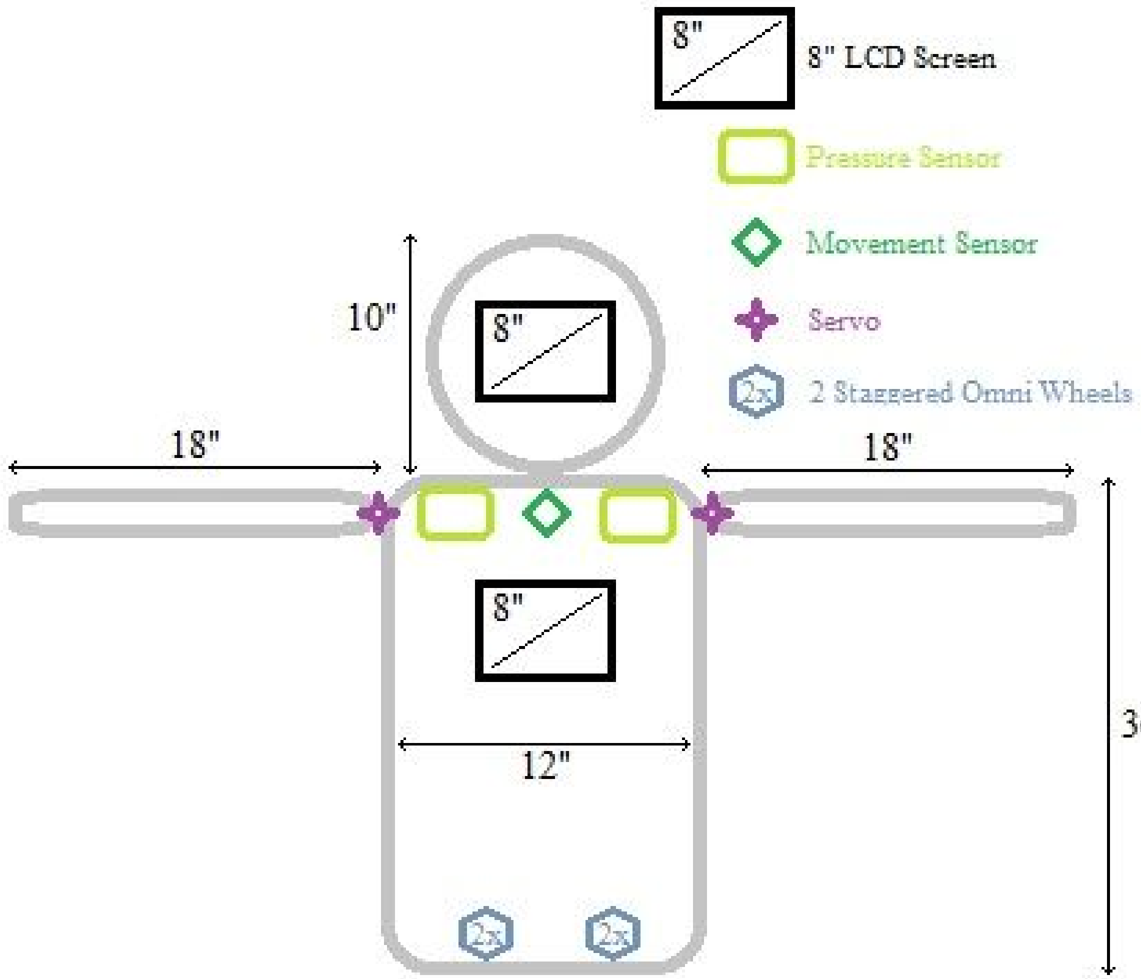


Figure 2: "Sydekick" Physical Diagram



Physical Diagram Description

The physical diagram of "Sydekick" has been illustrated above in *Figure 2.* The robot's head will be an ellipsoid in shape as to mimic that of a young human being's. The torso will be rectangular with rounded edges for aesthetic and safety reasons. Arms will rotate on a servo motor, as to limit the degree of motion and be confined to a set speed, which will be discussed in more detail in the description of the speed throttling block. The same will apply to the omni wheels with their respective blocks. Pressure sensors will be placed on the "shoulders" of the robot and a movement sensor, the variety which has not been decided, will be placed above the "chest". Any additional dimensions of the robot have not yet been decided as they will depend on the size and dimensionality of the hardware and other mechanical aspects not yet deemed necessary.

Functional Overview

Subsystem 1 (Green Blocks) - Processing

Central Printed Circuit Board Equipped with ATMega128 System-on-Chip

This is the central processor for the robot. It receives power from the battery that will described in its own section. We have chosen the ATMega128 SOC due to simplicity and versatility. The sensors, top LCD screen, servos and the wheels will be driven through this module. The Raspberry Pi will be used for computational power and memory capabilities for software endeavors.

Raspberry Pi 3

This auxiliary device will connect to the module described above and it will receive power from the battery as well. This will be used for computational power and memory density. The games and central LCD screen will be operated and interfaced with the Raspberry Pi.

Rechargeable Battery

The battery used as the power source for the robot will be, most likely, the Turnigy 5000mAh 6S 40C Lipo Pack with XT90. This battery has been chosen due to its capacity and power specification. Additional details about the power module of this circuit will be determined as the project advances.

Subsystem 2 (Blue Blocks) - Programming

Central LCD Screen

8 inch LCD screen mounted on the “torso” of the robot (similar to a teletubby). It will utilize capacitive touch capabilities as to introduce touch screen functionality for games. The LCD will interface with the Raspberry Pi for power and data.

Android SDK

Will be used for the development of applications on the Raspberry Pi. We will be utilizing a lot of open source resources to leverage the Android SDK. The applications will be interfaced through the central LCD screen.

Google Play Services

Used for the creation of games within the Android applications. We’ll be leveraging past experience on building Android applications to work on developing the Custom Games (mentioned below).

Custom Games

Android games using Google Play Services and will display on the central LCD screen and run on the raspberry pi. Our team will be designing Simon Says which will incorporate pressure sensors across “SydeKick” and will command the child to touch different areas of the robot. A list of a few of the games include:

- Simon says
- Tickle
- Social based games

Movement and Dynamics Control Program

Will be drive the wheels and arm servos with throttled speeds as per safety specifications. This will be run on the ATMega128 SOC. This program will need to ensure that the wheels operate in tandem and do not erroneously choose different directions to revolve in.

Since we are working with omni-directional wheels there will be two axes of rotation. The first will set the speed of the robot's movement and the latter will set the direction. The arm servos, however, will only be operating within one rotational axis.

<u>Speed Throttling</u>

The speed throttling program will consist of certain safety parameters built into the robot in order to limit the speed and movement of the robot as to avoid any harm to the child. The safety specifications will be determined soon as we get more information, though we aim to make contact with a few different toy and children's robot designers as to establish these standards.

<u>Facial Expression Interaction</u>

This module will operate on the ATMega128 SOC and will effectively use various reactions to give the child a more complete and humanoid playtime experience. It will know when to smile, laugh, gasp, and also have a generic face programmed as well. The emotions will act a reward system for game completion or to make the gaming experience more friendly.

Subsystem 3 (Army Green Blocks) - Sensors

<u>Left and Right Pressure Sensors</u>

Both arms will contain pressure sensors to play games with the child. This will be interfaced through the PCB as described in Subsystem 1.

<u>Movement Sensor</u>

The direction/ability to move will be gauged through a sensor that will be able to measure proximity towards the child. This will allow the team to keep safety in mind and design proper precautions and maintain a set distance between the robot and the child. This will also be interfaced with the PCB as described in Subsystem 1.

Subsystem 4 (Purple Blocks) - Arms

<u>Left and Right Arm Servos</u>

The servo motors will be driven through the PCB. They will be utilized to get arm mobility for the robot across one rotational axis.

Subsystem 5 (Turquoise Blocks) - Wheels

<u>Four Omnidirectional Wheels</u>

The wheels on the motorized base will be connected through the PCB which is mentioned in Subsystem 1. These will be useful in the robot navigating its way towards the child and making sure that it is in close proximity.

Subsystem 6 (Grey Blocks) - Miscellaneous

<u>Top LCD Screen</u>

The top LCD screen will be positioned on the head of the robot and will display a variety of emotions using a humanoid face. It will be connected to the central PCB which will use the Face Expression Interaction program to choose which face it needs to display depending on responses to game progression of the child. Power for this module will also be provided by the battery, but will run through the PCB's main power lines.

Block Requirements

Subsystem 1 (Green Blocks) - Processing

Central Printed Circuit Board Equipped with ATMega128 System-on-Chip

- This will be functional if it will be able to interface all of the components. This will involve the following:
  - Closing the circuit of the robot
  - Smoothly running all programs necessary for robot, simultaneously
  - Take sensor inputs and successfully analyze findings

Raspberry Pi 3

- The Raspberry Pi will be considered functional if it can run not only the Android-based games on the central LCD module, but also be able to communicate with the SOC described above.

Rechargeable Battery

- This block will be considered functional if it is able to provide power to the entirety of the robot and also be able to charge in an intuitive manner.

Subsystem 2 (Blue Blocks) - Programming

Central LCD Screen

- This will be considered a success if it is able to do two things.
  - Display, in a graphically pleasing way, the programmed Android games.
  - Have seamless touch screen functionality through capacitive touch.

Android SDK

- This block will be deemed successful if we are able to develop using the Android SDK on the Raspberry Pi.

Google Play Services

- This block will be noted as complete if we are able to interface with Google Play Services on the Raspberry Pi.

Custom Games

- This will be deemed as functional if we can successfully get Simon Says to work for 2 minutes with a user playing the game. Additionally, we would like to create Tickle which is another game that can be played for a set amount of time.

Movement and Dynamics Control Program

- This block will be considered successfully built if the following occurs:
  - Robot moves, translationally, with uniform motion and safe speeds
  - Movements of the robot are correct
  - Be able to control the movement of the robot with safety standards in place.

Speed Throttling

- This module would be successfully programmed if it prevents any harm that could occur to the child in playing with the robot.

Facial Expression Interaction

- This will be deemed as functional if we can successfully get different facial expression on the face LCD. Examples of this will include Happy and Sad faces. Happy faces while playing a game or a Sad face when something goes wrong or an answer is incorrect.

Subsystem 3 (Army Green Blocks) - Sensors

Left and Right Pressure Sensors

- These sensors will be deemed functional if we can properly read their inputs during games and respond accordingly. This will be possible if we can integrate this with the PCB correctly.

<u>Movement Sensor</u>

- This sensor will be successful if it maintains a set proximity from the user by utilizing its sensors data and responding accordingly with the motorized base. A successful utilization of the motorized wheels will allow the "SydeKick" to adjust distance appropriately.

Subsystem 4 (Purple Blocks) - Arms

<u>Left and Right Arm Servos</u>

- The Arm Servos are deemed successful if they can integrate with the PCB and move the arms up and down appropriately. They will also be deemed successful if they halt at certain preset threshold that we set in order to take care of precautions.

Subsystem 5 (Turquoise Blocks) - Wheels

<u>Four Omnidirectional Wheels</u>

- This subsystem is successful if the robot is able to move autonomously based on input data from the "Movement Sensor".

Subsystem 6 (Grey Blocks) - Miscellaneous

<u>Top LCD Screen</u>

- This will be deemed successful if we can graphically represent a face through the LCD Screen face. This intertwines with the "Facial Expression Interaction" software component.

Motivation for Blocks: A breakdown of each of the blocks and why it matters to the overall solution of project is explained below:

- **Green Blocks:** This is pivotal to success of the project and will act as the brain/processing power of the robot. This will be important to creating a good user experience for the child because it will be the power behind the motors/servos and LCD's. These are the features that make the humanoid the most life-like and create the best experience for the user.
- **Blue Blocks:** The Android and LCD will be a huge player in creating the interface that allows the child to play with the robot. Through games like Simon Says and Tickle our team hopes that we can create a fun and therapeutic experience for the child.
- **Army Green Blocks:** This will be important for the user experience and enjoyment of the child because we are projecting faces onto the LCD screen. This is so that it will emulate a happy and emotion-full environment.
- **Purple Blocks:** The arms will be helpful to interact during games with the child. They also really help bring together the idea of a human presence that the child can create a symbiotic relationship with. The safety hazard comes into play with the child if the rotation is too fast or too high. We will be looking into this more and making sure that we measure speeds and limit the height of the rotation of the hands.

- **Turquoise Blocks:** The wheels are a crucial part to the robot and it allows our group to circumvent creating "legs" for the robot. This is a simpler design specification to make it so that the robot can follow and be with the child. Our team hopes to create a safety precaution here where the robot will make sure that it stays at least 1 foot away at all times in order to not get too close.
- **Grey Blocks:** This block will be incorporating the face for the partial humanoid. Through this, as mentioned before, the team is looking to display faces and a happy environment for the child.

Risk Analysis

The PCB will be the most difficult block because I think based on our general knowledge base it will be the newest knowledge that we will have to retain and then apply. Our team is also not extremely knowledgeable about the power circuitry so this will involve reading a lot of literature that explains how power will work within the scope of our project.

It will also be crucial that we develop a robot that is safe for children. This means that there are many factors that need to be considered in terms of durability, robot movement, and ultimately the games that the child will play to ensure that it is truly a therapeutic robot not a dangerous one.

Ethics and Safety

As a preface, "SydeKick" has to be built with extra precaution because of the children that are using it, in this case that will be children that have autism. This section will be divided into robotic specific hazards and then hazards related users interfacing with the robot.

During development its important to take into consideration the overall appearance of the robot and making sure that we take care of our parts. The first being the mechanical build, it will be crucial to have all parts completely consumer ready before building. This means that all parts need to be soldered and smoothed out to prevent users getting there fingers caught. The second concern is the wiring, integrating the PCB and Raspberry Pi with the humanoid design will require extensive wiring which will need to be done very diligently. Our group will be extra careful in making the appearance product ready in order to make it as safe as possible for the child. To best solve the wiring and soldering problem it will be important as a team to make every part modularly perfect. This means that we can not leave wiring and soldering till the end. During usage of the robot it will important to take in to account the the arms and motorized base. Both of these needs to be tested and retested in order to make sure that the user does not get hurt. Our group will be solving for this by looking running different tests on the robot to see what will be the fastest speed we can operate the robot at. There will be a safety precaution in the arms so that they don't raise to quickly or too high in order to avoid damage. Additionally, the motorized base will also be fine tuned so that it always stays "x" feet away from the user. This "x" will be decided on later when we get closer to being able to test the product.

An ethical issue that we could see coming into play is whether or not it makes sense to leave a child with autism to play with a robot. Robotics is a very fast-paced and constantly advancing area of study which is not always fully understood. With this being said it creates an ethical puzzle of whether or not it's okay to push the responsibilities of people to nurture kids to a robot. I think this problem is shown in IEEE Code of Ethics (#5) where the goal of IEEE as a whole is to help improve the understanding and capabilities of individuals when it comes to new and emerging technologies[6]. The best way “SydeKick” will avoid this issue is to create an environment where parents need to be around with the child while they are playing and having therapy sessions but allow enough space to where their full attention is not commanded. As an emerging technology continues to grow its important to start giving more responsibility to technology while also not completely unlatching. IEEE Code of Ethics (#9) will be another really important code to keep in mind because safety has to be the paramount priority. Throughout building as well as usage by consumers this project will take every precaution necessary to maintain safety standards. This will include following lab safety trainings as well as taking the best care of our equipment and documenting our processes.

References:

[1] “Data & Statistics on Autism Spectrum Disorder | CDC .” *Centers for Disease Control and Prevention,* Centers for Disease Control and Prevention, www.cdc.gov/ncbddd/autism/data.html

[2] Weir, William. “Robots Help Children with Autism Improve Social Skills.” *YaleNews*, 22 Aug. 2018, news.yale.edu/2018/08/22/robots-help-children-autism-improve-social-skills.

[3] Firth, Shannon. “Autism Therapy From a Robot?” *Medpage Today*, MedpageToday, 9 Mar. 2015, www.medpagetoday.com/pediatrics/autism/50386.

[4] Firth, Shannon. “Autism Therapy From a Robot?” *Medpage Today*, MedpageToday, 9 Mar. 2015, www.medpagetoday.com/pediatrics/autism/50386.

[5] Price point has not been decided yet because its not yet clear which parts we will be able to leverage ECEB resources from and which ones will have to be bought seperately.

[6] “IEEE Code of Ethics.” *IEEE - Advancing Technology for Humanity*, www.ieee.org/about/corporate/governance/p7-8.html.