A Voice for Autism

FINAL REPORT

DEC1606
Josh Abbott - Micron
Dr. Chinmay Hegde
Cameron Cornick / Team Lead
Ashlyn Freestone / Communication Leader
Wen-Chi Hsu / Webmaster 1
Yiru Gao / Webmaster 2
Zach Snyder / Key Concept Holder
Dec1606@iastate.edu
http://dec1606.sd.ece.iastate.edu

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1 Introduction

1.1 PROJECT STATEMENT

For our project, we are working with Micron to build a device that will help people with autism communicate. The goal is to build a tablet with a touchscreen interface, and an app that will run on the tablet, or be downloadable onto an Android device. There are other devices on the market that fill this need, but we can offer something unique to the public if we meet all the specifications outlined by Micron.

1.2 PURPOSE

This project is important because we have the chance to greatly improve the quality of life of many people. Ideally, this device would make lives easier for those with autism by improving their ability to interact with their surroundings, and get what they want out of life. There are also countless other members of society that would benefit from a device, whether they are victims of strokes or seizures or any other debilitating affliction. There are currently devices on the market, but if we are able to create a budget-friendly, customizable device, then we will have something different to offer consumers.

1.3 GOALS

There are two main goals to accomplish: develop an application and create a customized tablet. The application will be available to download on the user's personal Android device, or they have the option of buying the tablet with the software installed. The app needs to be customizable, so that it can grow with the user. Our ultimate goal is to create something that will allow people to only have to buy one device, and be set for a long time. Most products for kids on the market are very unsophisticated, and the user would likely need to upgrade as they grow up.

2 Design

2.1 SYSTEM SPECIFICATIONS

2.1.1 Non-functional

The main non-functional requirement of the tablet is that it needs to be durable and aesthetically pleasing. Durability is the main concern and can lead to functional difficulties, and the device can find itself in the hands of users that may not have fully functional motor skills. The device will also end up being carried around constantly by the user.

The software side of things also faces certain requirements that don't influence whether or not the device works, but can greatly determine the utility of the device. The application should have a response time of less than half a second maximum for any UI selection, excluding loading the data for the given view. Data loading for the app shouldn't exceed more than a few moments at a time.

2.1.2 Functional

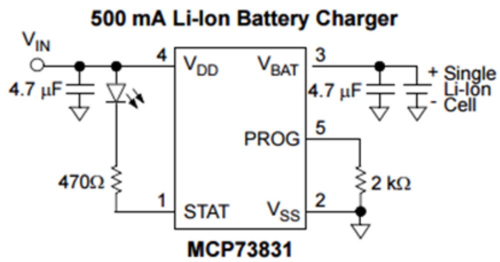
The requirements that we designed and created the hardware portion of our project were as follows. The battery should be large enough to power the device for at least a twelve-hour stretch of time. We also needed to be sure that the battery didn't weigh down the device or that the safety was endangered through the use and setup of the battery. The applications ability to suggest relevant words is also limited by the amount of memory available to store dictionaries, so there is a need to make sure capacity concerns are met. Another requirement that we noted but didn't entreat with a response included an enclosure, we did so because designing such an enclosure was deemed out of the relevant skill area of our team.

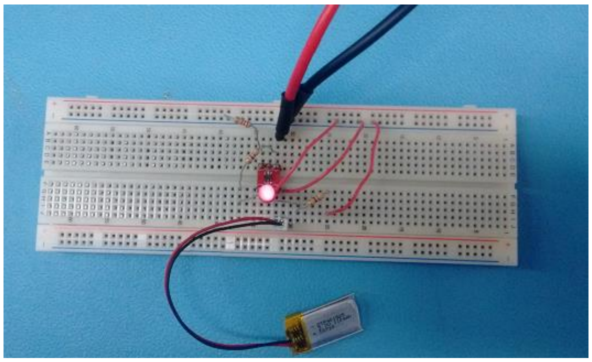
Building upon the hardware, our application needs to facilitate and improve communication between the user and other people. In this regard the device needs to allow the customization to match each user, the text needs to be easily readable, and the concepts and words need to be understandable to a large audience.

2.3 DESIGN SETUP

To meet the above requirements, we arrived at our current final design. Our physical device is based off of the raspberry pi education and development board. Upon the raspberry pi, we are running an android operating system. Other pieces of hardware that were setup or utilized include a battery charging circuit, a USB Wi-Fi dongle, microSD card with more than 8 GB of memory, and a touchscreen module specifically design for the raspberry pi.

For the battery charging circuit, we used an integrated circuit. We initially tried a more complicated design, but after talking to the parts shop, we decided on the following implementation. This will work for a single cell Li-Ion battery.





For language help, we filtered words from WordNet to get the most frequently used 20k words into our database. We kept the feature called lexicon which define the rough topic of the word. In addition, the database contain the count of word's lexicon appeared in WordNet to represent the weight of the word. For each words in our dictionary we also built their n-gram model by crawling from Internet. For the sake of saving computation power, we only retrieve 700MB data at a time which comes from Twitter, blogs, and newspapers; and we selectively save the top 10 trigram for each words.

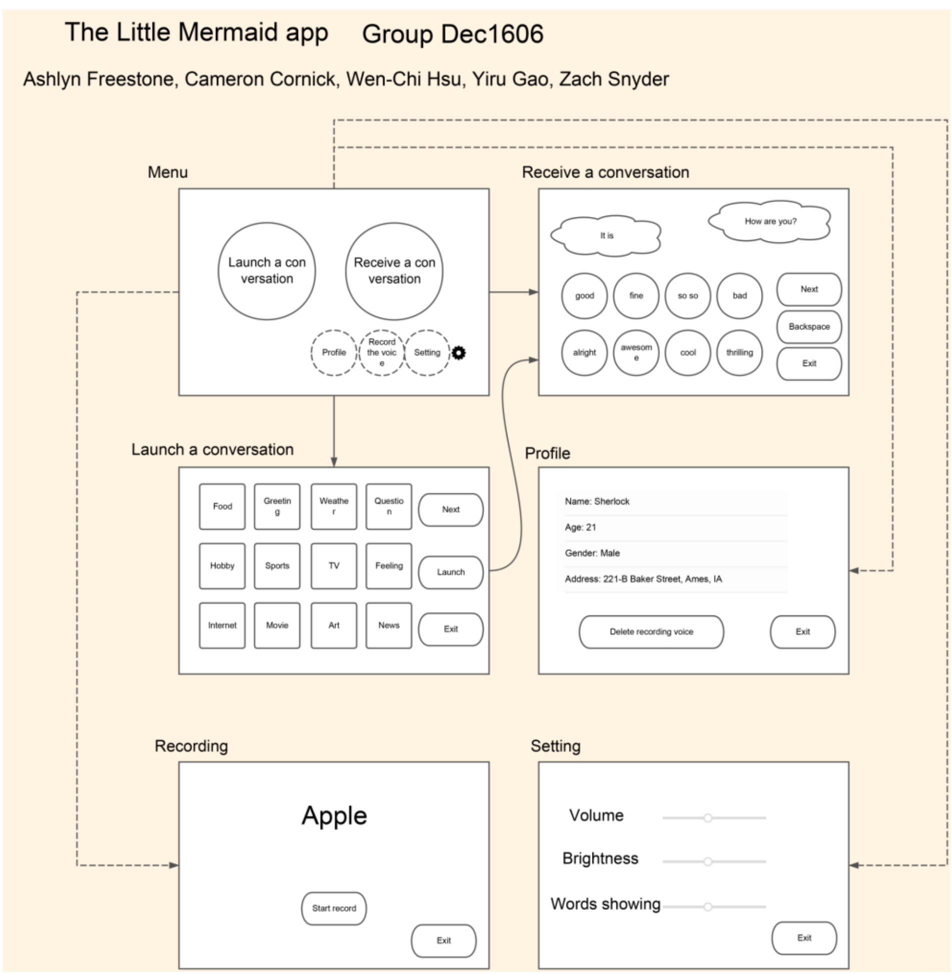
The words suggestion is based on our dictionary and the words that the user has chosen in the receiving view. The influence of lexicon should weigh more heavily because the app needs to learn about the user before guessing an n-gram value before the user chooses any words. After adding some words to the sentence, the n-gram value will be weighted more than the lexicons' value. In fact, the words will be sorted in order of a heuristic function value with inputs of the word's lexicon value, user choice of topic, and current n-gram value.

$$f(x) = l * e^{\frac{i}{4}} + g * \left(1 - e^{\frac{i}{4}}\right)$$

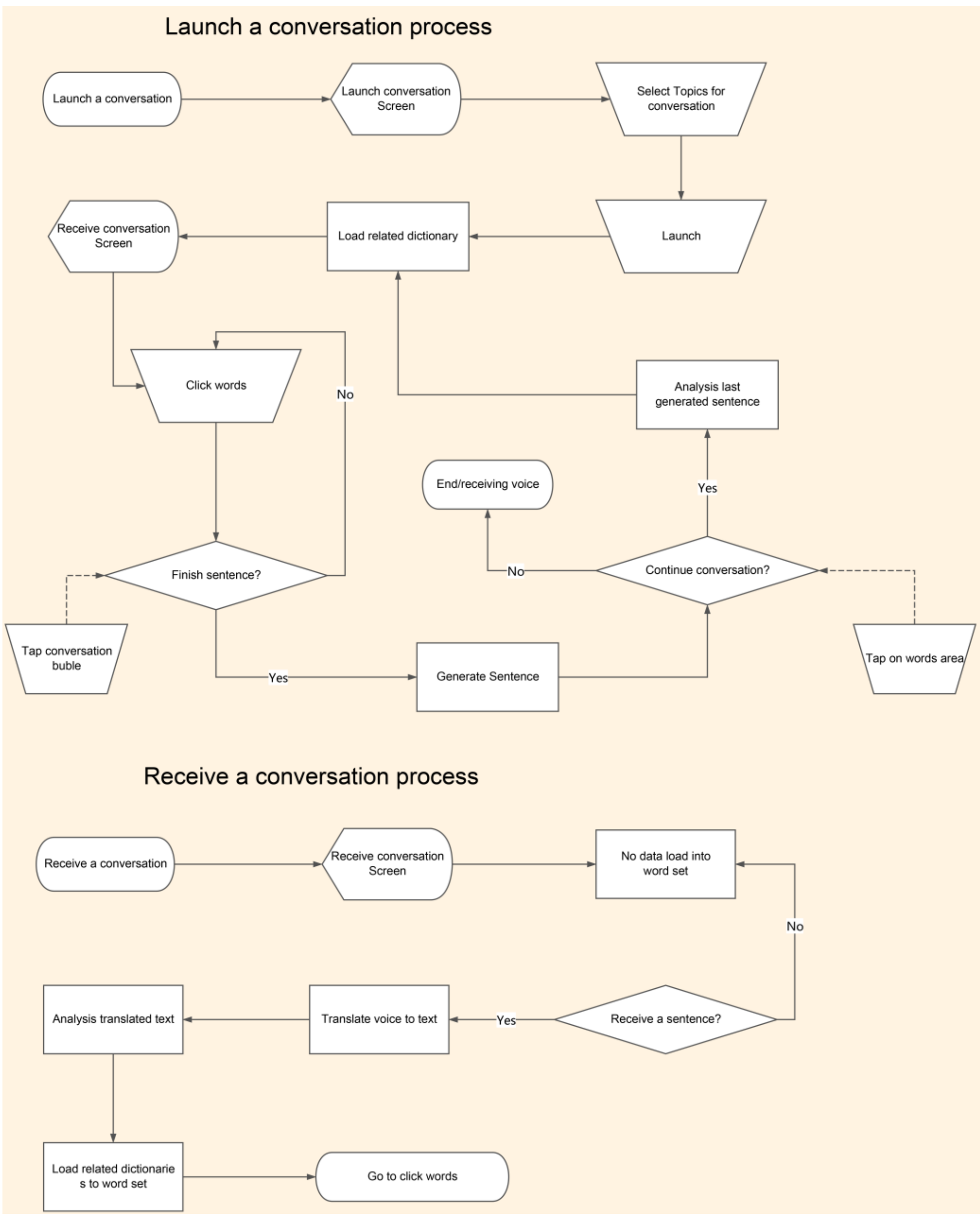
The f(x) is our heuristic function, l represents lexicon value and g represents n-gram value, *i* is the index the word will be appeared in the sentence.

The database is stored in Firebase, a cloud storage developed by Google. It supports offline data retrieving and provides basic security for user and our dictionary.

We also deployed app to API.AI to entity analysis to find some unique location or time which cannot be found in our dictionary. The sentiment analysis is in testing when we wrote this document, and we are not sure if it would work before the project due. But since we plan to create a prototype solution, our current testing result is good enough to show the concept we made.



User will first enter Menu Screen and choose to launch a conversation or receive a conversation. When launch a conversation, user can choose several topic and combine them together to start a conversation. Starting a conversation will navigate user to receive conversation screen with related word choice. For example, if user chooses “Food” and “Feeling”, the word set will likely to have “tasty”, “delicious” and so on.   Receive conversation is for listening other’s speech. It will judge from recognition and generate a word set to let user select. The Launch and Receive is the core of this project, the detail process flow is shown in the figure below.



Profile will store user's information and will infect word selection. It also allows user to erase the previous recording data of voice. Recording screen will record user's voice feature and replace machine original voice with user's voice when user finish the all process of recording test. Setting will change screen brightness, volume and words showing of receive conversation. Brightness and volume is essential design, since autistic people do not like too shining light and too loud sound. This is designed for their comfort to use the device.

The suggestion word will load from dictionary called WordNet. The WordNet has neural network structure and will suggest related word to the topic/sentence. However, forming a sentence also need to consider about grammar. For example, when we select "Food" and "Feeling" and intend to make a sentence like "I like the taste of that home-made restaurant". At the beginning of sentence, we still need a subject rather than a "Feeling" or "Food". The word suggestion would also affect by the factor of previous words selection. For example, if I choose "What", the next word is highly likely to be a noun like "weather" or verb like "is" for the next. We use Stanford NLP library analysis those situations to enhance the functionality of suggestion. Stanford NLP provides Java API that perfectly fits our goal.

3 Testing

3.1 HARDWARE

To test the hardware involved first and foremost the ability to turn on the device, and after that was checked off we continued with the tests that would allow us to see if we met our requirements. One of these tests was focused on our battery and its use. This test would have involved charging and then using the device on battery power only. After several power cycles, we will be expecting an average time to discharge to be around seven hours based on high and low power consumptions specified for the device components. There were no other issues with the battery and the charge circuit, this includes checking for heat or other abnormal battery behavior. The other test on the hardware was that there were no loose connections and this was checked by shaking the device. The device passed.

3.2 SOFTWARE

There were three types of tests for the software. First one is M-M test. We plan to have two machine has app talk to each other and see if the machine can make a conversation or not. The topic will be narrow down into few in the first stage and will eventually become large scale and complex (We probably would use Siri to test spontaneous of language use). Second is M-H test. This will let a person speak to machine and see machine can recognize voice and generate right word set or not. The third one is A-H test. We will let autistic people to try this app and see if they will be comfortable to use it or not. We will make a survey to measure the result of the test. Due to not a fully complete setup, lack of connections to desired end user, and university paperwork, we were unable to do the A-H testing in any capacity.

4 Results

At the end of our second semester we have progressed very far through our project. We didn't get to a full finished product that is ready to get into the hands of users across the world. We explored, deeply, a wide variety of topics and processes that made us all better engineers at the end of the day. The state in which we leave our project is a device that's missing a few dots of I's like a battery charging circuit that can handle the extremely large battery that we had purchased or a speaker that would plausibly fit into a properly sized case and not a salvaged speaker from a defunct TV. These were solutions that were on the horizon and just out of reach for our team. Our software designs were reaching the pinnacle what we would never have guessed at the start of last semester. We have implemented an app that can interface with a user and bring their thoughts to the world around them. We have even gone so far as to implement a system that is able to take spoken words and suggest a response to a user. Our project was designed and pursued with a pursuit of bringing good into the world, and we received just as much good in return from the growth of all the members in this group as engineers.

5 Conclusions

Our experience in senior design has been very beneficial for all of our group members. From the moment we first banded together, we have pushed each other to new heights. The very start of this project was mired in debate as to what the project request entailed and how best to complete it. The debates also lead to a better understanding of the problems facing a large amount of people in our society, as not only those with autism face difficulties in communication but countless more people. In our research we found that while many solutions can exist for a problem, there can be many more issues that those solutions can't solve that interconnect with the problem of communication.

This project has taught us the value and skills needed to properly present a project, as well as to document our progress. It has lead us to a better understanding of what it means to participate in a group project where each person relies on another and there is no possible way for one student to complete it all. Our design process understanding and skills were put to the test as we hurdled over pitfalls and decisions that we were forced to make. With this combination, our project and presentation skills have improved greatly.

A1 Appendix Use and Caution

Using the App and Project:

- Using the app and project is as simply as making sure that the power is turned on.
- After the tablet or the project powers on and makes it to the home screen, simply select and launch the app.
- From there the options run similar to the software design section above. Simply select different buttons to perform different options.
    - One can select to "Speak" and choose what gets put through the speaker.
    - Another option is "Receive" where the device will "listen" and suggest responses to the user.

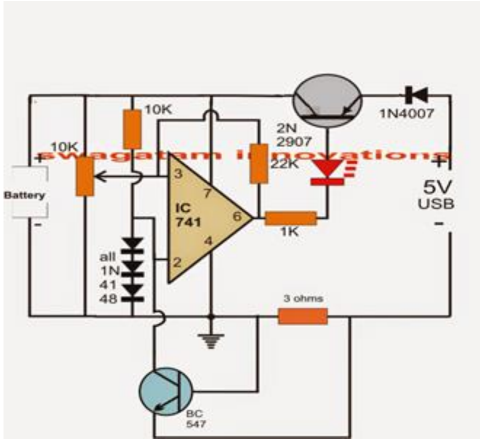
Battery Charging Circuit – Walkthrough

Charging a single cell Li-Ion battery using the battery charger that we built is very simple. The five Volt DC input voltage is connected to pin four of the IC, the positive terminal of the battery is connected to pin three, and the negative terminal is connected to ground. It is very important to only charge Li-Ion batteries with circuit specifically designed to do so. Failure to do so can result in a dangerous situation for the user.

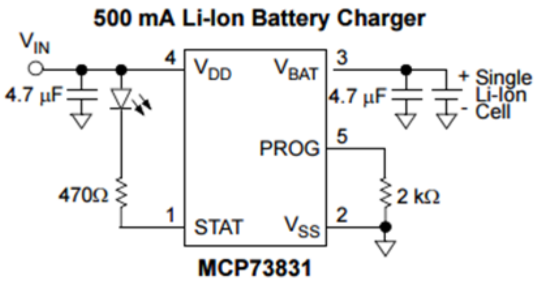
A2 Appendix Revisions and Revisits

Battery Charging Circuit – Design Revisions

Our initial circuit used for the Li-Ion battery is below.



After having trouble getting this circuit to work and talking with the parts shop, we decided to use an integrated circuit to perform the task.



This circuit worked right away and was less complicated than our first design. Ultimately, this will only work with a single cell Li-Ion battery, so we couldn't use it in our final board design.

Doing the Project Again:

Our group has been through several iterations and directions that we were looking into implementing for the goal of a communication device. While we were always committed to the end goal of solving the problem, we didn’t always agree on the solution to the problem. A part of this came from our experience in our courses. One solution that we recognize as the best if we were to return day zero last semester is the idea of scrapping the self-made tablet and pursuing a software solution. A straight scrapping of the tablet wasn't something the hardware specialized members liked as it would mean a new project already halfway through the semester due to our late start. The solution that we would pursue starting over is to setup a program of tablet and device re-use with an app being developed. This was seen as a solution due to the fact that of the commonality and no lack of shortage of factory refurbished or used phones being sold for sub fifty dollar amounts. This solution is still not trivial as the safety and integrity of the devices becomes paramount. There is also the issue of creating an extremely strong case while not affecting the usability of the device.