



Voice Activated Robotic
Hand - Sign Language
Gestures for the Impaired
Hearing

Kimaya Satavalekar

80 Pages
27.6 cm x 21.2 cm

Ruled 7 mm • Ligné 7 mm

EXERCISE BOOK
CAHIER D'EXERCICES

NAME/NOM Kimaya Satavalekar

SUBJECT/SUJET Science Fair 2024-2025



ASSEMBLED IN CANADA WITH IMPORTED MATERIALS
ASSEMBLÉ AU CANADA AVEC DES MATIÈRES IMPORTÉES

12107

Detailed Plan - September 21, 2024

Basic Overview → Robotic humanoid hand/arm that will recognize a word I say and translate to American Sign Language (ASL)

General Timeline:

October → Constructing humanoid hand + ~~3D printing~~
November + December → Voice Recognition ↙
January → Feb → Model Training ↘

Materials Needed:

- ~~3D printed parts~~ (no more 3D printing)
 - Voice Recognition Module
 - Arduino + IDE
 - Different coras → Nylon, fishing rope
 - Servo motors → standard + micro size
 - Superglue + screwdriver (assembly)
- Nylon has been recommended online, in terms of strength

IMPORTANT CRITERIA:

- 1) Functionality + Motion (Range)
- 2) Design + Aesthetics!
- 3) Cost + budget

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Date: September 22nd, 2024

- Installing Ultimaker Cura for 3D printing and slicing
- Started research on 3D printing + slicing

(MODULE IS NOT MACHINE LEARNING!)

Date: September 23rd, 2024

- Want to start with a basic test to generally understand the process: Control one ~~servo~~ servo or LED with voice recognition module
- Need to find affordable Voice Recognition Module component, prices are between \$52 - \$70!
- Also find a full list of what I need and 3D printing files and list of materials!

Date: September 24th, 2024

List of Materials (New) for Robotic Arm:

- Types of cords:
 - ↳ Nylon Paracord (thicker, may be the best option)
 - ↳ Kevlar cord
 - ↳ Fishing line (between 0.5 mm and 0.8 mm) → through fingers
- Micro servo motor (I have an Adafruit Industries one)
- Voice Recognition Module

Tonight, I ordered 5 pack of ~~mini~~ micro servo motors (MS18), a pack of jumper wires, ~~an~~ a servo driver (16-channel 12 bit PWM J2K PCA9685) for the servos, and pigtail cables.

Date: September 25th, 2024:

- Servo motors, jumper wires and adapter arrived
- Planning on first learning How TO control multiple servos at once in servo driver, then begin arm!
- Basic revision on micro servos and characteristics!

Date: September 27th, 2024

- All ordered materials have arrived: Servo driver, power adapter
- Ran one servo motor today, test #1
 - ↳ I was able to control ONE servo with a potentiometer + arduino board
- Now, time to control 2 with servo driver!
I was able to do it! Yay!
- New issue: When not connected to computer for power (5V power supply), the servo twitches! Why?
 - ↳
- I need to order fishing line.

Not enough power
without power supply.

Date: September 28th, 2024:

- Today, I was able to control 5 servos, which I labelled 1, 2, 3, 4, and 5 with my keyboard!

Date: September 29th, 2024:

- Now, I'm going to start building a basic model of my hand, without 3D printing and without fishing line or voice recognition.
- Need a very thin rope to fit into servo hole!
 - ↳ Using sewing thread for TEST 1 of hand
- I worked all day and finally built my first version of the robot arm, with cardboard, straw, electric tape!

Date: September 30, 2024:

- I ordered the Voice Recognition Module today. It is arriving October 5th.
- Since my first test is over, I've come to a few conclusions: range of motion and functionality, as well as aesthetics is not the best.

- I need to make ~~the~~^a wrist and it should be able to rotate too. Also, since I'm using cardboard, it is flimsy.
- The aesthetics + design can be better too. It currently doesn't have an amazing look.

October 1st, 2024:

- Deciding to start constructing, new, better looking and smoother mechanical model.

October 2nd, 2024:

- In construction process of Version TWO!
 - ↳ Could not find an exacto knife yesterday, ran to the store to grab one!

October 5th, 2024:

- Busy week!
 - ↳ Bought an exacto-knife yesterday to cut cardboard
- Today, Voice Recognition Module got delivered!
 - ↳ Study it tomorrow!
- Made lots of sketches of mechanical arm → templates

Date: October 6th, 2024:

- Worked all day, finally finished my first finger test model!
 - ↳ Very good, had actual joints like a real finger.
- Problem with the sewing thread, can break very easily.
 - ↳ May need to try out fishing line!

Date: October 7th, 2024

- Working on understanding + doing research on Voice Recognition Module V3
 - ↳ 80 commands? Or is it 255?

Date: October 8th, 2024 :

- Test program with Voice Recog. Module
 - ↳ Realized that my module needs pins to put in breadboard. If I stick straight into breadboard with jumper wires, can damage chip!
- Working on second, better finger instead. Look nicer.

Date: October 10th, 2024 :

- Tried to build finger #2, did not work very well. Finger spacing is off.
- Thinking of "spring" tension. It has to be able to pull the finger back whenever it is pulled forwards.

Date: October 12th, 2024 :

- Fishing line delivered today
- Fishing line test vs. sewing thread test conducted
 - ↳ Sewing thread breakable with hands.

Date: October 13th, 2024 :

- Tried doing the spring tension but sewing thread broke.
 - ↳ Proves how weak it is. Time to try with fishing line

Date: October 14th, 2024 :

- First string tension did not work. Trying second one. I need a new finger → used up all trial ones.
- Have not soldered yet, need to order soldering pins from Amazon.
- The string spring tension idea worked, but I think a rubberband on the back of the finger will work better.

Continued ↓

- I also need to make a lot of trial robotic fingers.
↳ Starting to make them.

October 19th, 2024:

- Made 4 fingers (most likely for testing)
↳ Tried spring action 2nd time, but with toothpicks securing string, not working well.
- Trying rubberband for better spring tension → Not good!
- Going to solder voice recognition module pins in next week sometime.

October 20th, 2024:

- Rubberband finally worked WELL! → Spring tension is functional.
- Tried it out with servo motor, ^{finger} it isn't bending fully, servo motor can only move it so far + too much friction in joints.

October 21st, 2024:

- After second rubberband trial, not working well anymore.
↳ Rubberband disadvantages: can snap, loosen, etc.
Too many risks.
- Going to try spring tension (fishing line) strategy again.
↳ Soldered voice recognition module early in morning. Starting experimentation on it, soon.

October 23rd, 2024:

- Fingers are not cooperating!
↳ Going to continue working with string
- Working on Voice Recognition module tomorrow.

October 24th, 2024:

- Got voice recognition module to work!
 - ↳ Turns LED on and off with the commands "open" and "close."
- Need to find new voice recognition module, this one only is able to load 7 commands at once. I need 26+ commands (for alphabet).

October 25th, 2024:

- Looked at online pulleys for fingers, new voice module (holding over 26 commands to load), and better tension alternatives to rubberbands → Eg. Steel Spring Bands
- ↳ Returning Voice Recognition Module soon!

October 26th, 2024:

- Created chart of degree positions for each finger.
- Spent whole day using chart to make a basic version of my project.

↳ My initial cardboard hand responded to 7 of 7 commands "a" to "g", producing ASL signs.

ERROR → Everything is working well, but the thumb servo is always twitching and going haywire. I switched it out, and the new one did the same thing. Something might be wrong with the first connection in the servo driver.

October 31st, 2024:

- ~~I was~~ Since I can only have 7 commands max loaded in, did further research on previous voice recognition modules (V2).
 - ↳ V2 had a group system in place
- I want around 30 active commands, how to do that? I might be able to use a group system.
 - ↳ For this, I POSTED a question on Stack Overflow.
Currently, no replies.

Continued ↓

November 1st:

- Cutting out more fingers

November 2nd, 2024:

- Today, I did research of better alternatives for speaker independent voice recognition modules
 - ↳ SimpleVR - \$48 including shipping
 - ↳ EasyVR 3 Plus - \$52 including shipping

November 3rd, 2024:

- Started writing code to figure out grasp system with V3 module. Not going to buy another one, too expensive.

November 4th, 2024:

- Finished building 5 good fingers, NO FRICTION! 😊

November 5th, 2024:

- Constructed all 5 fingers and hand base → PUT TOGETHER THE FULL HAND!
- Encountered an issue: Fingers were too long, so 180° turn on servo does not pull it fully.

November 9th, 2024:

- Saw videos of other people using ^{pulleys} ~~pitfalls~~ to fix this issue.
- Did research on pulleys and calculated half of circumference for 180° + radius.
 - ↳ IT WORKS!

November 10th, 2024:

- Today, I made all 5 pulleys to test it out.
↳ ACCURATE measurements are important!
- Encountered issue with servo 180°, and SG90 servo does not work.

November 11th, 2024:

- I finished the full hand + took pictures!! It looks extremely realistic, I'm very satisfied. WORKS WELL!
↳ Maybe also paint it later?
- Time to work on voice recognition module.

November 12th:

- Voice Recognition Module Group system is not working. I need to post another post on Stack Overflow (both of mine got shut down).
↳ 26 commands between index 12-37.
- Issue: How to switch between group system? The recognizer only detects words that are LOADED in. Otherwise, how to detect?
- (I may need to get SimpleVR module. The issue is that SimpleVR can only be directly shipped from external, unfamiliar websites online. If I get it, will return the Voice Recognition Module VB).

Currently, hand progress:

- Functionality + Motion → Partial mark because fingers are good
- Cost + Budget → but not sturdiness of pulleys.
- Design + Aesthetics

November 13th, 2024:

- Snap back motion isn't working, I've tried many ways.
 - ↳ Need to order different voice recognition module, preferably SI + More than 26 active commands

November 14th, 2024:

- More module research, order module soon.
 - ↳ EasyVR 3 plus

November 15th, 2024: - November 18th:

- Constantly working on snapping back motion
 - ↳ Rubberbands keep snapping,
 - ↳ Wider elastic bands have too much tension
- What do I use?

November 19, 2024:

- FINALLY figured it out → Create 2 sized pulleys, bigger pulley for longer back side.
- Also, micro Mitzzi motors do not have enough torque to pull finger → 1.4 - 1.9 kg/cm!
- Need to buy MG996R standard **HIGHER TORQUE** servos!

November 20, 2024:

- MG996R servos got delivered today!
 - ↳ 9 kg/cm TORQUE!! Extremely fast too, 60°/sec.
- They also work on same PCA servo driver (16 channels)

November 21, 2024:

- Considering to 3D print the hand once my full program is set and cardboard hand is working.

November 22nd:

- Decided to put cardboard hand on hold for now, look at different options
- Ordered mannequin hand from Amazon
- Also ordered Fortibit EasyVR 3 plus + shield from Mouser Canada

November 23rd, 2024:

- Started writing report for science fair

November 29th, 2024:

- EasyVR 3 plus came today, spent SO LONG soldering onto shield and trying to get it to work.
 - ↳ Figured it out!
 - ↳ Downloaded the EasyVR commander to start training commands. Works well!!

Problem: what about NOISY environments, like Science Fair?

November 30th, 2024:

- The program isn't working! Too many errors and EasyVR module not connecting to program
 - ↳ How do I use new syntax to control servos?

December 1st
~~November 31st, 2024:~~

- Not many guides to help me out on syntax for EasyVR 3+.
 - ↳ Used basic generated sketch for program!

December 2nd, 2024:

- I only had to add to the "void action()" function to control servos! It works!

December 3:

- Trying again to use strings and pulleys on my finger → IT ISN'T WORKING!

December 4th, 2024:

- Got a reply in Stack Overflow Robotics community. Someone told me to try using types of springs, specifically helical springs.
 - ↳ Don't have helical springs, but I decided to use ballpoint pen springs!
 - ↳ Ballpoint springs won't work from the back because they are too small to stretch that much.

December 5th, 2024:

- FINALLY WORKED! Springs last longer too!
 - ↳ Instead of back of finger, I attached the springs INSIDE the fingers, because then they have a shorter distance to stretch.

December 6th, 2024:

- ordered a kidzlabs basic string-driven hand for another hand model.
 - ↳ Arriving December 10th.

December 10th, 2024:

- Springs between bottom of finger and hand are not working.
- Started writing my report
 - ↳ Titled "On the Integration of Speech Recognition for the Servo-based control of Humanoid Robotics"

December 11th, 2024:

- KidzLabs robotic hand arrived early, started assembling + putting together

December 12th, 2024:

↳ Very sick + sore throat, so leaving voice commands for a bit

December 15th, 2024:

- Worked on integrating voice commands with Kidz Labs robotic hand

↳ Hand is good because it has automatic snap-back due to the material.

December 16th, 2024:

↳ The hand is slowly losing tension due to constant bending of the fingers!

↳ I got a 3D printer from GLE Jingle Contest 2024! I won for the submission of this project idea!

↳ Now I may use the 3D printer to print an actual hand.

December 17th, 2024:

- I discovered an online voice recognition google based platform known as Teachable Machine.

↳ You can train an audio model using Teachable Machine

December 18th, 2024:

↳ started to train basic model with only A and B on Teachable Machine

↳ Will be better than EasyVR 3+ because it is machine learning.

December 19th, 2024:

- Used Edge Impulse to convert the basic A+B machine learning model into proper file suitable for Arduino.

↳ The file not integrating into the Arduino ~~IDE~~ (Uno)

↳ TOO BIG to be used with Uno, ML doesn't work on it.

- * POC = Proof of Concept
- * ML → Machine Learning

December 20th, 2024:

- Found out that larger, more capable Arduino boards, like the "Arduino ~~Bot~~ Nano 33 BLE Sense" are used for ML.*
- Expensive! \$\$\$

December 21st, 2024:

→ EXPLORING OPTIONS + PATHS:

- ① → ML isn't possible with Arduino Uno
 - Continue using EasyVR 3+, but also explore programming hand to recognize WORDS!
- ② → OR continue seeing different strategies to incorporate ML into project.

OPTION ONE IS THE BETTER PATH → Option 2 is not Feasible
Option 1 unlocks more possibilities!

December 22nd, 2024:

→ GAME PLAN:

- School science fair is due end of January → basic project needs to be completed.
- Background research conducted
- Basic hand design + POC* completed
- Expenses Evaluated!
- Report MOSTLY done

Criteria covered:

- Functionality + Motion
- Cost
- Design + Aesthetics

December 23rd:

- ↳ Today I programmed the hand to sign "CANADA" with the letters "C", "A", "N", "A", "D", "A"
- ↳ I need to find a way to add a WRIST to my hand.

December 24th - January 6th, 2024:

- ↳ I was on vacation, so I had to leave the project on hold for a bit.

January 9th, 2024:

- ↳ Following words with lots of letter variety will be trained:
 - ↳ "CANADA"
 - ↳ "ADVENTURE"
 - ↳ "EXCITEMENT"
 - ↳ "FOUNDATION"
 - ↳ "REVOLUTION"
 - ↳ "CELEBRATED"
- ↳ So far, these are all the words I have.
- ↳ I also need a wrist movement for letters like "C"

January 11th, 2024:

- ↳ I got my final 3D printed hand model!
 - ↳ Made of 3D print material + stainless steel
 - ↳ I added wrist movement to the hand by connecting a larger, high torque servo to bottom!! Finally works!

January 12th, 2024:

- ↳ Now, last thing is finishing my program + voice commands
 - ↳ Voice commands so far are working → words have higher detection rate than letters
 - ↳ "D", "B", "E", "G", and "V" sound similar.

January 18th, 2024⁵:

↳ All words are trained and working in LOW-NOISE environments.

↳ Level of success has not been determined

January 19th, 2024⁵:

↳ I have tried testing each word in crowd noise setting and it is rarely being detected.

↳ What if I try another type of mic that I have at home? I can try to use a singing/presentation microphone.

↳ Upon further research, I figured out it is called a DYNAMEC microphone + cardioid microphone.

January 20th, 2024⁵:

↳ This mic works EXTREMELY well!

↳ Few more commands to add:

↳ CALGARY

↳ ALBERTA

↳ SCHOOL

↳ BOOKS

↳ LEARNING

↳ EDUCATION

↳ APPLE

↳ AMAZING

↳ ZEBRA

↳ ORANGE

January 21st - 22nd:

↳ Today, I'm starting comprehensive research on sensors, EasyVR 3F, and other categories.

↳ My science fair video will be filmed tomorrow for school round.

January 23rd, 2025

- ↳ I filmed my school round video. My logbook is also finished now.
- ↳ I still have some testing, research, and analysis left!

January 24th, 2025

- ↳ Finished research on servo motors + how they work.

January 25th - 30th, 2025

- ↳ Worked on my report a bit. Maybe I should finish high priority task like trifold first and then work on my report.

February 2nd, 2025

- ↳ Maximum 30 pictures can fit on the trifold if placed landscape-wise.

- ↳ ~~Slides~~ required: Divide my trifold into hardware + software section, and we can have analysis + applications in middle.

Results
as well

ALL SLIDES (for trifold):

- Problem
- Servo motors
- Servo driver *
- Analysis
- Voice recognition / Easy VR3+
- Conclusion
- Arduino
- Limitations
- Microphone *
- ASL
- Angle Conversion
- Verbal Commands
- Program development

Applications
too

- I started testing of how well the command "CANADA" works in low noise, no noise, moderate noise, and high noise. I will create a bar graph for this.

February 3rd, 2025:

↳ I finished drawing my data analysis bar graph + my servo motor detailed drawing.

February 4th, 2025:

↳ Today I decided I need to create a visual that is appealing and explains the full hardware

↳ Also a block diagram and flowchart combined!

↳ I drew 6 small servos, an Arduino board, an EasyVR 3+, servo driver, microphone

↳ Sadly, they ended up being way too small in comparison to my trifold.

↳ I need to restart these soon.

February 5th - 7th:

↳ I finished making larger copies of the block diagram + colouring them.

February 8th / 2025:

↳ May not have much time for the rest of the weekend, so I need to work on more pictures now.

Other pictures:

- Techstack diagram (program)
- PWM explanation

February 15th, 2025:

↳ Started writing trifold slides

↳ All pictures are done.

February 21st, 2025:

Calculation of total final hand cost:

- 1 MG-996R servo → \$2.20
- 1 Robotic Hand → \$104.38
- Easy VR 3r → \$58.02
- Arduino UNO → \$20
- PCA9685 servo driver → \$1.45
- Microphone → \$10
- Female Plug Audio → \$2.50
- Power Pigtail Female-Male → \$0.95

TOTAL = \$199.50

Most Robotic hands themselves are over \$200! This one includes voice recognition. Medium to high robotic hands between \$500 - \$5000 generally.

February 22nd, 2025:

↳ All the written slides created are:

- Abstract
- Problem
- Analysis
- Conclusion
- Cardboard Hand Trial
- Plastic Hand Trial
- Limitations
- Applications
- ~~Improvement~~
- ASL (Letters → Angles)
- Servo driver
- Arduino
- EasyVR 3r
- Servo motors

Need to add:

- Improvement?
- Microphones (Condenser Vs Dynamic?)

Continued ↓

↳ Pictures that need colour-printing:

↳ Code: CANADA code *(Letter A?)

↳ All trials picture (2) + final (1)

February 23-25th, 2025:

↳ I finished giving and getting my trifold slides ready. I just need to glue to my board.

March 1st, 2025:

↳ Print out other things:

* ↳ 3 pictures of each robotic hand

↳ Citations

↳ Method (all hand feedback)

* ↳ Servo motor code

* ↳ CANADA code

↳ ASL Each letter chart

March 2nd, 2025:

↳ I glued all the letters for the title. Time to give the subtitle and all slides.

↳ By MARCH 14, I NEED PLATFORM BASICS FILLED!

March 19th, 2025:

↳ I'm finally done the full project!

↳ Trifold ✓

↳ Report ✓

↳ Video ✓

↳ It's been a fantastic journey, making my voice activated robotic hand a success!