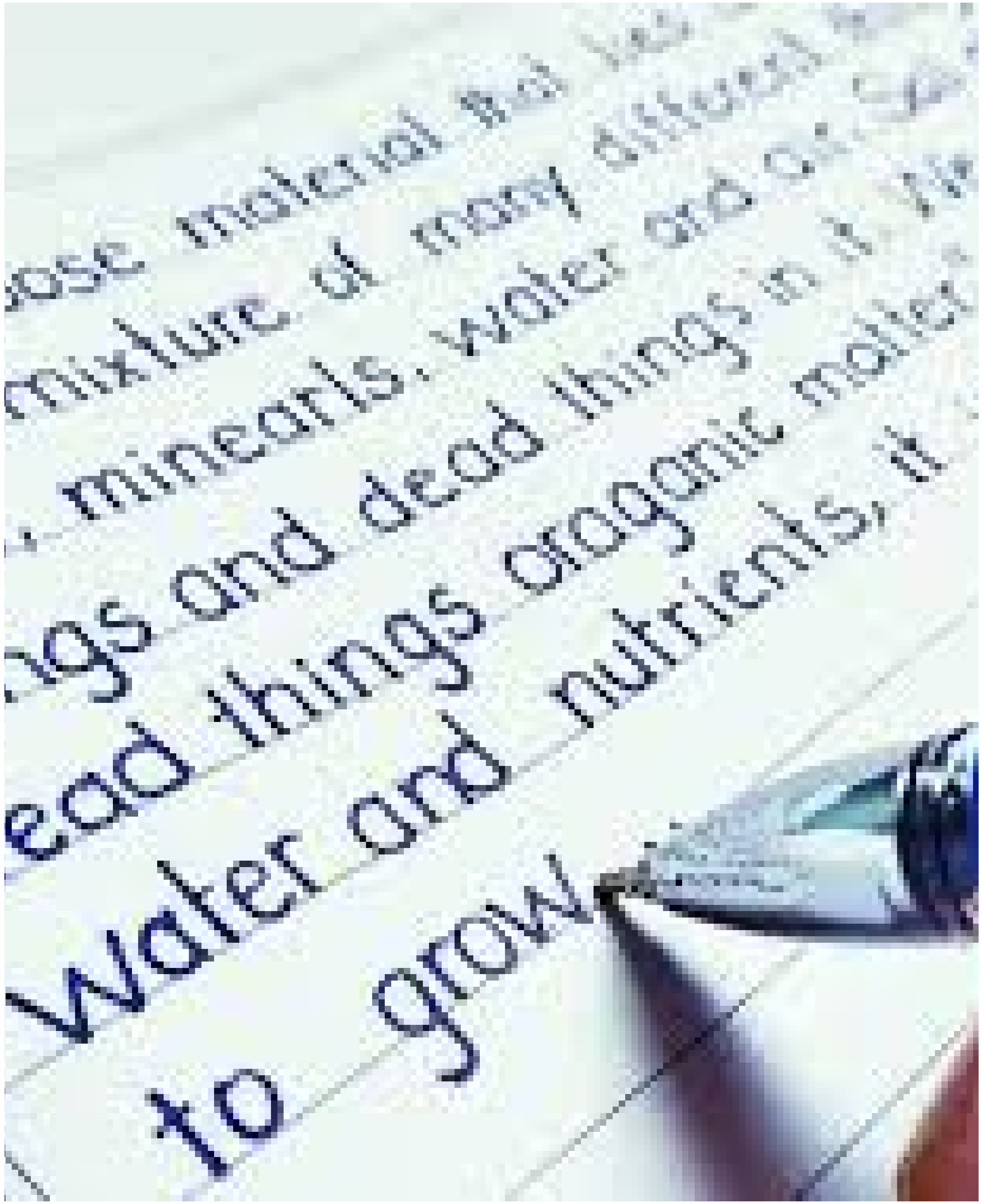
AMRITA
VISHWA VIDYAPEETHAM

Speech-to-text handwriting system using a XY plotter Robot

group 2

Gokul Krishna - 23128
Krishna Prakash – 23138
Rahul B – 23114
Danda Lokesh – 23123



Introduction

- Handwriting is an essential form of communication, but many individuals struggle with writing due to **disabilities, motor impairments, or time constraints**.
- Speech-to-text technology has advanced significantly, enabling real-time transcription.
- Integrating speech recognition with robotic handwriting offers an innovative solution for automation and accessibility.

Project Objectives

Objective:

- Build a robot that listens to live speech and converts it to text in real time
- Convert spoken words into handwritten text using an XY plotter.
- Develop a real-time system that accurately transcribes speech to physical handwriting.
- Optimize motor movements for efficient and legible writing.

Key Features:

- Continuous audio capture and preprocessing
- Real-time speech recognition (ASR)
- Immediate text output with dynamic display

Problem Statement

- Handwriting can be challenging for individuals with **physical disabilities**, motor impairments, or handwriting difficulties.
- Traditional typing and digital printing lack the personal touch and human appeal of handwriting.
- Existing speech-to-text systems focus on digital output rather than generating handwritten text.
- Limited solutions exist for automated handwritten transcription that integrates AI with robotics.

Project Scope

- **Speech-to-Text Conversion:** Develop an speech recognition system to transcribe spoken words into text without relying on external APIs.
- **Text-to-G-Code Transformation:** Implement algorithms to convert recognized text into optimized G-code commands for an XY plotter.
- **XY Plotter Control:** Utilize Arduino and GRBL firmware to precisely control stepper motors and servo mechanisms for accurate handwriting output.
- **Real-Time Processing:** Enhance system efficiency by implementing parallel execution of speech recognition, text processing, and motor control.

Methodology/Approach

1. **Speech Recognition:** Implement an offline speech-to-text module with streaming recognition for near-instantaneous text output.
2. **Text-to-G-Code Conversion:** Utilize predefined stroke-mapping techniques to generate optimized G-code for handwriting.
3. **Motion Control:** Develop a GRBL(G-Code Reference Block Library)-based motion planning system for smooth and precise pen movements on the XY plotter.
4. **Parallel Processing:** Implement multi-threading to handle speech processing, text-to-G-code conversion, and plotter control simultaneously.
5. **Real-Time Optimization:** Fine-tune stepper motor speed, acceleration, and servo control to minimize latency.

Novelty

- **Real-time execution:** Unlike previous works that batch-process input, this system executes handwriting immediately upon speech detection.
- **Optimized G-code generation:** Precomputed handwriting strokes reduce processing time and improve handwriting clarity.
- **Parallelized execution:** Simultaneous speech recognition, G-code conversion, and motor control enhance efficiency.

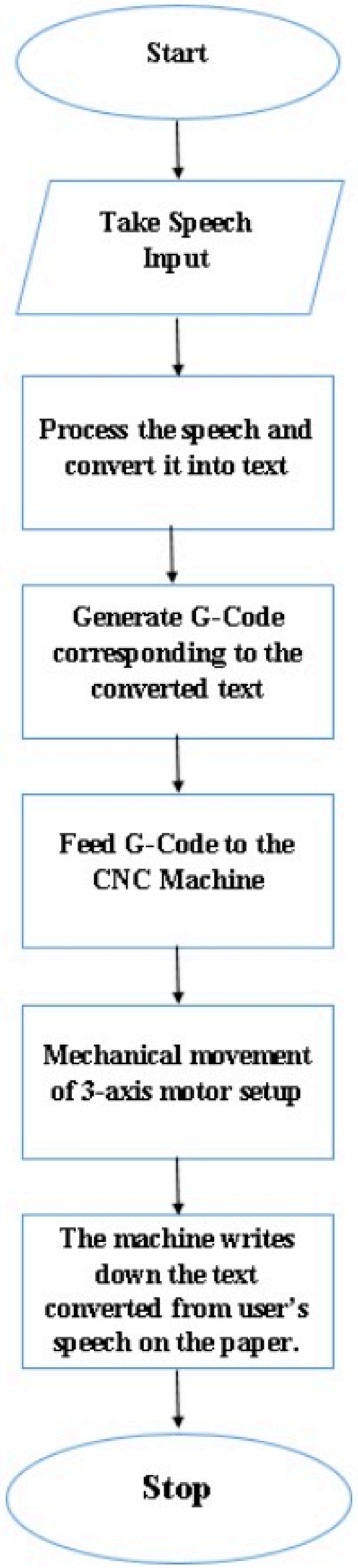
What is Speech to Text

- Converts spoken language into written text
- Used in virtual assistants, transcription services, voice commands
- Mathematical Foundations:
- Signal Processing
- Deep Learning & Optimization

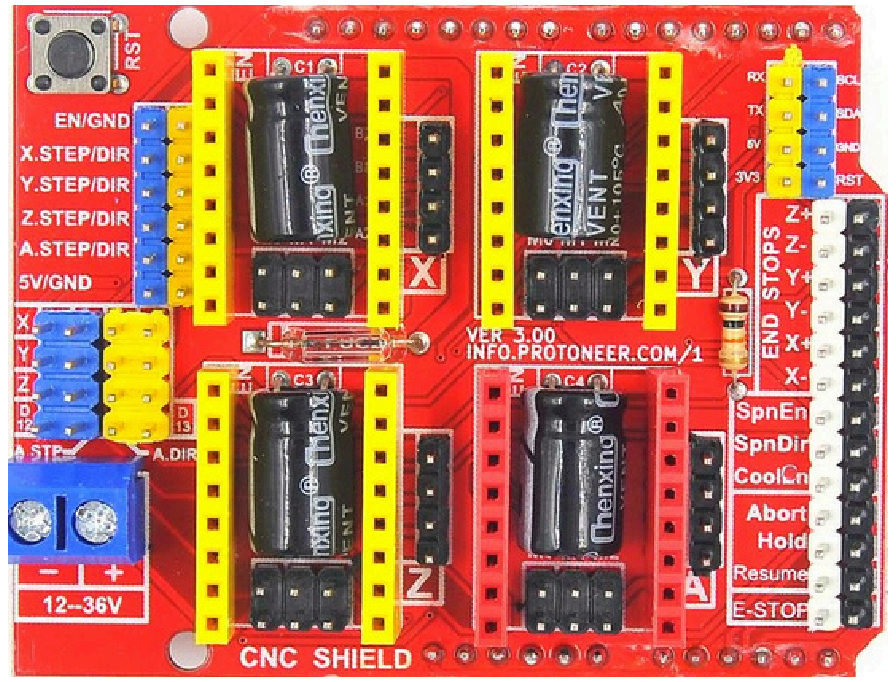
Signal Processing

Capture the voice signal
Preprocess the signal (Remove noise, normalize, filter)
Extract important features (MFCC, Spectrogram, etc.)
Pass features into an NLP model (Convert speech into text)

Flow Charts


Start
Take Speech Input
Process the speech and convert it into text
Generate G-Code corresponding to the converted text
Feed G-Code to the CNC Machine
Mechanical movement of 3-axis motor setup
The machine writes down the text converted from user's speech on the paper.
Stop

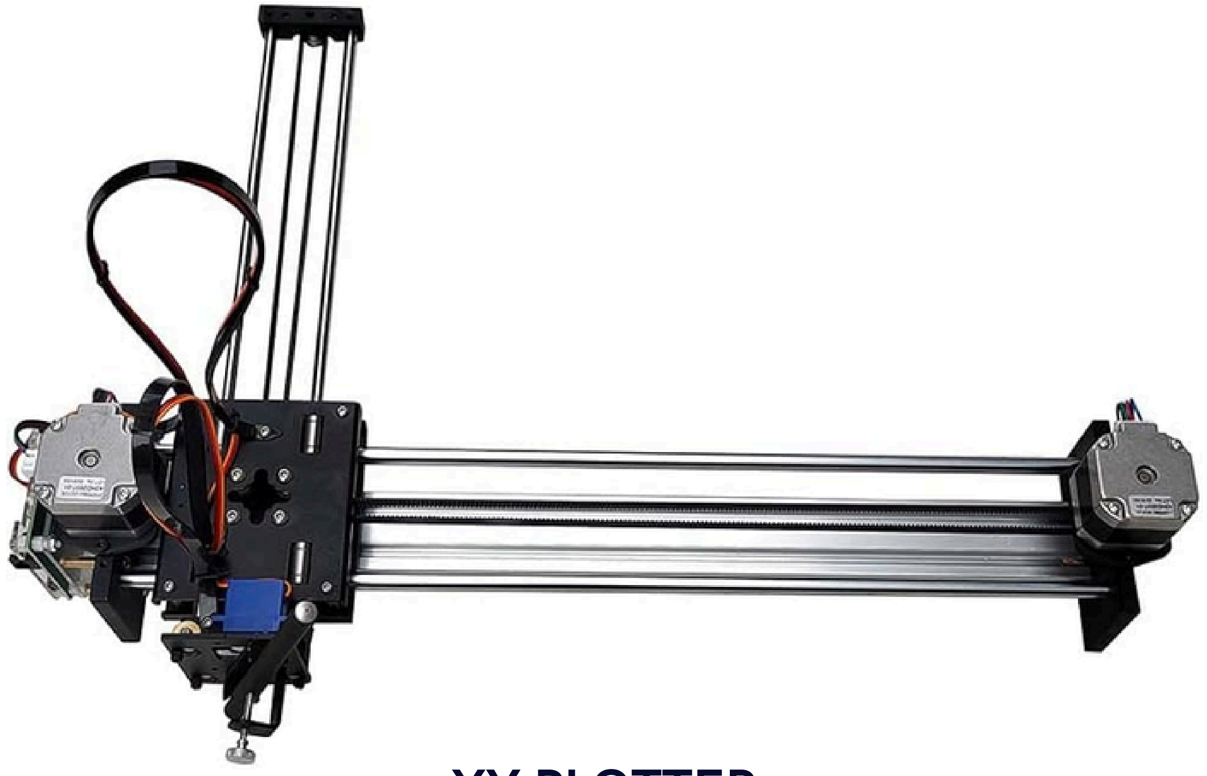
Hardware



CNC SHIELD

ARDUINO UNOD

STEPPER MOTORS



XY PLOTTER

SERVO MOTOR

Challenges & Risks

1. **Speech Recognition Interference**:

- Background noise affects the accuracy of speech-to-text conversion.
- Variability in accents, pronunciation, and speaking speed may lead to misinterpretations.

2. **Stroke-Based Handwriting Conversion Complexity:**

- Translating digital text into human-like handwriting strokes is challenging.
- Requires accurate vectorization and stroke order processing to ensure legibility.

3. **Mechanical Accuracy & Stability of the XY Plotter**:

- Ensuring smooth, precise motor movements is critical for legible handwriting.
- Stepper motors may introduce small positional errors, affecting stroke alignment.

Literature Review

- Desai (2021) developed a speech-enabled handwriting machine using CNC technology, where **speech-to-text conversion was integrated with G-code generation** for precise robotic writing control [1].
- Yuvaraj et al. developed a low-cost, **Arduino Uno-based robotic arm** designed to assist individuals with physical challenges by enabling control through speech recognition.
- Balaganesh et al. (2010) presented a robotic arm capable of writing based on speech recognition, marking an early advancement in speech-driven automated handwriting [3].
- Aditi et al. (2019) discussed an automated writing and drawing machine, emphasizing CNC-based execution for **improved accuracy in robotic handwriting** and artistic rendering [4].

References

[1]Yash Desai, "Speech Enabled Handwriting Machine using CNC," 2021 5th International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2021, pp. 1303-1307, doi: 10.1109/ICICCS51141.2021.9432107.

[2]"Design and Development of Voice Based Writing Machine for Alphabet" by J. Jenitta, Roshan M.N., and Sushmitha from AMC Engineering College, India:

[3J. Jenitta, Roshan M.N., and Sushmitha, "Design and Development of Voice Based Writing Machine for Alphabet," International Journal of Management, Technology And Engineering, vol. 9, no. 5, pp. 4268-4273, May 2019.

[4]M. Balaganesh, C. S. Aadhitya, E. Logashanmugam and R. Manikandan, ”Robotic arm showing writing skills by speech recognition,” INTERACT-2010, Chennai, 2010, pp. 12-15, doi: 10.1109/INTERACT.2010.5706158

[5]M. Aditi, S. Karpagam, B. Nandini, B. S. Murugan, 2019, Automated Writing and Drawing Machine, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) ETEDM.

Thank you!