ECE-GY 6483 Final Project Demo

Motion Detection with Gyroscope

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Objective Overview

- Use the data collected from an gyroscope (the one integrated on STM32F429I) to record a hand movement sequence as a password to "unlock" a resource.
- Save the recorded sequence on the microcontroller (STM32F429I), using a “Record Key” feature.
  User then must replicate the password within sufficient tolerances to unlock the resource.
- Read 60 sigmoid-processed samples for password and inputs from user.
- Movement Extraction & Data Preparation for DTW: save the full length data array into double vectors.
- Use Dynamic Time Warping (DTW) algorithm to calculate the similarity between the recorded password and the user entry.
- A successful unlock is indicated by a green LED blinking 3 times, if the answer is below 90% will be indicated by a red LED blinking 3 times.
- Implement a GUI view that display the stage for current operation: Recording or not recording.

General Design

- Press on-screen GUI button or on-board user button to start recording a password
- Subsequent presses would allow user to enter an input (password entry attempt)
- Blink green LED if correct, red if wrong
- Show “UNLOCKED” on screen if correct, “WRONG PASSWORD” if wrong
- Press RESET button to reset password

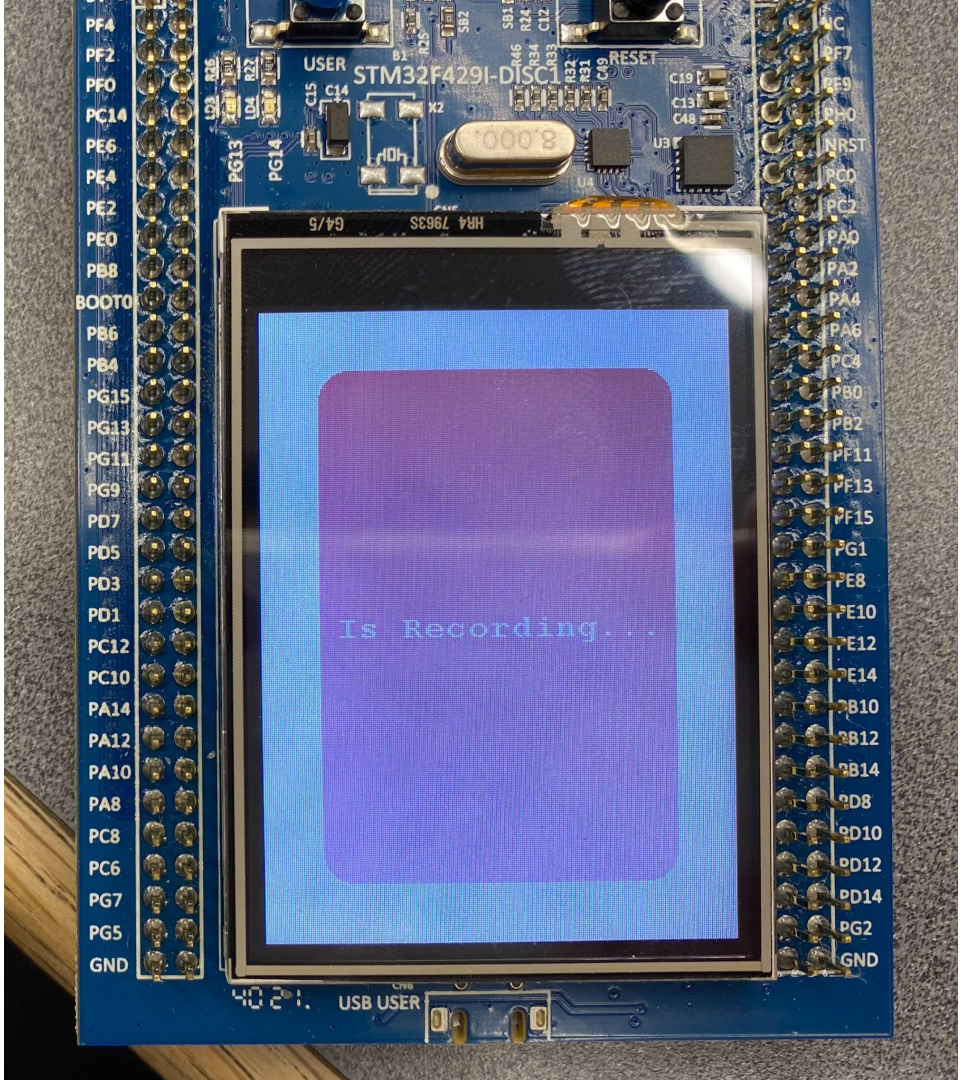
Record Key

To record a movement, the user should press the on-board blue user button OR press the "RECORD" GUI button on touch screen, both of which will start the recording process.

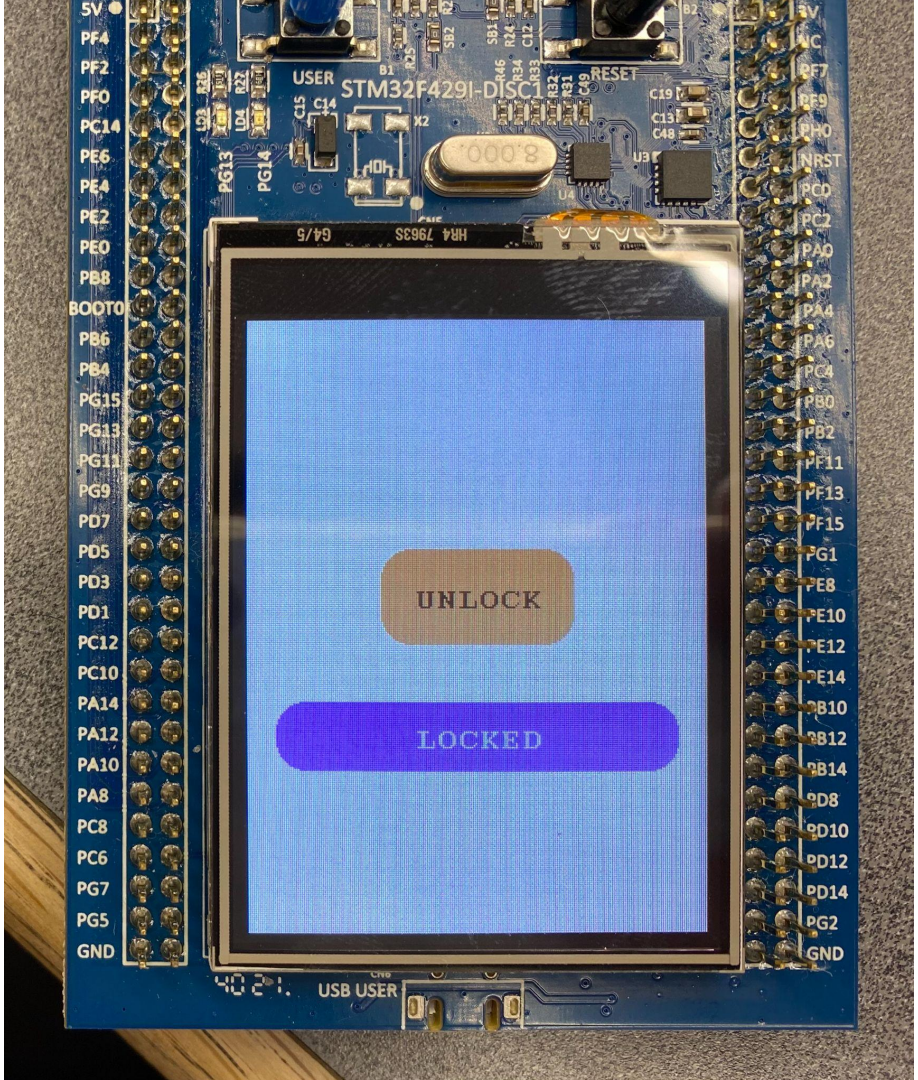
The system then records the hand movement sequence (angular speed readings) through the gyroscope and saves it to the microcontroller RAM in vector form.

GUI: Password Setup

GUI: Recording Data



GUI: Password Recorded, Waiting for User Entry



Unlock Resource

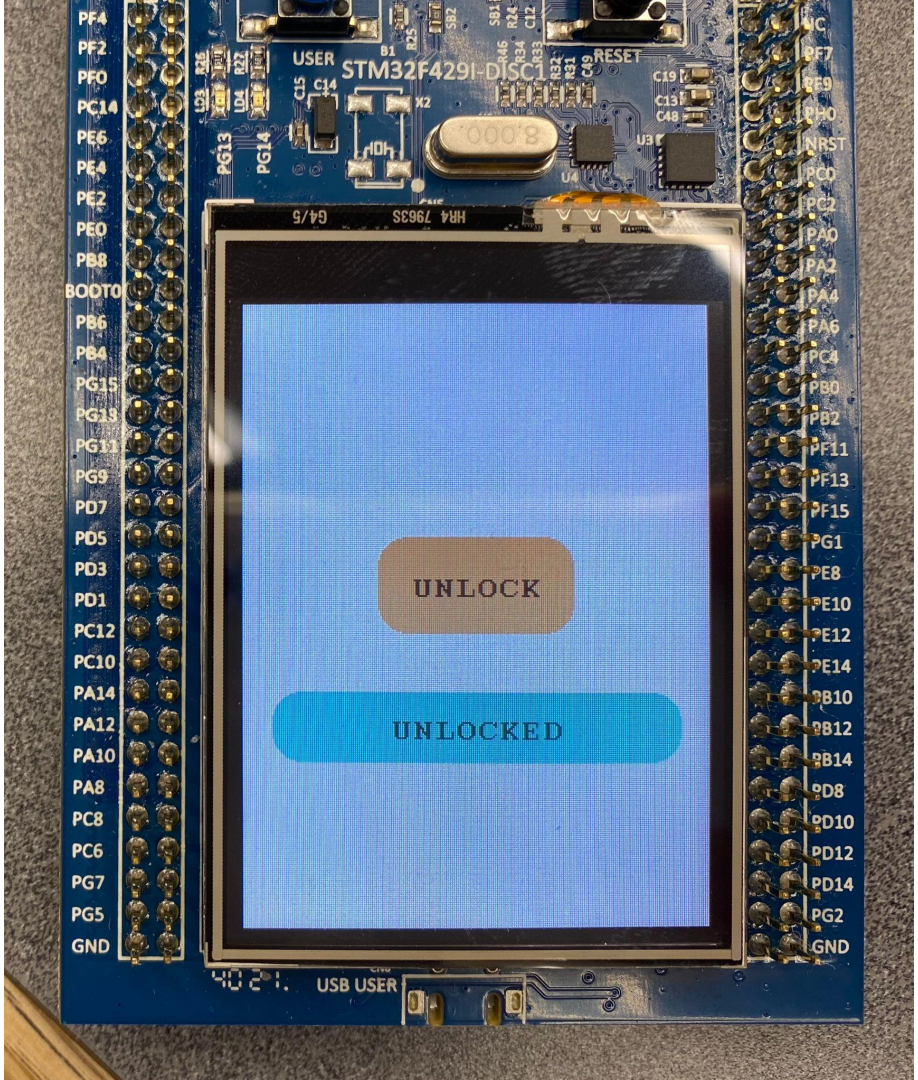
To unlock the resource, the user should press the "UNLOCK" button on touch screen or re-press the blue user button on board to start the unlocking process.

The system then records the user's movement into another set of vectors. Once the user input sequence is recorded, the system compares it with the recorded password sequence using DTW.

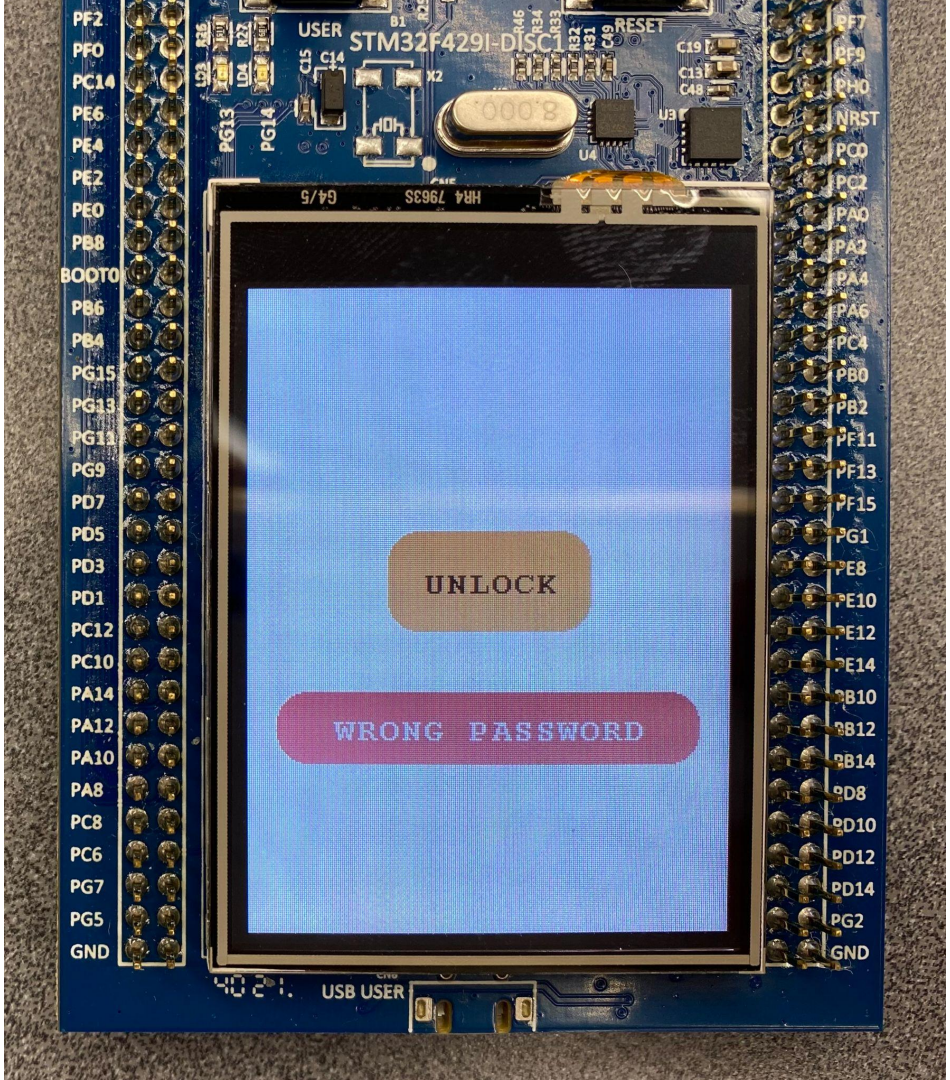
If the sequence matches within a certain tolerance, the GUI would alert that "UNLOCKED" on the screen and blink its green LED.

If resources unlock unsuccessful, the GUI would alert that "WRONG PASSWORD" on the screen and blink its red LED.

GUI: Password Correct - “UNLOCKED”



GUI: Wrong Password



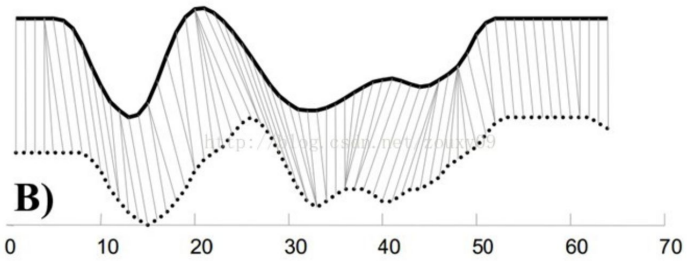
Data Processing

- Read real-time angular speed from gyroscope at fixed sampling rate (20Hz)
- Pass raw reading through Sigmoid function
- Use c++ vector to hold data samples (one vector for each axis x, y, z)
- Compare vectors of angular speed readings (password and user entry) through the Dynamic Time Warping algorithm

Data Processing: DTW (Dynamic Time Warping)

Function imported from a public Git repo: https://github.com/cjekel/DTW_cpp/tree/master

- Measures the similarity between two temporal signals.
- Returns the smallest-possible summation of Euclidean Distances between the two signals' sample points.
- Smaller distance -> more similar; larger distance -> less similar
- Commonly used for voice recognition.



Demonstration of Dynamic Time Warping with Euclidean distances between two signals

Design Demonstration (Demo Video on Youtube)

We have recorded a video demonstration of the unlock sequence, which shows that the recording process is repeatable and robust.

We have tested the device with movements of different angles, directions, speeds, and delays, and it has been able to recognize the correct unlock sequence consistently.

The video demonstration shows how the design works and how the user can perform the hand gestures to unlock the phone easily.

(YouTube link goes there)

https://youtu.be/4LeJFdSLmkI