HelpMeRecall

Project Proposal

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1. Introduction

1.1. Problem

Short-term memory loss is a problem in people, particularly as people age. Many individuals have difficulty remembering recent activities throughout the day and in some cases people may forget routine tasks like eating or taking medication. According to the Alzheimer's Association, 7.2 million Americans aged 65 and older suffer from Alzheimer's in 2025 and is expected to grow in coming years.

Although the younger population generally don't have Alzheimer's, students and professors can be forgetful. Under the pressures of academia and constant deadlines, it's easy to forget self-care. However, these issues can begin to be resolved with a person who can also care for others or more simply, a device that can log your activities as you go on with your day.

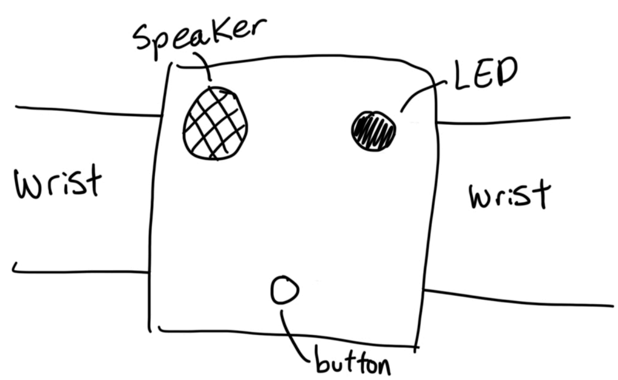
1.2. Solution

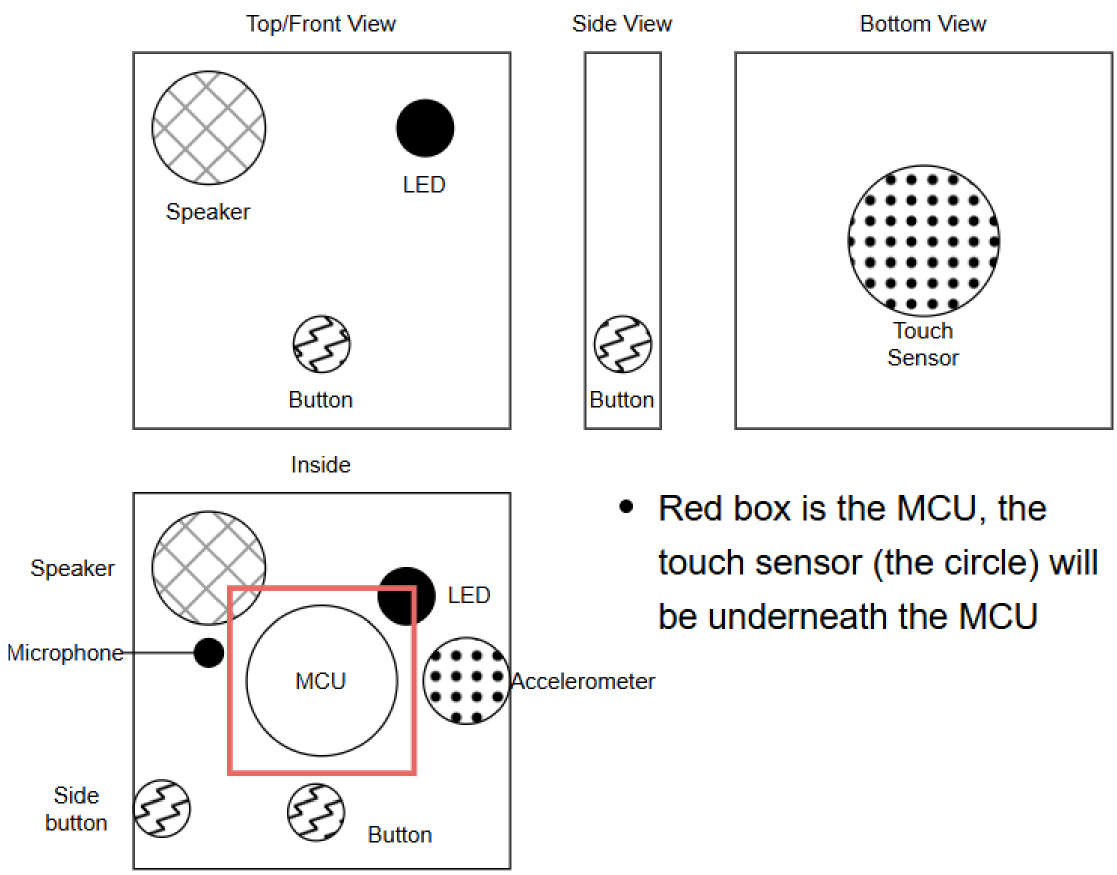
A standalone assistive device that supports activity logging and recollection using sensor-gated voice interaction. Users will be able to verbally log activities they have completed and later query if a specific activity has been performed. The device is always on and will be verifiable with an LED and voice input will be accepted only if a capacitive touch sensor detects the user.

The device will use an onboard microphone and on-device audio processing via the microcontroller to perform keyword detection. To increase detection of supported keywords, there will be various keywords for a specific activity. In the case of taking medicine, it might be medicine, medication, pill, drug, and prescription. To validate the logged action, the action is only logged if an accelerometer detects physical movement around the time of logging in order to reduce false logging. When a log is accepted, the device will provide haptic feedback via a vibrating motor. Logs will also be timestamped and stored in local memory. When the user queries through their activities, an integrated speaker on the device will note the activity as well as its timestamp. Logs will reset automatically at midnight but there will be a reset button to clear all logs and a separate button to delete the latest log in case of accidental logging.

1.3. Visual Aid

The device will not communicate with other external systems and everything will be enclosed in the box with peripherals as shown below. On the outside users will be a speaker, LED, 2 buttons, and a touch sensor. On the inside you will also be able to see the MCU, accelerometer, and a microphone. The inside of the box will use subsections to divide up the box as needed, such as a small subsection for the speaker to help it stay in place. The user wears the device on their wrist, and can see its speaker, a button, and the LED.



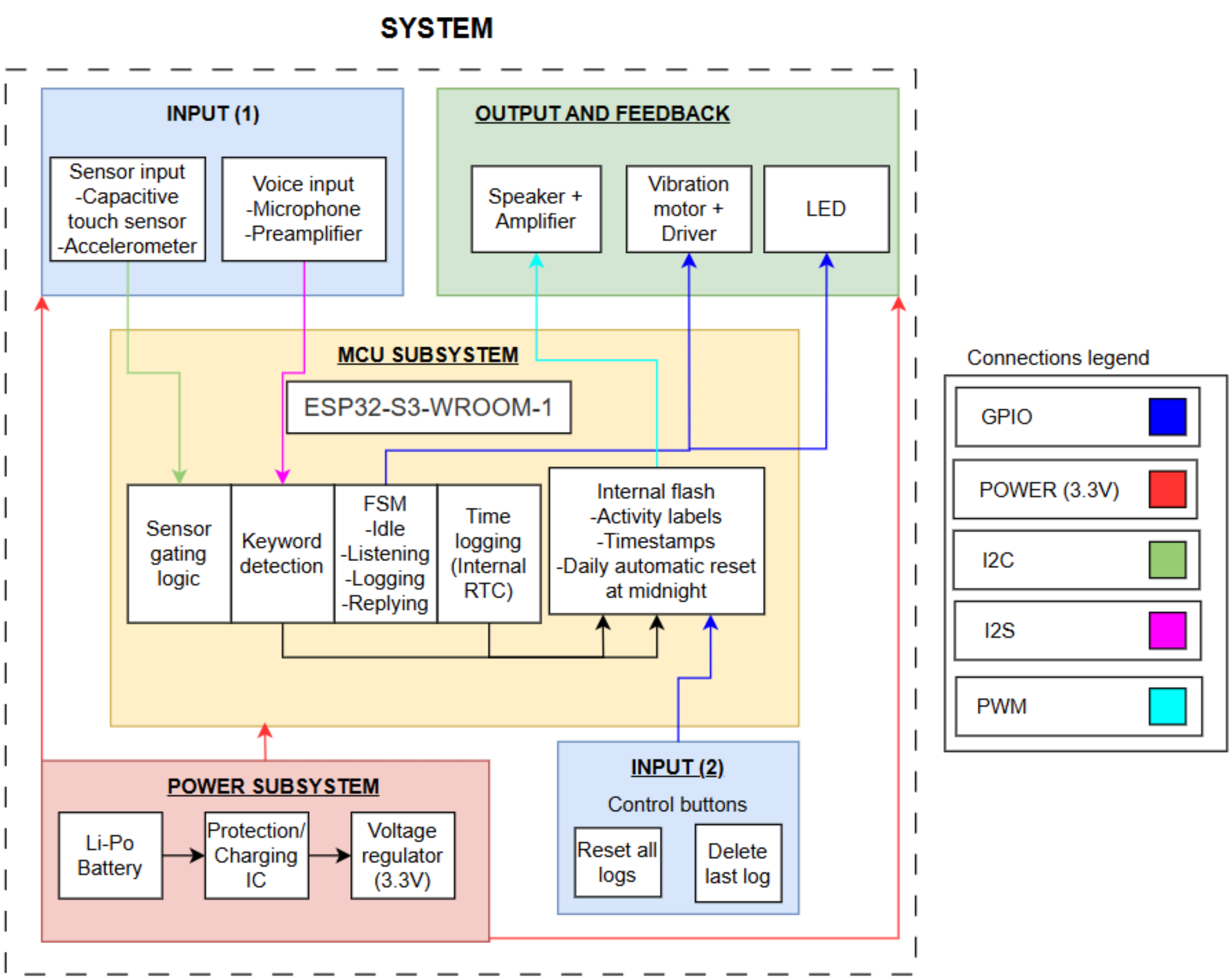


1.4. High-level requirements list

1. Correctly detects supported keywords with an accuracy of at least 80% in a quiet environment, measured as the ratio of correct detections to intentional logging attempts within the listening windows with a false log rate < 2 unintended logs per hour in normal conversation when the device is worn.
2. Upon successful logging, haptic feedback can be felt by the user within 2 seconds through a vibration of 2 seconds and properly updates the activity log.
3. When the user queries whether an activity was completed, the system shall retrieve the corresponding stored log and provide an audible response within 3 seconds, and the response must be clearly intelligible to the user when worn on the wrist in a quiet indoor environment.

2. Design

2.1. Block Diagram



2.2. Subsystem Overview

The HelpMeRecall system consists of four subsystems:

1. MCU subsystem (Microcontroller): Executes the finite state machine (FSM with states of idle, listening, logging, and replying.), performs keyword detection, manages timestamps using the internal RTC, and coordinates all input/output behavior. The MCU also is responsible for storing the activity voice logs. Allows automatic reset at midnight to support daily repetitive tasks.

2. Input Processing Unit: Captures audio input, validates user interaction using a capacitive touch sensor, and verifies physical motion using accelerometer data.

3. Output and Feedback: Provides user feedback via speaker (audio response output), vibration motor (haptic feedback for confirmation of logged activity), and LED (status indication for different FSM states).

4. Power subsystem: Supplies regulated voltage rails to all electronics and enables portable operation for a minimum of 10 hours.

System flow:

1. In the idle mode(also functions as the start state), the accelerometer and the touch sensor remain active.
2. When touch is detected by the sensor, the MCU enters listening mode.
3. In the listening mode, the microphone captures audio, which is then processed for keyword detection.
4. Simultaneously, accelerometer data is evaluated within a validation window to act as sensor gating.
5. Only if the keyword detection and motion validation are satisfied, the activity is timestamped, stored in memory, and haptic feedback is triggered.
6. Upon user query, logs are retrieved and the response is output through the speaker.

2.3 Subsystem Requirements

Subsystem 1: MCU subsystem (Microcontroller)

The MCU Subsystem contains the ESP32 microcontroller, internal RTC, flash memory, FSM logic, keyword detection algorithm, and sensor gating logic. It manages all system states (Idle, Listening, Logging, Replying), processes voice input, validates sensor data, stores activity logs, and generates output responses. This subsystem enables high-level requirements 1, 2, and 3.

Interfaces:

- Power of about 3.3V from power subsystem
- I2S input from microphone (sampling rate greater than or equal to 8 kHz)
- I2C input from accelerometer (3.3V)

- GPIO input from capacitive touch sensor and control buttons (3.3V)
- PWM output to vibration motor driver (output and feedback subsystem)
- PWM audio output to audio amplifier
- GPIO output to LED (3.3V)

Requirements:

- Transition between FSM states occurs within 200 ms.
- Keyword detection within 3 seconds of receiving the speech input from the user.
- Store at least 50 activity logs in non-volatile memory.
- Automatically reset logs at midnight (or maintain the 24-hour).
- Retrieve and respond to a user query within 3 seconds.

Subsystem 2: Input processing unit

Voice input processing: Captures the voice input from the user and performs keyword detection on a limited vocabulary, where each action can be mapped to multiple set keywords to improve detection.

Sensor gating and activity validation: Uses a capacitive touch sensor and an accelerometer to detect motion, which ensures that voice input is only received and accepted if the device is worn and recent movement is detected by the accelerometer instead of continuous voice recognition. A "cooldown" period is enforced where the microphone will be disabled for 10 seconds if there's motion but no logging during the listening period multiple times in a row to help conserve some battery.

This subsystem supports the high-level requirement 1.

Interfaces:

- Power of about 3.3V from the power subsystem
- Microphone I2S audio signal to MCU subsystem (sampling rate greater than or equal to 8 kHz)
- Accelerometer interface: I2C to MCU subsystem
- Touch sensor output (HIGH when activated) to MCU subsystem

Requirements:

- Activate listening mode only when the touch sensor signals high (activated).
- No voice input logging if no motion is detected within the validation window.
- Disable microphone after 10 seconds of invalid attempts.

Subsystem 3: Output and Feedback

Uses a speaker for audio feedback as a response to the user’s query. This subsystem also provides haptic feedback as an indication of an accepted user voice log. To indicate if the device is on, the LED is green. If the device is listening, the LED is yellow. If the device is low on power, the LED will be red. This subsystem contributes to the high-level requirements 2 and 3.

Interfaces:

- Power of about 3.3V from the power subsystem
- 3.3 V PWM input signal to vibration motor driver (3.3V) from the MCU subsystem
- PWM audio input from MCU to amplifier
- GPIO input (3.3 V) to RGB LED from the MCU subsystem

Requirements:

- Activate vibration within 2 seconds of log confirmation.
- Provide vibration duration of 2 to 3 seconds.
- Provide audible response to the user when in a quiet indoor environment.
- Respond within 3 seconds of the query.
- LED shall reflect the current FSM state without perceptible delay.

Subsystem 4: Power subsystem

The Power Subsystem consists of a 3.7V nominal Li-Po battery, a protection/charging IC, and a voltage regulator. This subsystem provides power to the MCU subsystem, the input processing subsystem, and the output/feedback subsystem. It ensures stable operation across idle, listening, logging, and replying states.

Interfaces:

- Power of about 3.3V from power subsystem to the other subsystems

Requirements:

- Output voltage of about 3.3V under full load.
- Support 10 hours of operation under regular use.
- Support peak current of at least 300 mA.

2.4. Tolerance Analysis

An aspect of our design that has a potential big feasibility issue is to be able to make the activity log trustworthy without being extremely power hungry. We hope to get the battery life to 10 hours of logging without recharging.

There will be 4 main states (idle listening, logging and replying) in our project that will draw power from our battery. In the idle state it’s the accelerometer, touch sensor, and LED that will be on and active. In the logging state it’s the speaker, amplifier, and LED. In the listening state it’ll be the microphone and

LED. In the replying state it'll be the speaker and LED. Below is a table of the components and their voltage and current.

Component	Voltage	Current
Processor	3.3 V	100 mA
Digital MEMS microphone	3.3 V/1.8 V	1.4 mA/2.2 mA
Capacitive touch sensor	1.8 V	17 µA
Accelerometer	3.3 V	3.6 mA
Speaker (1 W), 8 ohms)	NA	NA
Amplifier	5 V max	3 mA max
Coin vibration motor	3 V	1 A
RGB LED	3.3 V	20 mA

Using the table above, in the idle state we calculate about 0.0779 W consumed, for logging it's about 1.015 W, for listening it's at least 0.07062 W, and for the replying state it'll be about 1.066 W. If we assume an average of idle for 10 minutes, logging for 10 minutes, listening for 35 minutes, and replying for 5 minutes, we'll get 0.312 W on average per hour. Assuming a 90% efficiency and a 3.7 V battery with 500 mAh, we get 1.665 W of usable power which translates to ~5.3 hours for the device. This means that we may need to expand the casing size of the device to house larger but more powerful batteries and/or save battery through other ways.

3.0 Ethics, safety and societal impact

A major ethical concern for our device is that a facility such as a nursing home can try to use our HelpMeRecall device as a replacement for an actual nurse that would otherwise be tasked to be caregiving to patients with Alzheimer's or other major cognitive impairments instead of using it as a supplement. This will conflict with the avoid harm and public welfare priorities the IEEE has listed, as it might lead to needs not met

A second ethical concern would be privacy and consent risks enacted from the audio interactions. Since the device uses a microphone, it can end up capturing sensitive personal information or end up recording other bystanders. This would raise privacy concerns under ACM's privacy and confidentiality principles

A third safety concern would be that false reassurance can be a real harm mode. If our device incorrectly confirms an action such as thinking a patient took their medicine, it can end up; causing a double dose or missing out on medicine. IEEE makes an emphasis to be honest and realistic in claims, so the device must post an honest measurement in confidence percentage.

References:

"Alzheimer's Disease Facts and Figures." *Alzheimer's Association*, www.alz.org/alzheimers-dementia/facts-figures. Accessed 13 Feb. 2026.