

Strid Secure Design Document

By

Nick Schroeder

Harrison Wang

Janine Zhu

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TA: Aniket Chatterjee

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1. Introduction

1.1 Problem

One of the most common injury risks with older adults is falls. More than 14 million adults in the US over 65 years old report a fall every year, which leads to 3 million trips to the emergency room and 1 million hospitalizations, almost 319,000 are for a hip fracture (Centers for Disease Control and Prevention [CDC], 2026a; CDC, 2026b). Data from 2019 indicates a problem of a similar magnitude, with 290,130 hip fracture hospitalizations in the target population, of which 88% are caused by falls (Moreland et al., 2023).

Most patients receive a wheeled walker to aid with their recovery, although many receive limited instruction before leaving the hospital for independent home recovery. Thomas et al. (2010) determined that 92% of these patients received a wheeled frame upon discharge, and that 32% of patients who changed aids were either using an inappropriate one or using it correctly. While healthcare professionals are able to guide patients in the proper use of these walkers, this professional observation inherently isn't possible in independent home environments, hence why an alternative method is needed. Customer discovery interviews conducted by the Stride Secure medical and business team with physical and occupational therapists further identified walker abandonment, poor walker positioning, unsafe turning, excessive gait speed, and low-light ambulation as common contributors to falls during the early recovery period.

1.2 Solution

Current smart mobility devices generally address isolated aspects of mobility, such as gait initiation or weight distribution, and often require specialized equipment. Stride Secure instead augments an existing walker with real-time behavioral feedback that targets multiple modifiable fall-risk factors identified through both published literature and stakeholder interviews.

Our goal for this project is to design and implement a working prototype of Stride Secure as a lightweight, reusable clip-on device that transforms a standard walker into an intelligent rehabilitation support system. Using motion sensing and proximity sensing, the prototype provides configurable visual and auditory cues to encourage proper walker positioning, remind patients to use their walker, promote safer walking speed, and reinforce safe mobility behaviors during the first 2–6 weeks following discharge.

1.2 Visual Aid



Figure 1: Common walker 1



Figure 2: Common walker 2

Many commercially available walkers have a horizontal bar at the front of the walker, also known as a front crossbar or cross brace. We plan to attach the Stride Secure device to the crossbar with clamps, as highlighted with red boxes in both Figure 1 and Figure 2. The mechanical housing and clamps of the device are designed to accommodate various walker crossbars. From this housing unit, there will be sensors properly oriented towards the user to collect the appropriate metrics. The orientation of the device is crucial for sensor data collection, since the data is used for real-time feedback to the user. There will also be LED indicators and a volume knob that will allow the user to see alerts and adjust volume levels. These will be available on the top side of the mechanical housing. Essentially, this mechanical housing unit will rest at the indicated position to contain the entirety of our unit that will do the appropriate data collection and analysis, while allowing for an accessible user interface on the top.

1.3 High-Level Requirements List

To consider our project successful, our safety suite must fulfill the following:

- Due to its need to carry out full days of work, the system must be able to run on a single battery charge under clinically expected operation for a full day.
- The sensor array must be able to take in proper data to recognize prominent user error with 90% accuracy for our prototype, providing a strong baseline to build upon in future iterations of the project.
- The processing system must be able to take in all data from the sensing system and properly determine whether a hazardous state exists with 90% accuracy.

2. Design

2.1 Block Diagram:

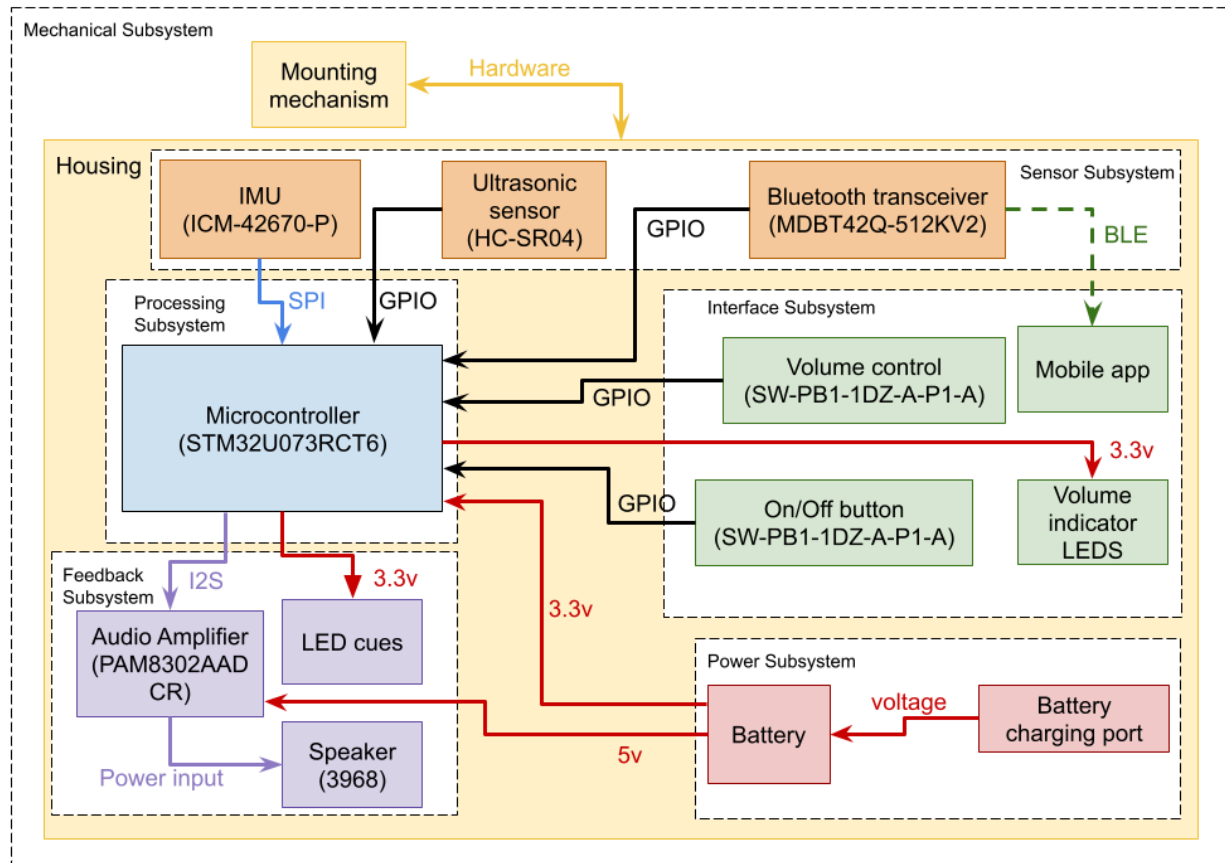


Figure 3: Stride Secure Block Diagram

All subsystems of Stride Secure are important for the high-level requirements outlined above in section 1.3. The mechanical subsystem houses all the sensors and the PCB for the device. It also mounts the device to various walkers. The processing subsystem uses the data collected from sensors and decision algorithms to output instructions to the feedback system. The processing subsystem also intakes user inputs to turn the system on/off or control the volume. The interface subsystem enables a smoother user experience with the use of accessibility friendly buttons. Users could struggle with mobility or fine motor control, so large, easy-to-press buttons make it easier for them to operate the device. The feedback system provides audio and/or visual cues and instructions to improve the use of the walker. The power subsystem powers all the on-board components to increase battery life, for a full day of usage.

2.2 Mechanical Subsystem

This subsystem is the mounting mechanism for the device as well as the housing for all electronic parts such as sensors, microphones, and the microcontroller. The mounting mechanism should be adjustable for a variety of walker models. The housing should be a COTS

product such as the 75065K51 enclosure. Additionally, to optimize sensor functionality and feedback system placement, holes can be drilled into the COTS housing for mounting components in the necessary orientations.

Requirements	Verification
The mechanical subsystem must securely attach to standard front-wheeled walkers without permanent modification, and the attachment must withstand routine walking, turning, sit-to-stand transition, and other daily activities and routine cleaning.	- Attach the Stride Secure device to a walker and walk a circuit that reflects a user's daily life for an hour. - Clean the casing using common cleaning solutions and products.
The mechanical subsystem must be lightweight and not interfere with normal walker operation or stability.	Compare walker usage without the device and with the device, keeping track of ease of use. Ensure that the user is not dragging the walker due to added weight at the front cross bar of the walker.
The mechanical subsystem must have a simple installation and removal procedure.	Show a picture of the proper orientation of the device to a person unfamiliar with stride secure and have them attach the device to the walker with instructions that would be given to a customer/user.

2.3 Sensor Subsystem

This system must be able to detect the walker's motion and orientation and the user's proximity to the walker. An IMU (MPU6050) would be used to detect falls or excessive leaning of the walker. Integrating the collected acceleration data from the IMU can be used to determine walker speed. This system will have an ultrasonic sensor (HC-SR04) to determine the user's location relative to the walker, allowing it to detect if the user drifts too far in or out of the walker. The determination of whether to or not to use lidar is in consideration pending further analysis by the team.

Requirements	Verification
The sensor subsystem must detect continuous walker motion, orientation, and user	Check that the sensor continuously sends data to the microcontroller to be evaluated.

proximity relative to the walker.	
The sensor subsystem must operate consistently with different walker models and user heights/physical profiles.	Test the sensor reliability and accuracy with users of different height/physical profiles. An example of height ranges is 4'9" to 6'.

2.4 Processing/Control Subsystem

This subsystem processes sensor data to make real-time cues for the user. The subsystem will have a microcontroller (STM32U073RCT6) to intake data collected by the sensors and provide real-time instructions to the feedback system. It can use its flash memory to store data as needed, and as the most power-efficient current model in STM's lineup, it will support the need for efficient power consumption. The cues and instructions will be issued to the feedback subsystem depending on predetermined/inputted mobility states to delineate what are safe and unsafe use patterns. The inputs from the interface subsystems, such as volume and brightness controls, will be processed to be reflected in the feedback subsystem as well.

Requirements	Verification
The processing subsystem must reliably distinguish between normal use and unsafe behaviors, such as excessive distance from walker and rapid gait changes.	- Using the sensor subsystem, collect data of a walker being used with unsafe behaviors and compare it to data of a walker being used with safe behavior. Using these two sets of data, identify the best thresholds and standard deviations that define the difference between safe and unsafe boundaries. - The thresholds and standard deviations will be tested on a different test set of data, and the accuracy should be a minimum of 90%.
The processing subsystem must generate feedback decisions with minimal delay to support real-time correction.	Check the delay between the microcontroller receiving data from the sensor subsystem and when it sends instructions to the feedback subsystem. The maximum the delay should be is one second.
The processing subsystem must support personalized thresholds/alerts based on patient needs.	Adjust the volume of alerts from mute to high with buttons in the interface subsystem, and check that the volume level is reflected in the LEDs.

2.5 Feedback Subsystem

This subsystem provides the user with reminders based on information and data processed from the sensor subsystem and instructions determined by the processing/control subsystem. The instructions and cues are sent audio cues through a speaker. Visual cues, such as reminders to use the walker at night, would be small flashing LEDs for users who are hard of hearing or deaf. The LEDs would also be different colors for different warnings, which colors such as Red, Yellow, and Blue for users who may be red-green colorblind. Brighter LEDs will be used to improve nighttime visibility.

Requirements	Verification
The feedback system must provide real-time and understandable audio cues for unsafe walker use.	Demonstrate an example of unsafe behavior while using the walker and check that the device provides accurate verbal feedback/instruction.
The feedback system must provide real-time and understandable visual cues for unsafe walker use.	Demonstrate an example of unsafe behavior while using the walker and check that the device provides accurate feedback/instruction through different LED indicators for different instructions.

2.6 Power Subsystem

This subsystem powers the device and all the electronic components. This subsystem will be designed for compatibility with the variable input voltage of a battery pack and to distribute power to the variety of devices running on the system. Given that the devices all run at voltages near or above our chosen battery chemistry's typical cell voltage, the system will run on switching converters to provide the needed voltage boost. Components will be selected such that the converters remain controllable, keeping connected components within chip ratings and sticking to a standard 30% ripple current criteria for conventional converters to remain controllable.

Requirements	Verification
The power subsystem must operate for at least one full day (~12 hours) of typical use without recharging.	Drive the system off a power supply, determining the battery capacity required to reliably carry that energy
The power subsystem must maintain safe	Operate the system for 1 hour with as many devices as expected in standard operation powered

operation without overheating during continuous use.	on, tracking the temperature of power conversion devices throughout.
The power subsystem must be safely enclosed to prevent user exposure to electrical components.	Power lines will be carried through insulated wire or insulated PCB traces, and the exposed leads inside the device will be inside the case, such that routine use will not expose users to possibly risky power lines.

2.7 User Interface Subsystem

This subsystem is for users to input volume and device status settings. Any user inputs for instruction volume or alert intensity can be adjusted with larger buttons for mobility accessibility. The subsystem must be intuitive for users of all ages and backgrounds to become familiarized with and use. If there is additional time, the subsystem will also initialize/define basic mobility states for safe and unsafe use patterns with a mobile app. All inputs from the interface subsystem will be implemented by the processing subsystem.

Requirements	Verification
The interface subsystem will provide a simple on/off mechanism suitable for older adult users.	The on/off system will be implemented with a simple momentary pushbutton, which is easy to understand.
The interface subsystem must allow users to mute or adjust volume when appropriate.	Check that one button increases the volume until a set maximum volume is reached and that the other button decreases volume until there is no volume at all/the device is muted.
The interface subsystem will be easy to operate by individuals with fine motor struggles.	We will use large buttons spaced apart such that they can easily be pushed without fine manipulation of the fingers. This will be validated by checking the system with people who have such fine motor challenges to ensure that they can manipulate it
The interface subsystem must include clear indicators for device status (active, low battery, muted).	We will validate this by checking that someone who does not know our system understands what the status lights and its associated labels means.

• The interface subsystem will be intuitive to use, without the requirement for more than 10 minutes of explanation.	• We will work with people who are not working on the project and thus do not know its details to validate that they can learn to use it and understand its feedback quickly
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2.8 Tolerance Analysis:

One of the primary technical risks is accurately detecting unsafe walker use. Stride Secure will use motion and proximity sensors to identify behaviors such as improper walker positioning, walker abandonment, excessive walking speed, and unsafe turning. However, natural differences in users' gait patterns, everyday movements, and walker designs may result in false positive or false negative detections. Excessive false alerts could cause users to unnecessarily alter their walking pattern and can cause users to disregard notifications. False positives could create a false sense of security that would be counterproductive for patients. To mitigate this risk, detection algorithms will be developed and refined through iterative testing with clinicians and end users. Clinical trials and developing a refined detection algorithm are outside the scope of our project. Our final product will be a proof-of-concept prototype that would allow for data collection and can give appropriate alerts, but will not be trained with real patient data to develop a refined algorithm.

Another technical challenge is determining the user's position relative to the walker. Differences in the user's physical profile, including their height, walking style, and recovery stage, make it difficult to establish universal thresholds for safe positioning. The project will therefore evaluate combinations of inertial measurement units (IMUs), proximity sensors, and rule-based algorithms to improve detection reliability across a range of users while minimizing unnecessary alerts. The prototype should be tested amongst users of different heights and will not falsely flag regular walking movements simply due to height differences.

Battery life is an additional design consideration. Continuous sensor monitoring, audio feedback, and nighttime illumination can increase power consumption and therefore limit operating time. The decision will prioritize low-power components, efficient software, and a rechargeable battery capable of supporting a full day of use. The design will also incorporate battery indicators and notifications to reduce the risk of device failure. The battery life can be tested by being left to continuously monitor sensors throughout the length of a full day.

The device must also remain securely attached to the walker during normal use. Repeated loading, vibration, accidental impacts, and cleaning could loosen or damage the mounting mechanism over time. Mechanical testing will evaluate the durability of the attachment system over repeated installation and removal cycles, while ensuring that the device remains secure and does not interfere with normal walker operation.

Of the mentioned interfaces, we expect the computing analysis of operating conditions to be the most difficult, though this isn't inherently computable. We expect it to work because the key criterion, user distance and weight placed on the walker, are relatively simple to work out in theory, but carrying that over to implementation is the one thing our group has less expertise in.

The circuit design has been relatively straightforward, as our component sizing was carefully assessed to provide buffer and make sure our developed systems work as intended.

3. Cost and Schedule

3.1 Cost Analysis

Part #	Description	Manufacturer	Quantity	Extended price	Link
STM32U073RCT6	Processor	STMicroelectronics	1	\$3.97	Link
HC-SR04	Proximity Sensor	SparkFun Electronics	1	\$5.25	Link
ICM-40609-D	Inertial Measurement Unit (IMU)	TDK InvenSense	1	\$5.87	Link
MDBT42Q-512KV2	Bluetooth Transmitter	Raytac	1	\$4.95	Link
PAM8302AADCR	Audio Amplifier	Diodes Incorporated	1	\$0.67	Link
3968	Speaker	Adafruit Industries	1	\$4.95	Link
MH2029-601Y	Ferrite Bead	Bourns Inc.	1	\$0.10	Link
RMCF0805FT10K0	10kohm Resistors	Stackpole Electronics Inc.	7	\$0.70	Link
RNCP0805FTD5K11	5.11kohm Resistors	Stackpole Electronics Inc.	2	\$0.20	Link
RC0805FR-07330RL	330 ohm Resistors	YAGEO	4	\$0.40	Link
ERA-6AEB203V	20kohm Resistor	Panasonic Industry	1	\$0.10	Link
PTN0805E9002BST1	90kohm Resistor	Vishay Dale Thin Film	1	\$0.10	Link
MBKK2012T4R7M	4.7uH Inductor	Murata	1	\$0.28	Link
MLZ2012N220LT000	Inductor	TDK	1	\$0.15	Link
C0805F104K1RACAU TO	0.1uF Capacitor	KEMET	8	\$2.56	Link
GMC21X6S106K6R3 NT	10uF Capacitor	Cal-Chip Electronics	3	\$0.84	Link

GMC21X5R224K35NT	0.22uF Capacitor	Cal-Chip Electronics	1	\$0.26	Link
GMC21X7R225J25NT	2.2uF Capacitor	Cal-Chip Electronics	3	\$3.48	Link
TMCP1D105KTRF	1uF Capacitor	Vishay Sprague	1	\$0.34	Link
TL8W9226M010C	22uF Capacitor	Vishay Sprague	1	\$1.20	Link
SW-PB1-1DZ-A-P1-A	Buttons	Adam Tech	3	\$1.35	Link
Engineering Labor	Equivalent cost @ \$35/hr	UIUC ECE Department	200 hrs	\$7000	

The estimated total cost of the stride secure device is approximately \$7,037.72 at this time.

3.2 Schedule

Date	Task	Team Members
9/10	Project Approval	All
9/15	First Team Meeting	All
9/21	Discussion with Machine Shop	All
9/30	1st PCB Order	Nicki, Harrison
10/5-10/7	Design Review, Order parts	All
10/8	Revise and Order New PCB Design w/ Feedback	Nicki, Harrison
10/23	Have a working prototype of data collection from sensors on breadboard	All
10/30	Begin Soldering	All
11/6	Attach and calibrate unit to walker	Nicki, Harrison
11/6	Prototype app/digital UI	Janine
11/20	Have a working prototype to begin algorithm training	All

4. Ethics

Stride Secure is designed to supplement clinical rehabilitation rather than replace physical therapy or professional clinical judgment. Ethical considerations will be incorporated throughout the design process by clearly communicating the device's capabilities and limitations. Users will be informed that Stride Secure provides behavioral guidance and safety alerts, but cannot fully eliminate the risk of falling or replace professional medical care. User privacy will also be considered when implementing alerts. Configurable alert settings will allow users and clinicians to adjust notification volume based on individual needs and to avoid overly intrusive alerts in public settings.

The project will also consider accessibility and equitable use. Stride Secure is designed to attach to walkers that patients already receive during rehabilitation, allowing users to simply purchase an optional add-on rather than requiring them to purchase a specialized smart walker. This approach reduces additional equipment requirements and costs, allowing the technology to be used with a wider range of patients with any walker, rather than limiting it to only those who can afford a specialized smart walker. Design decisions will account for differences in user height, gait patterns, mobility limitations, and recovery stages to maximize the breadth of Stride Secure's potential application.

Much like the IEEE Code of Ethics' standards of integrity, responsible behavior, and professional conduct (*IEEE code of Ethics*), safety is a primary consideration since the device is intended for use on a mobility aid. The device can have an impact on the welfare of the public. To ensure the impact on the welfare is positive, the attachment mechanism must remain secure during normal walking, turning, impacts, and repeated use without interfering with the walker's stability or operation. The enclosure will use lightweight construction and rounded edges to reduce the risk of injury. The product enclosure will ensure electrical safety through the appropriate isolation and protection of electrical components. Battery indicators will help prevent unexpected loss of functionality. Thorough testing will be conducted to evaluate the mechanical and electrical safety, sensor reliability, and alert behavior and adjustability before user testing.

Stride Secure will also be developed with applicable engineering and medical device standards in mind. Relevant FDA requirements for medical devices, including quality system, labeling, registration, and device-listing requirements, will be considered during development. Applicable electrical, battery, electromagnetic compatibility, and mechanical safety standards will be reviewed as the hardware and enclosure are finalized. Engineering decisions will prioritize user safety, reliability, accessibility, and responsible communication of the device's capabilities and limitations.

5. References

Centers for Disease Control and Prevention. (2026a). Older adult falls data.
<https://www.cdc.gov/falls/data-research/index.html>

Centers for Disease Control and Prevention. (2026b). Facts about falls.
<https://www.cdc.gov/falls/data-research/facts-stats/index.html>

IEEE code of ethics | *IEEE*. IEEE. (n.d.). <https://www.ieee.org/about/corporate/governance/p7-8>

Moreland, B. L., Legha, J. K., Thomas, K. E., & Burns, E. R. (2023). Hip fracture-related emergency department visits, hospitalizations and deaths by mechanism of injury among adults aged 65 and older, United States 2019. *Journal of Aging and Health*, 35(5–6), 345–355. <https://stacks.cdc.gov/view/cdc/126881>