



STATERA: An Adaptive System for Fall Prevention using Galvanic Vestibular Stimulation

Authors: Ishan Kasam (CEO), Tanay Mangal (CIO), Arnav Prabhudesai (CMO), Nichelle Thinagar (CTO), Chris Xu (CTO).
Advisor: Dr. Crowthers



Introduction

- Falls are the **leading cause of injury** for adults aged 65+, with over **14 million older adults**, about **1 in 4**, reporting a fall each year. (CDC, 2026)
- Falling once **doubles the chance of falling again**, making early balance intervention especially important. (CDC, 2026)
- Vestibular dysfunction affects about **35.4% of U.S. adults aged 40+**, or roughly **69 million Americans**. (Agrawal et al., 2009)
- Vestibular dysfunction increases fall risk by disrupting posture, gaze stability, and spatial orientation. (Agrawal et al., 2009)

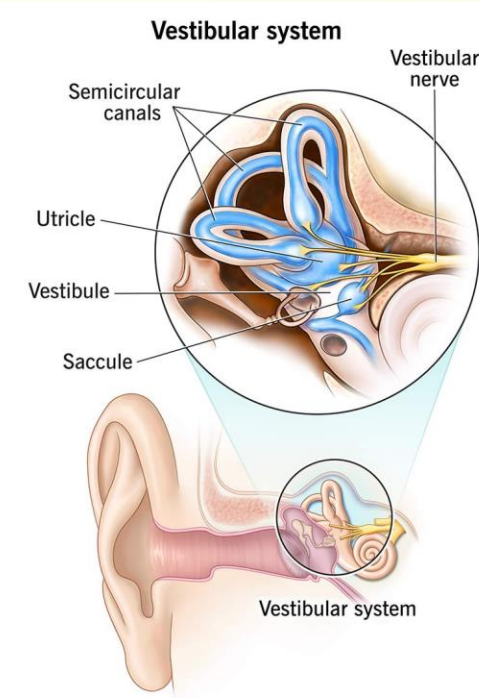


Figure 1: Vestibular system anatomy showing the semicircular canals, utricle, saccule, and vestibular nerve within the inner ear.

Problem Statement

There is no low-cost wearable device that can detect early balance loss and provide real-time vestibular feedback to help prevent falls before they occur.

Engineering Goal

Create a wearable device that uses IMU motion sensing and galvanic vestibular stimulation to detect instability and assist balance correction in real time.

Competitor Analysis

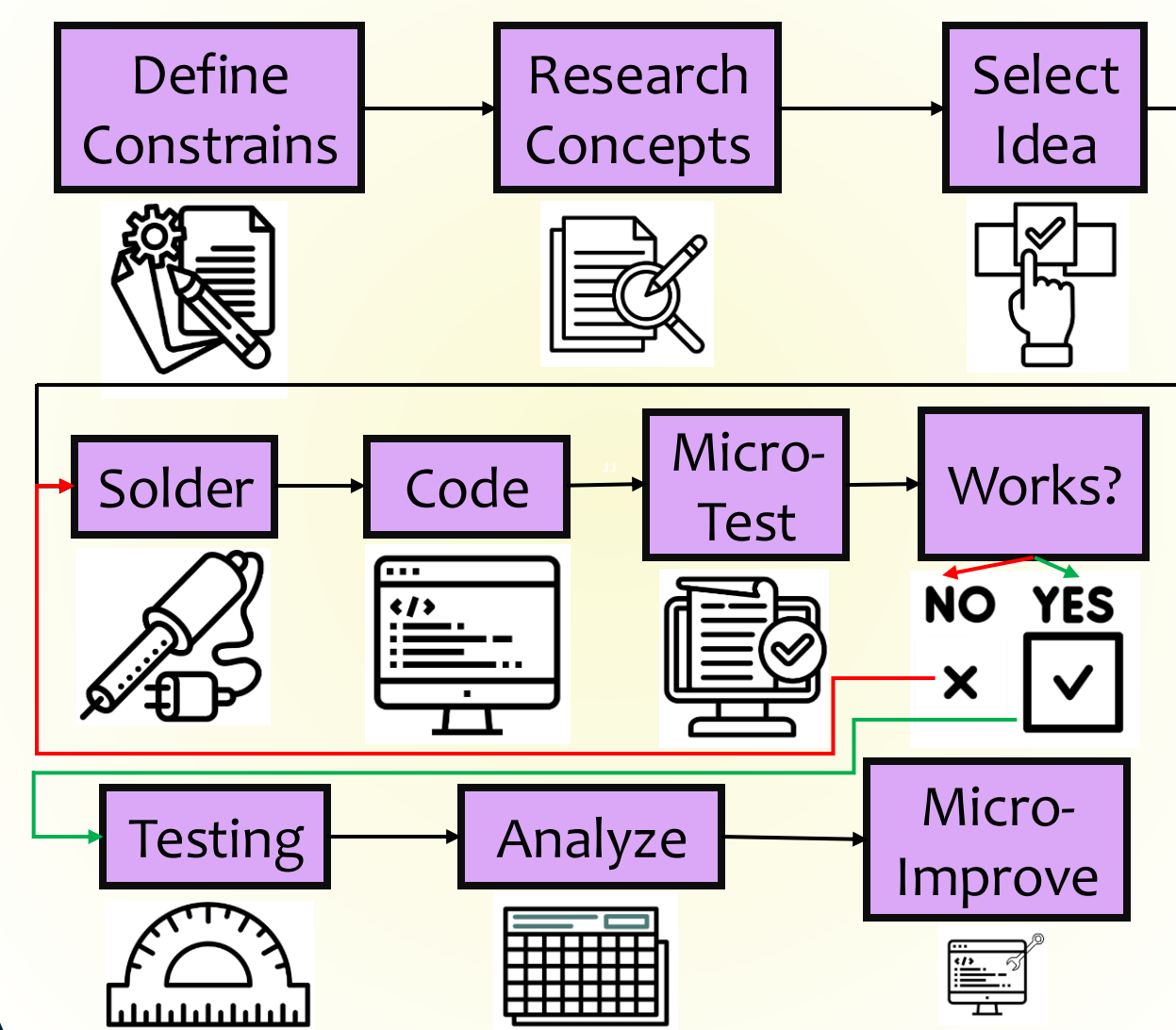
Device	How it Works	Strengths	Limitations
Cane	One-point ground support	<ul style="list-style-type: none"> Cheap Portable 	<ul style="list-style-type: none"> Requires arm Worsens natural balance
Walker	Multi-point body support	<ul style="list-style-type: none"> Very stable Popular 	<ul style="list-style-type: none"> Bulky Slow Limits mobility
Watches and Phones	Detect fall-like motion with IMUs with Alerts	<ul style="list-style-type: none"> Wearable Portable Alerts 	<ul style="list-style-type: none"> Alerts Afterwards No prevention

Decision Matrix

Criteria / Requirements	Level	Idea 1	Idea 2	Idea 3
Wearability and Comfort (40)	L1	37	35.5	35.5
Fall Prevention Effectiveness (30)	L1	27	30	30
User Safety (15)	L1	12	15	15
Non-Invasive Design (15)	L2	15	13.5	15
Mobility Preservation (15)	L2	15	15	15
Cost Accessibility (15)	L2	15	13.5	13.5
Usability and Appearance (15)	L3	15	15	15
Ajustable Assistance(10)	L3	10	10	10
Total (155):		146	147.5	149
Topsis (1):		0.808	0.89	0.894

Methodology

Engineering Flowchart



Ideas

- Idea 1**
Auto balancing fluid ballasts that use IMUs to detect falling orientation and correct.
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- Idea 2**
AFO which corrects to prevent falls after detecting one using IMUs.
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- Idea 3**
Using a measurement system to detect falls which then used Galvanic Vestibular Stimulation to prevent falls.
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Evolutions Of Design

Design 1: Flex Sensor Detection

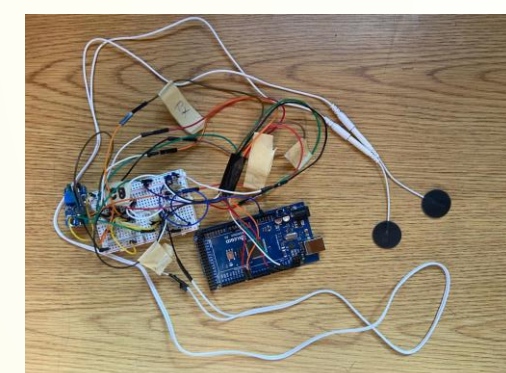
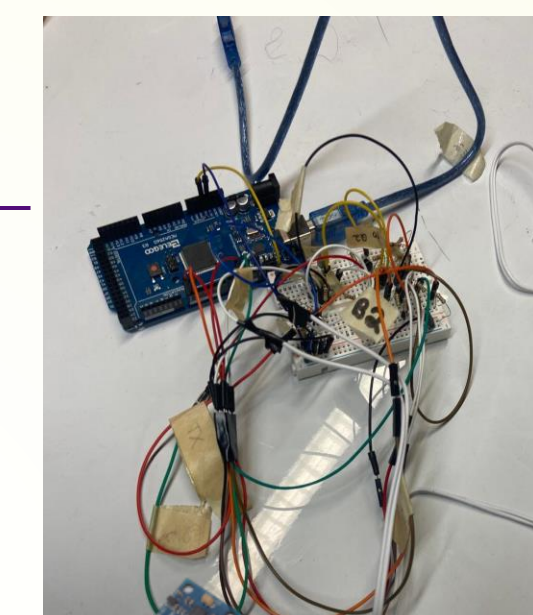


- | | |
|--|---|
| Pros: | Cons: |
| <ul style="list-style-type: none"> Easy to use Noninvasive | <ul style="list-style-type: none"> Very poor fall detection capabilities Wire management difficulty |

Design 2: 1 IMU Detection

- Pros:**
- Simple
 - Effective fall detection
 - Easy mounting

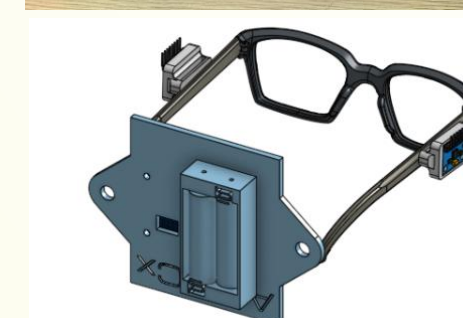
- Cons:**
- Many false positives
 - Hard to detect falls early



Design 3: 3 IMU Detection

- Pros:**
- Robust fall detection
 - Few false positives
 - Low latency

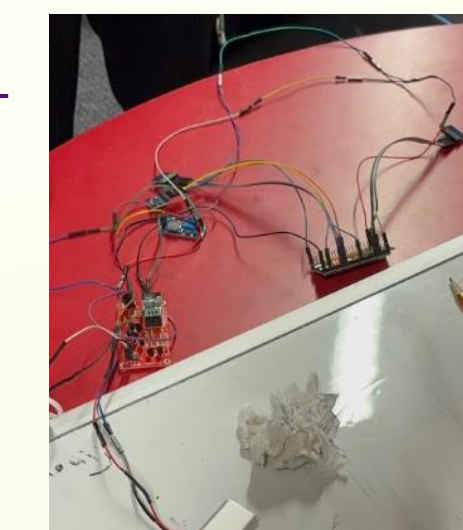
- Cons:**
- Bulky mounting
 - Not "stylish"



Design 4: PCB

- Pros:**
- Strong fall detection capabilities as before
 - Sleek design and stable mounting

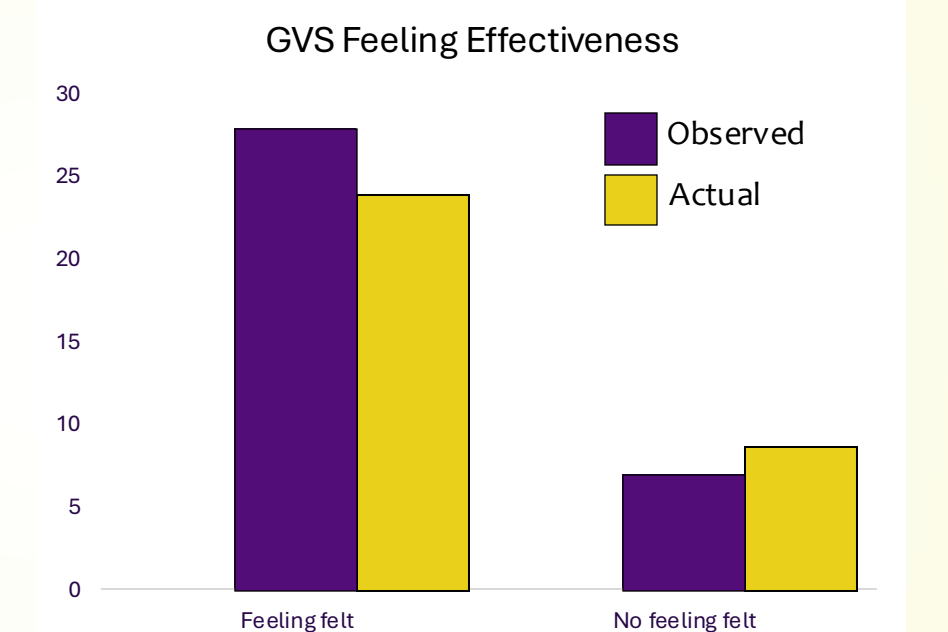
- Cons:**
- Complex development and integration



Design Study II

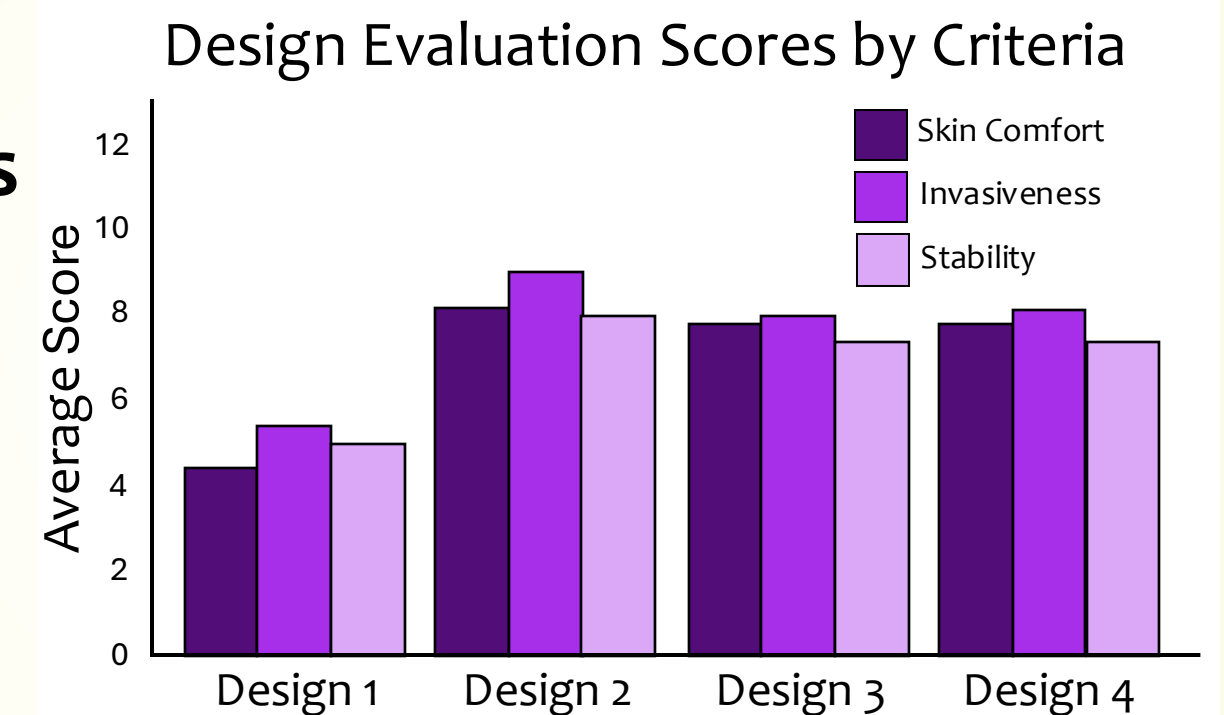
GVS Functionality Accuracy

Purpose: To see if the GVS system can preventing falls while not causing unintentional falls.



Comfort Across Designs

Purpose: To track the comfort through the progression of the design.



CONCLUDING STEPS

Conclusion

- IMU-detected falls varied widely in nature, highlighting that robust pre-fall detection will require extensive training data
- The glasses-mounted form factor proved comfortable and viable for real-world, everyday use
- Fixed-current GVS can modulate balance to varying degrees by adjusting charge duration alone
- GVS shows strong potential as a viable, non-invasive approach to fall prevention, warranting further development and clinical exploration

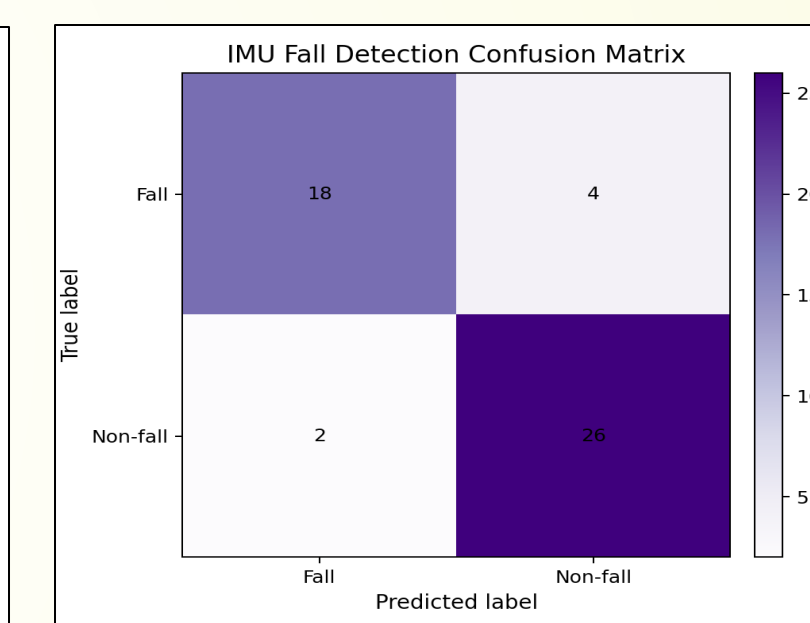
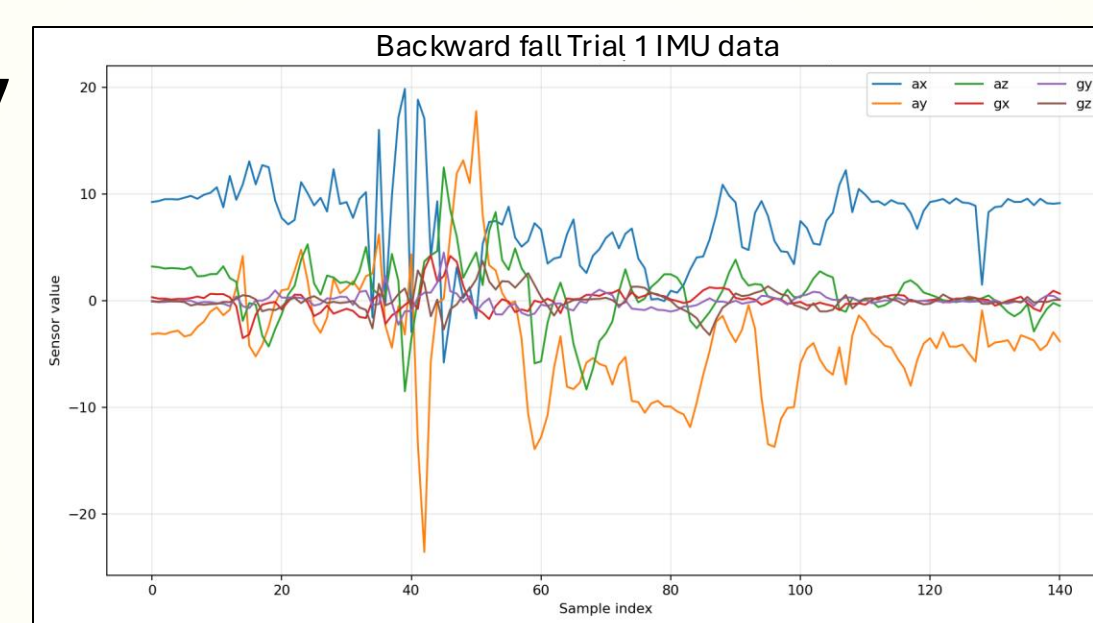
Future Work

- Further improve fall detection algorithm to better classify different types of movements.
- Improve upon the adaptability of the system in terms of the current applied.
- Improve upon the physical design for comfort and wearability based on extensive feedback from the target audience.

Design Study I

IMU Fall Detection Accuracy

Purpose: To see if the IMU can classify whether certain actions are falls or just walking noise.



KEY REFERENCES

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