SITIWEAR

Fall, Gait, and Sedentary Monitor

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INTRODUCTION

Approached by Dr. Todd Shatynski

- **Specialty.** Sports Medicine
- **Interest.** Nonsurgical treatment of injuries

Poor Patient Monitoring

- **Patient Self Reporting.** Unreliable and vague
- **Need.** **Wearable device + monitors patient physical activity**

INDUSTRY GAP

Existing Solutions

Wearable Fitness Trackers. Apple Watch, Oura Ring, and Fitbit

Need for Novelty

Software as a Medical Device (SAMD) ~ Clinically Validated.

- Supports healthcare decisions
- Monitors and **analyzes** physical activity

CLINICAL REQUIREMENTS

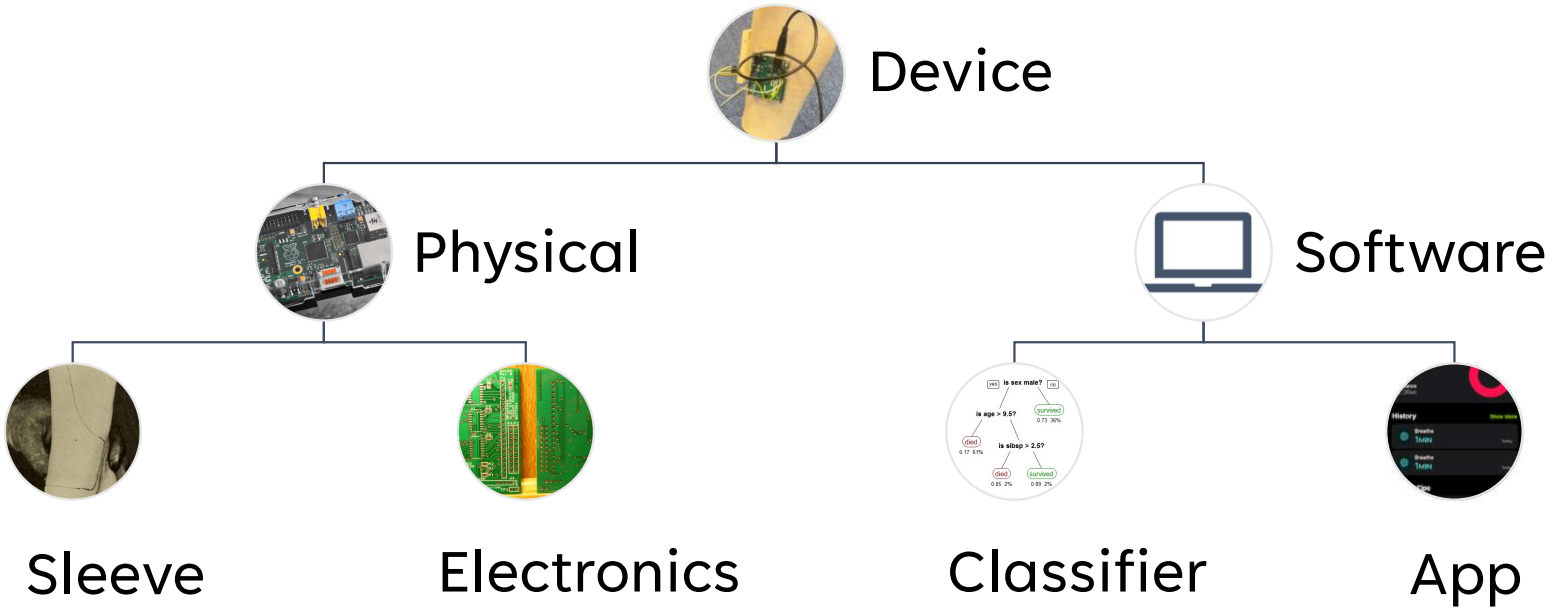
ACTIVITY TRACKING — Continuously monitor levels of physical activity to identify sedentary behavior

WEARABILITY — Safe, wireless, rechargeable, comfortable, lightweight, etc.

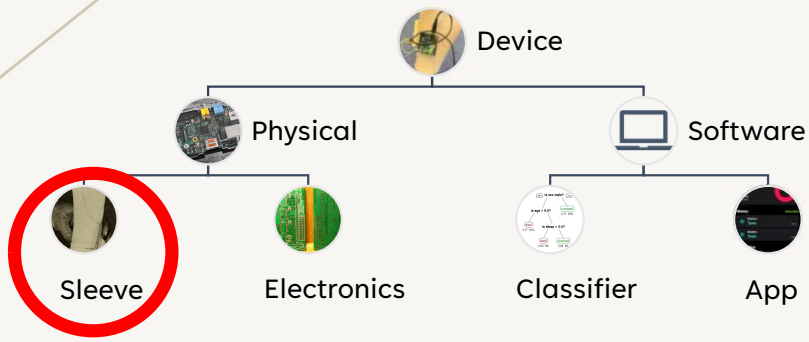
GAIT MONITORING — Capture gait metrics such as stride length, cadence, and stability

FALL RISK ASSESSMENT — Analyze motion patterns to detect signs of increased fall risk

DESIGN OVERVIEW



DESIGN – ANKLE SLEEVE



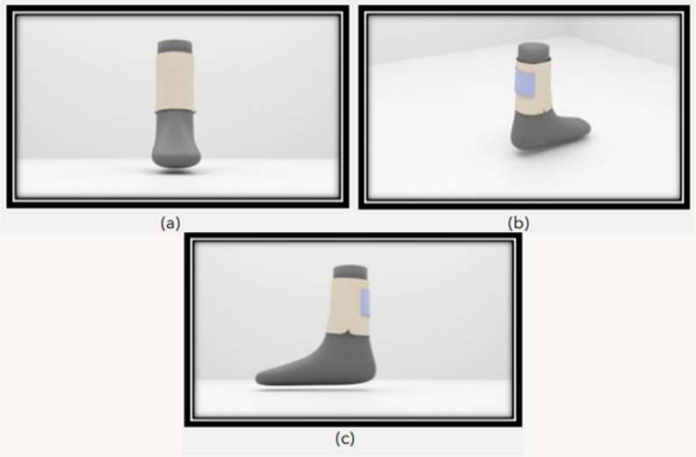


Fig. 1 CAD Multi-View of Device

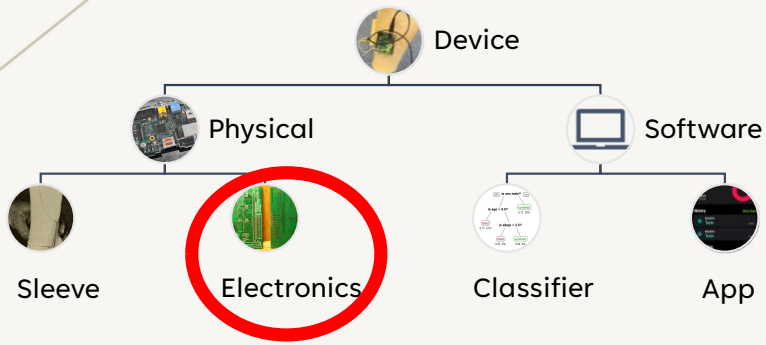
Location. Ankle

- Produces accurate IMU data
- Discrete

Material. Polyester-Spandex

- Hypoallergic & Elastic
- Easily manufactured

DESIGN – ELECTRONICS



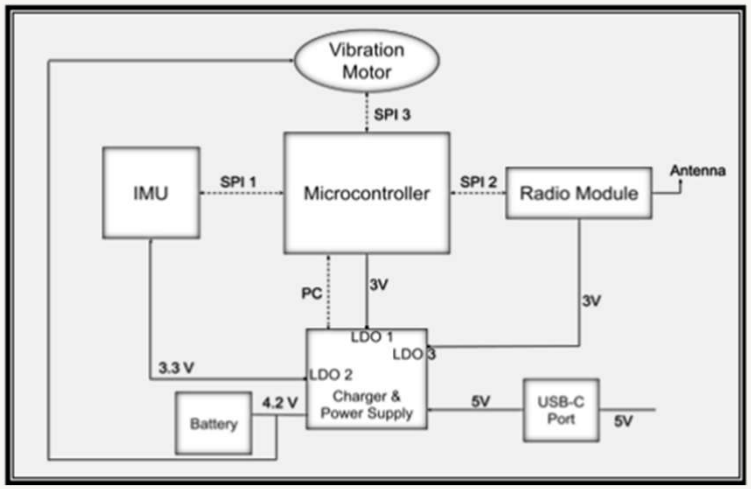


Fig. 2 Function Block Diagram

Key Board Components

IMU Sensor. MPU-9250

Microcontroller. STM32L476

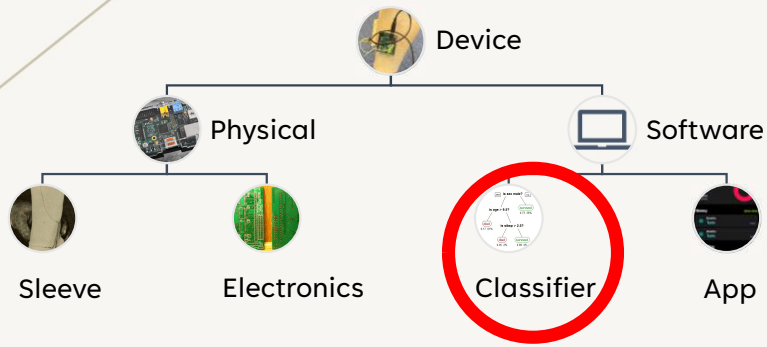
Battery. Li-Po24 mA

Charger & Power Supply. ADP5350

Radio Module. DWM1000

Vibration Motor. NFP-C1030

DESIGN – CLASSIFIER



Dataset. IMU Data

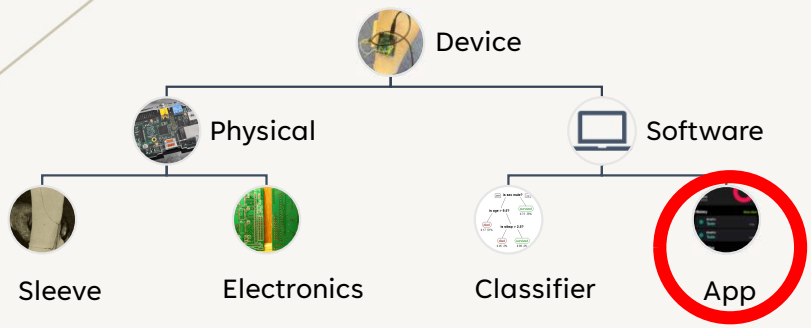
- 6 Inputs (ACC & GYRO 3 Axes)
- Labeled Activity Entries

Classifier Type. XGBoost

Timestamp	Ax	Ay	Az	Gx	Gy	Gz
18:12:13	-244	-16732	-3360	-3088	2326	-763
18:12:13	-380	-16248	-1900	-3072	2087	-1892
			...			

Table 1 IMU Output Data

DESIGN – APP



Key Features

Motion Classification Tracking

Fall Risk & Physical Lifestyle Assessment

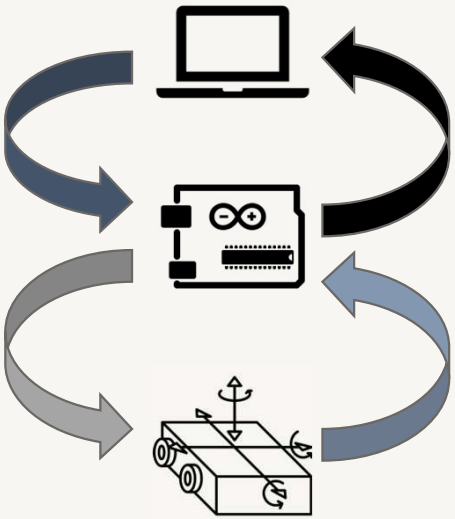
User & Physician Friendly UI/UX

Fig. 3 Homepage Design

PROTOTYPING OVERVIEW

1. Laptop. Power Supply & Runs Python Script

2. Arduino Uno. Initializes IMU



4. Arduino-Laptop. Transfers Data to Laptop as Text File + Laptop Processes the Data

3. IMU. Transfers Data to Arduino

PROTOTYPE FABRICATION

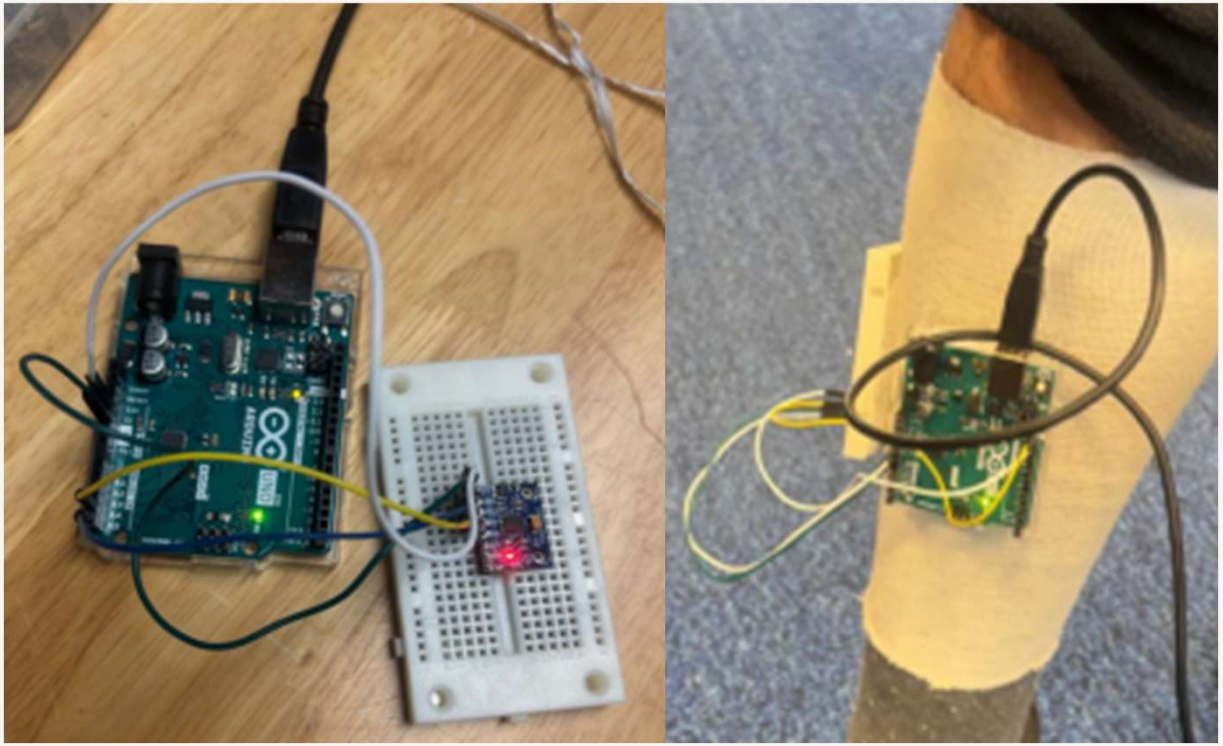


Fig. 4 Arduino and Breadboard (L) & Assembled Prototype on User (R)

PROTOTYPING
DATASET BUILDING

Activity Types

- Laying Down
- Normal Gait
- Abnormal Gait
- Falling
- Standing
- Sitting

Conduct Each Activity and Label the Data

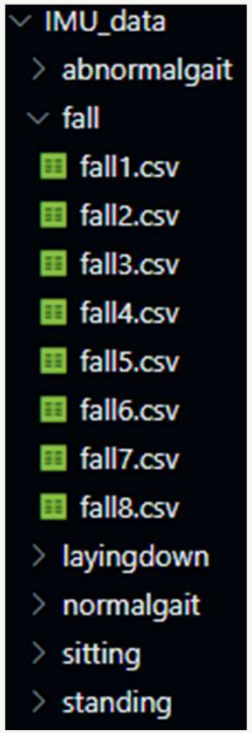


Fig. 5 Dataset Folder

PROTOTYPING
CLASSIFIER TRAINING

Classification Report:

	precision	recall	f1-score	support
abnormalgait	0.99	0.97	0.98	1523
fall	0.98	1.00	0.99	1523
layingdown	1.00	1.00	1.00	1523
normalgait	0.98	0.97	0.97	1523
sitting	1.00	1.00	1.00	1523
standing	1.00	1.00	1.00	1523
accuracy			0.99	9138
macro avg	0.99	0.99	0.99	9138
weighted avg	0.99	0.99	0.99	9138

Confusion Matrix:

```
[[1480    8    1   32    2    0]
 [   0 1521    0    2    0    0]
 [   0    3 1520    0    0    0]
 [  18   19    0 1480    3    3]
 [   1    1    0    1 1520    0]
 [   0    0    0    2    0 1521]]
```

Cross-validation Accuracy: 0.97

Fig. 6 Activity Type Classification Model Training Performance

PROTOTYPING
PROOF OF CONCEPT

In Real-Time...

Test 1. Differentiate between normal and abnormal gait

Test 2. Activate vibration motor after 5 minutes sedentary behavior

Test 3. Detect a fall

PROTOTYPING VALIDATION

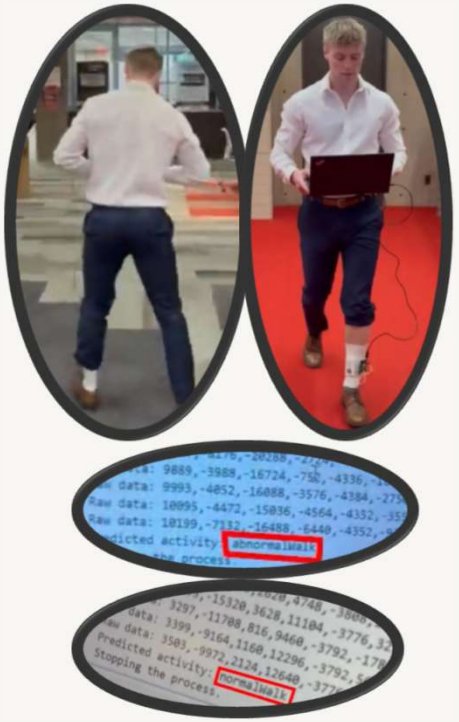


Fig. 7 Test 1

Fig. 8 Test 2

Fig. 9 Test 3

FUTURE WORK

PROTOTYPE ITERATION

Work towards a device that meets all the clinical requirements

FDA VALIDATION

Hardware. Class II Medical Device

Software. Software as a Medical Device

Requires 510(k) clearance

THANK YOU

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