# FallGuard Pro

A Fall Detection System for Elderly Persons

Group 20

Supervised by :
Ms. Vishmi Embuldeniya

# Content

# Problem Statement

Many individuals over 70 or with mobility-impairing conditions rely on constant supervision to prevent dangerous falls. However, continuous monitoring isn't always possible, increasing the risk of serious, even life-threatening injuries. Hence, prompting that a better solution be developed for this issue

# RESEARCH GAP

## LACK OF A MULTI-MODEL SYSTEM

Most existing systems that utilize fall detection models and tools normally focus on the utilization of only one model instead of combining the computational intelligence of multiple models to assess if someone is about to fall or in the process of falling. To summarize, given that most systems only consider a single model it tends to lead to issues with making proper prediction, reducing reliability

## CONSIDERING ALL POSSIBLE VECTORS

In terms of considering every possible vector in which a fall may occur, most existing systems simply ensure that at least one possible approach is considered instead of considering multiple approaches. Hence, leading to there being vast miscalculations and incorrect predictions in detecting a fall. So, merging multiple models to assess different approaches is a new approach to this issue

## IMPERFECT OCCLUSION MODELS

Given that the task of detecting objects that obstruct computer vision models is a challenge since it must always focus on one subject, most subjects tend to vary due to there being different and similar instances to it when detected by the model, hence leading to confusions in what the subject really is. A key factor to reconsider here is to opt for a different approach to detecting a fall instead of solely relying on one approach, hence the use of multiple models

(NGUYEN, T.-B., NGUYEN, D.-L., NGUYEN , H.-Q. & LE, T.-L., 2024. A REAL-TIME AND CONTINUOUS FALL DETECTION BASED ON SKELETON SEQUENCE. [ONLINE] AVAILABLE AT: HTTPS://LINK.SPRINGER.COM/CHAPTER/10.1007/978-981-97-5504-2_11 [ACCESSED 15 APRIL 2025])

# PROJECT AIM

To develop a real-time, multimodal fall detection and prediction system for elderly individuals living alone by integrating sensor data (accelerometer & gyroscope), camera-based posture analysis, and vital signs monitoring (heart rate & $SpO_2$), enabling early detection, accurate classification, and timely alerts through a web-based interface.

01. Choosing the most suitable machine learning models and algorithms to accurately analyze motion data, recognize postures and analyze physiological data for reliable fall detection and prediction.

02. Combining models to improve real-world performance using a fusion approach
Integrate multiple data sources to create a fusion model that enhances accuracy and handles real-life variability.

03. Designing a user-friendly web interface for real-time monitoring and alerts
Build a simple, responsive interface to display vital signs, movement data, and send alerts when a fall is detected.

# SWOT ANALYSIS

## Strenghts

**Multimodal approach** improves accuracy by combining sensor, camera, and vital sign data.

**Real-time detection and alerting** ensures timely response to fall events.

**Web-based interface** allows easy access and monitoring for caregivers or health staff.

## Weaknesses

**Hardware dependency** (sensors, camera, vitals monitor) may limit scalability or increase setup cost.

**Privacy concerns** with using camera data in personal spaces.

**Real-time processing** can be resource-intensive on lower-end systems.

## Opportunities

**Integration with smart home or wearable devices** for commercial deployment.

**Expansion to broader health monitoring** (e.g., early illness detection, elderly activity tracking).

**Partnership with healthcare providers** for real-world testing and adoption.

## Threats

**Data privacy and security regulations** (e.g., GDPR) could limit camera/vitals use.

**False positives/ negatives** may reduce trust in the system without constant improvement.

**High competition** from commercial fall detection wearables and systems.

# SOFTWARE DESIGN

### Multimodal Advantage

Combines camera, motion, and vitals to reduce false alerts.

### Core Modules

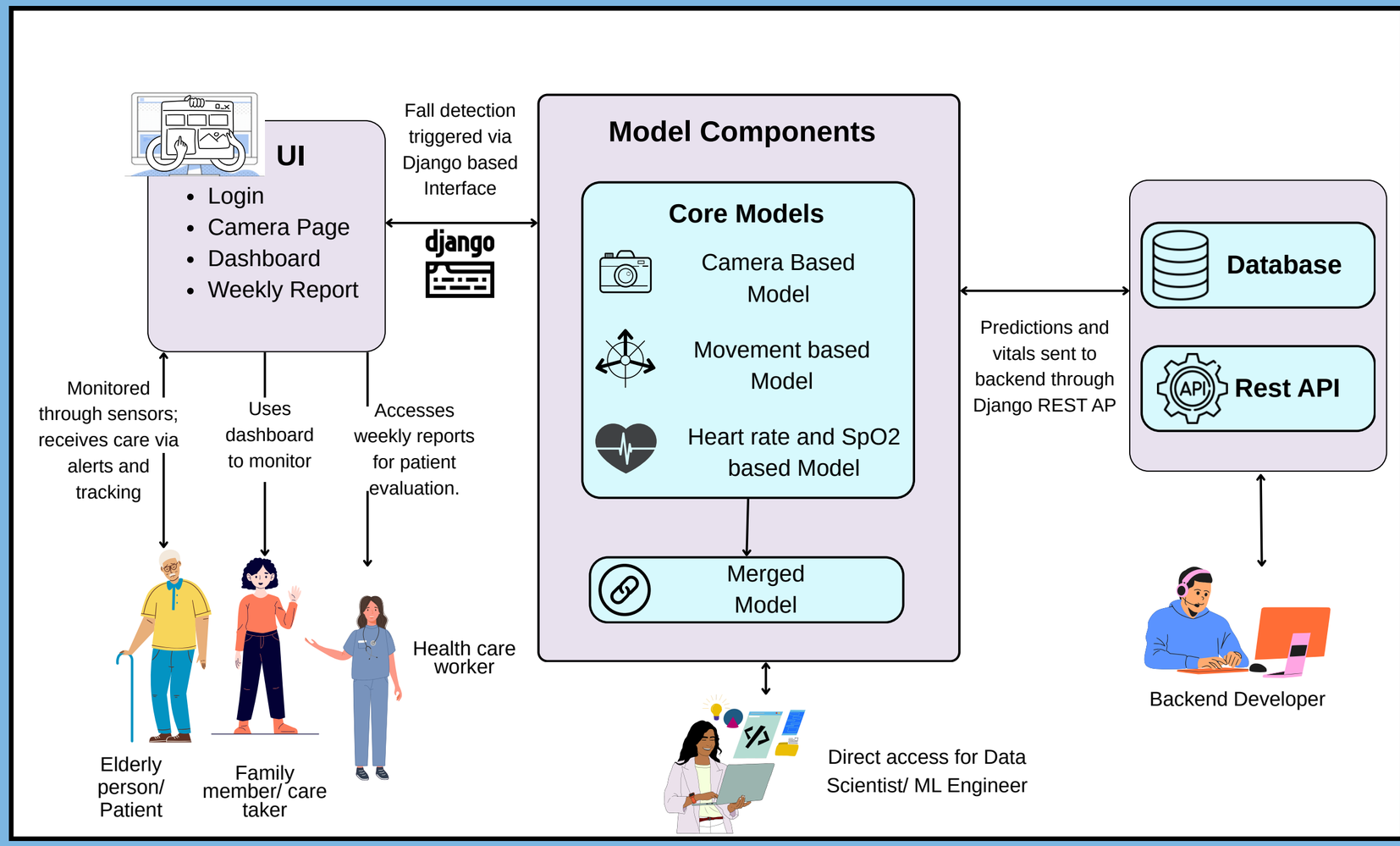
Camera, motion, and vitals fused to detect fall status.

### UI & Monitoring

Live feed, real-time graphs, weekly report for patient tracking.

### OOAD Structure

Modular Django classes enable scalability and easy device integration.



# IMPLEMENTATION

## MODELS

- Motion Sensor Model:

A 1D Convolutional Neural Network (CNN) was used to classify time-series accelerometer and gyroscope data for fall detection.

- Camera-Based Model:

A KNN classifier was applied to posture features extracted from camera input to detect abnormal body positions.

- Heart Rate Model:

A KNN model was trained on heart rate and $SpO_2$ readings to identify physiological patterns that may indicate a fall risk.

## FUSION

A rule-based fusion model combines predictions from the CNN (motion), KNN (camera), and KNN (vitals) models to improve overall accuracy and reduce false positives. The models run in parallel using multithreading, allowing real-time data processing and decision-making without delays.


## STACK

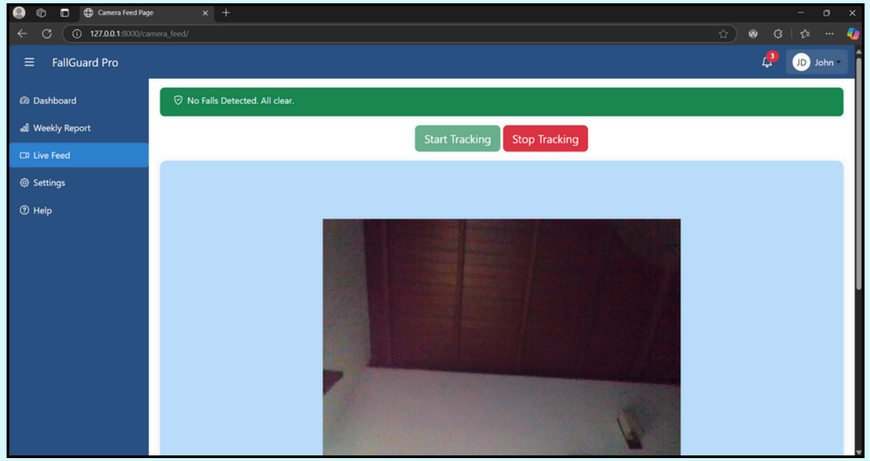
The system uses a Django backend to manage model inference and data processing, and a responsive web frontend built with HTML, CSS, and JavaScript to display fall alerts, vitals, and motion data in real time.

# SOFTWARE DEMONSTRATION

## Dashboard


## Weekly Report


Demonstration Video




## Camera page

# BUSINESS MODEL CANVAS

## 01 Key Partners

- Hospitals & clinics
- Elder care facilities
- IoT hardware suppliers

## 02 Key Activities

- ML model development
- Web platform integration
- Report generation

## 03 Key Resources

- ML models
- Sensors (IoT)
- Web platform (Django)

## 04 Value Proposition

- Real-time fall detection
- Remote patient monitoring
- Weekly health reports for doctors

## 05 Customer Relationship

- Direct access for caregivers
- Support for medical staff
- Alert system for family members

## 06 Channels

- Web application
- Healthcare partnerships

## 07 Customer Segments

- Elderly individuals
- Patients with mobility issues
- Family & healthcare providers

## 08 Cost Structure

- Development & maintenance
- Sensor & hardware costs

## 09 Revenue Streams

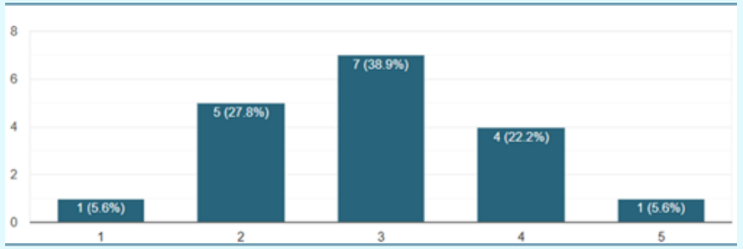
- Subscription plans
- B2B hospital licensing

# TESTING AND EVALUATION

## Model Summary

| Metric | Joint based camera model | Motion based model | Heart Rate based model |
|---|---|---|---|
| Precision | 0.91 | 0.81 | 0.87 |
| Recall | 0.88 | 0.93 | 0.88 |
| F1 Score | 0.90 | 0.87 | 0.79 |
| Accuracy | 0.88 | 0.90 | 0.89 |
| Support Vectors (P) | 786/1382 | 298/837 | - |

## Response Summary




### Method

Provided digital questionnaire for each patient and was distributed by the physiotherapist at her clinic (domain expert), time taken to answer full questionnaire varied between 5~10 minutes

### Conclusion

Responses mostly range from 2 to 4, indicating a moderate sense of unsteadiness in isolated conditions

## Evaluation Summary

### Methodology

Consulted technical and domain experts to critic and assess the application while handing out questionnaires to patients that have experienced fall-based injuries to assess their responses to the app

### Criteria

- **Scope**
  - Target Audience Relevant
  - Real World Applicability
- **Concept**
  - Detection Logic Soundness
  - Use of appropriate algorithms and tech
- **Goals**
  - Safety and independence enhancement
- **Design**
  - Accessibility (vision, mobility)
  - Ease of navigation and readability
- **Prototype**
  - Fall detection accuracy
  - System responsiveness
  - Alert mechanism effectiveness

# LIMITATIONS & FUTURE ENHANCEMENTS

## LIMITATIONS

### No Multi Language Support

The interface currently supports only one language.

### Moderate Model Accuracy

Current Models may not ensure precise fall risk prediction

### Camera Angle Sensitivity

Accuracy drips significantly with poor camera positioning

### Limited Stress Content

System doesn't factor in emotional psychological & lifestyle data when assessing fall risk

## FUTURE ENHANCEMENTS

### Cloud Storage Option

Offer proper storage systems to make data available to users at any given time

### Recommendation System

Incorporate a recommendation system for treatments and recommended specialists

### Improved Alert System

Develop an application port on mobile devices such that users receive a unique alert in the case of a fall

### Holistic Stress Profiling

Integrate emotional & behavioral data with vitals for smarter risk assessment.

# CONCLUSION

## *New Skills Acquired*

- ✓ Django Framework
- ✓ Real-time data handling
- ✓ Deployment of ML models into web apps
- ✓ Backend Development

## *Use of Existing Skills*

- ✓ Programming
- ✓ Machine Learning
- ✓ Version Control
- ✓ Web Development
- ✓ Data Visualization

## *Problems and Challenges Faced*

- ✓ Imbalanced fall risk classes
- ✓ Unreliable camera angles and lightening.
- ✓ Difficulty mapping vitals to meaningful risk levels

## *Publications*

**Research Paper Type**

Full Conference Paper

**Topic**

Fall Detection for Elderly Individuals

**Submitted to**

25th ICTer International Conference

**Status**

In Progress

# INDIVIDUAL CONTRIBUTIONS

## Ethan Perera

**Team Leader**

- Literature Review
- Developed Computer Vision/Occlusion Model
- Responsible for pre-processing and assessing datasets for the computer vision model
- Developed webpage and app for computer vision model on Django
- Developed initial framework for Django project
- Documentation

## Senuli Wickramage

- Literature Review
- Developed the Accelerometer, Gyroscope sensor Data model
- Developed the webpage for Weekly Report
- Created the weekly report document
- Worked on the simulation of sensor data
- Real time data visualization in the Dashboard
- Documentation

## Himansa Jayasuriya

- Conducted Literature Review
- Developed the Fusion Model
- Integrated three models to run in parallel in real time
- Implemented logging system with time-stamped fall statuses
- Created the Business Model Canvas
- Focused on UI logic and alert button for Dashboard status display

## Mevinu Gunaratne

- Literature Review
- Developed the Heart rate & SPO2 model
- Designed the fall risk prediction logic based on vitals
- Developed the webpage for the Profile page
- Contributed to report writing and final presentation
- Handled model selection and performance tuning.

# Q & A