Final Project Proposal

Topic: A Human Activity Recognition-Based Safety System

Pattern Recognition and Machine Learning CSC 588 - U17

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I. Introduction

Research question

How can human activity recognition (HAR) using smartphone sensor data be leveraged to develop an automated safety system for women, which detects abnormal activities and triggers real-time SOS alerts with location tracking, without the need for manual intervention?

II. Background and Motivation

In recent years, **Human Activity Recognition (HAR)** using smartphone sensors has gained significant attention due to its wide-ranging applications in healthcare, security, fitness tracking, and human-computer interaction. Improving personal safety is one of the most important uses, particularly for women and other vulnerable groups. As smartphone usage increases, using built-in sensors like gyroscopes and accelerometers to track physical activity in real time offers a practical and affordable way to ensure safety.

Several studies have successfully applied machine learning models to recognize activities like walking, running, standing, and sitting. For example, the **UCI HAR dataset** has been widely used to train classifiers on basic human movements. Models such as **Random Forests**, **Support Vector Machines (SVMs)**, and **Convolutional Neural Networks (CNNs)** have been used to classify human activities based on smartphone data with high accuracy. However, there has been limited research on using HAR systems for **real-time safety applications** involving emergency scenarios like sudden falls or erratic movements.

Traditional safety apps, particularly those designed for women, rely on **manual activation** of emergency features (e.g., pressing a panic button or sending a distress signal). These apps are effective but have a major limitation: in high-stress or incapacitating situations, the individual may not be able to initiate the alert. There is a critical need for an **automated system** that can recognize abnormal or distress-related activities and trigger an SOS without user intervention

A major challenge in this domain is the **detection of abnormal activities**, such as sudden falls or erratic movements, which could indicate distress or danger. Traditional HAR models classify routine activities (e.g., walking, sitting, running), but they often lack the ability to recognize and respond to **unexpected, emergency behaviors**. Women, in particular, face the risk of harassment or accidents in public spaces, and there is a pressing need for systems that can automatically detect such situations and **trigger an emergency response**.

Justification for the Chosen Problem:

Safety concerns, particularly for women in public spaces, remain a pressing global issue. Women may face harassment, accidents, or other forms of physical threats, making it crucial to develop proactive safety mechanisms. While many apps offer location tracking or panic buttons, these solutions fail when users are unable to manually activate them. Incorporating automated abnormal activity detection into existing systems can bridge this gap.

The proposed solution leverages the same smartphone sensors used in HAR to identify abnormal behaviors like falls, sudden sprints, or erratic movements, which may indicate

distress. By doing so, the system can trigger an SOS alert, sharing real-time location data with emergency contacts, thus providing timely assistance.

This approach not only addresses a critical gap in women's safety but also has broader applications for vulnerable populations, such as the elderly or individuals with medical conditions who may experience falls or emergencies. With the advancement in deep learning and real-time data processing, developing a reliable, automated system for safety alerts is now more feasible than ever.

Literature Review

Previous solutions for human activity recognition focused primarily on **fitness tracking** and **health monitoring**, where machine learning algorithms were applied to predict activities like walking, running, or sitting based on sensor data. In some safety applications, apps used GPS tracking or user-triggered emergency buttons to alert contacts, but few have combined **HAR** with real-time, sensor-based **automated safety responses**.

In the research domain, **machine learning models** (such as Random Forests, Support Vector Machines, and LSTMs) have been employed to classify user movements into predefined categories. More recently, **deep learning approaches**, particularly **Recurrent Neural Networks (RNNs)** and **Long Short-Term Memory (LSTM)** networks, have shown promise in processing time-series sensor data to achieve more accurate HAR.

However, few projects have integrated HAR with **safety systems**, and there is limited research on using abnormal activity detection for **real-time safety alerts** tailored specifically for women.

III. Objectives

This project aims to extend **HAR** with a **safety system** for women, capable of detecting abnormal activities such as **falls, sudden running, or erratic movement patterns**. The system will automatically trigger an **SOS alert** and share the user's real-time location with emergency contacts. By leveraging **LSTM networks** for HAR, the system will monitor regular activities while flagging potentially dangerous ones.

Key aspects of the solution include:

1. Collecting and preprocessing smartphone sensor data (accelerometer and gyroscope).
2. Building a robust LSTM-based HAR model for real-time activity classification.
3. Implementing a detection mechanism for abnormal behavior, triggering a safety protocol when such behaviors are detected.
4. Sending SOS messages with real-time GPS data to predefined contacts when danger is detected.

Expected outcomes

Activity Classification Accuracy: Aim for 90%+ accuracy in distinguishing regular activities.

Abnormal Activity Detection: Aim for high precision and recall in detecting emergencies (minimal false alarms).

SOS Response Time: Ensure alerts are sent within seconds of detecting a dangerous activity.

IV. Methodology

1. Machine Learning Model Selection: The core of the project is to develop a **Human Activity Recognition (HAR) model** that can classify activities using smartphone sensor data and detect abnormal or distress-related movements.

Proposed Models:

- Long Short-Term Memory (LSTM) Networks
- Convolutional Neural Networks (CNN)
- Random Forest Classifier (Baseline)

2. Abnormal Activity Detection: After classifying regular activities, the system will be enhanced to detect **abnormal activities** such as falls, sprints, or erratic movements, which may indicate an emergency. This could be achieved by:

- **Threshold-Based Detection**: Using thresholds for sensor data (e.g., high acceleration spikes) to flag abnormal behavior.
- **Anomaly Detection Models**: Train a model to identify normal activity patterns and classify any significant deviation from these patterns as abnormal.

3. Safety System with SOS Alert: The next phase involves integrating the HAR model with a **safety system** that sends real-time **SOS alerts**:

- **GPS Tracking and Location Updates**: Integrate location tracking (using **Google Maps API** or **Geopy**) to send real-time GPS coordinates when an abnormal activity is detected.
- **SOS Alert Functionality**: Upon detection of an abnormal activity, an SOS email or SMS is automatically sent to emergency contacts with the user's current location and the detected abnormal activity. This will use services like **SMTP** for email or **Twilio API** for SMS.

4. Tools and Frameworks:

- **Python** will be the primary programming language for the project.
- **TensorFlow/Keras** or **PyTorch** for building and training deep learning models (LSTM, CNN-LSTM).
- **Scikit-learn** for baseline models (Random Forest) and data preprocessing.

- **NumPy** and **Pandas** for data handling and manipulation.
- **Matplotlib** and **Seaborn** for visualizing data and model performance.
- **Google Maps API** or **Geopy** for location tracking.
- **Twilio API** for sending SMS-based SOS alerts or **SMTP** for email alerts.

V. Dataset: UCI Human Activity Recognition Dataset:

- **Source**: UCI HAR Dataset
- **Description**: This dataset is widely used for human activity recognition tasks. It contains sensor data collected from the **accelerometer** and **gyroscope** of a smartphone, worn on the waist by 30 volunteers. The data captures **six types of activities**: walking, walking upstairs, walking downstairs, sitting, standing, and lying down.

VI. Timeline

Week 1: Literature review, dataset preprocessing, initial data exploration.

Week 2: Basic HAR model with LSTM, initial performance evaluation.

Week 3: Optimized model with abnormal activity detection.

Week 5: Fully integrated and tested system with real-time activity monitoring.

Week 6: Final system performance evaluation, report, and presentation.

References

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