A project Report on

Safety Monitoring In Long Distance Sports

HIS - Safety Critical Computer Systems
Summer Semester - 2022

Under guidance of

Prof. Dr. Matthias F. Wagner

Submitted By

Name:	Matriculation ID:
Abu Saleh MD Nayem	1417388
Mohsina Binte Asad	1420867
Nur Uddin Muhammad Sayeed	1420731
Omme Salma	1420582
Md Tarikul Islam	1417964

Table of Contents

1 Abstract

In the world, Human activity recognition, which employs sensors to understand human actions, has long been investigated in order to create a simpler system with great precision. Body sensors are becoming more common in areas such as entertainment, security, and medical research [1] [2] [3]. Many academics have been looking at the use of body sensor data in healthcare. Many of them have been completed successfully with a very low error rate and we will integrate those with SCS. Data generated by various sensors can be captured remotely. In this project, we will mostly use a phone accelerometer. The accelerometer has been utilized in a variety of SCS applications including research, medical, engineering, and manufacturing. Our objective is to have a Safety Monitoring System for Long Distance sports, with the goal of remotely monitoring a sports person's activity using a smartphone. For this purpose, we developed an activity recognition system where we recognize sitting, standing, walking, running, downstairs, upstairs, and falling using LSTM (combination of Neural networks and Deep Learning). Falling will be accounted for in unusual scenarios and the remainder of the activities will be used to monitor the person's status i.e other things will be recorded simultaneously so that the monitoring team can identify his track of activity where team can see activity records from report and live graph chart.

2 Problem Statement

Human Activity Recognition (HAR) has become one of the trendiest research topics due to the availability of sensors and accelerometers [4] [5]. Activity recognition using sensory data has become an active field of research in the domain of pervasive and mobile computing. But currently, we see in many long-distance sports where unusual activities, for example, accidents occur and the sportsman needs immediate medical support to save life or avoid severe injury. Such long-distance sports can be marathons, Jogging, and Snow Skating. So, to provide a solution, we have planned to develop a safety-critical system for long-distance sports.

3. Objective

Develop a safety-critical system for long-distance sports safety.

- To recognize sportsman activities like sitting, walking, and running in real-time from accelerometer data.
- To notify the sports response team if any emergency situation occurs for any sportsman.
- To monitor sportsman activity in real-time.
- To keep sportsman events records for further analysis.

4. Requirement Analysis

The Software Requirements knowledge area (KA) is concerned with the elicitation, analysis, specification, and validation of software requirements as well as the management of requirements during the whole life cycle of the software product.

5 Design Model

5.1 Use Cases

There are six use cases for the implemented solution.

Table 1: Use cases

ID	Use case description	Functional Requirements
UC-001	In the mobile application, user will have to configure the server by using id and server address.	• Device unique id • Server address
UC-002	User have to set the activity recognition mode on, so that it will get permission to send the data to server.	There will be a turn on/off button in mobile application.
UC-003	• For monitoring, a device must be registered in the server as a monitored device. • Admin can define any other activities as alarm, so that it will be monitored as unusual activity. • System admin can change device details and alarm settings.	While registering a new device system will need, • ID/mac • Owner Name • Age • Gender • Email • Phone • Emergency Contact We will consider Fall as an abnormal activity.
UC-004	For receiving user's activities or events data server receiving service will have to start first. So that server will be in listening mode.	• Socket port defined by the system. • System operator can start/restart the service If needed.
UC-005	• There will be a monitoring panel, where response team can monitor real time activity. • If any activity received which is defined as alarm, system will rise an alarm and add that activity in alarm list. • Response team will check the alarm. Will take needed action for true alarm and ignore for false. • Finally takeover the alarm with taking proper notes.	Real Time view panel with, • Receive time • Source time • Device ID • User Name • Activity Make a sound when rise an alarm
UC-006	System users can check previous activity records.	Summary reports can be generated by • User • Device • Date and time • activity

5.2 Unified Modeling Language (UML Diagram)

Unified Modeling Language, or UML, is a visual language that helps software developers to visualizing, constructing new systems, specifically for drawing diagrams.

5.2.1 Use Case Diagram

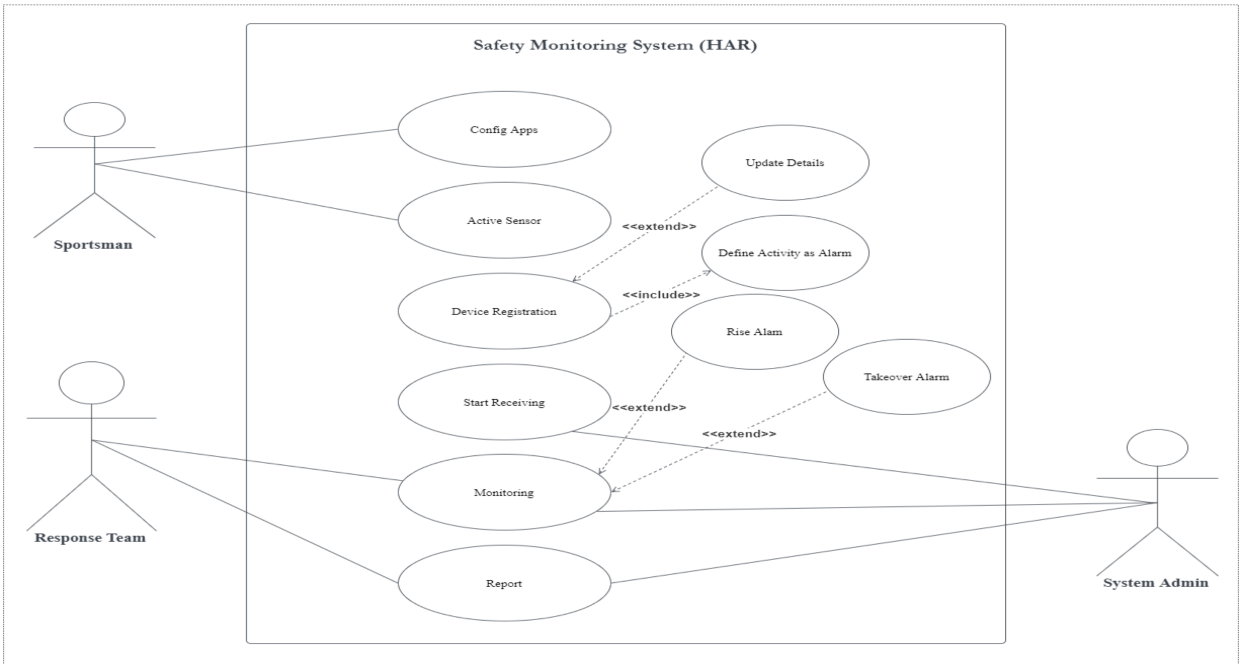

Figure 1: Use Case Diagram

5.2.2 Sequence Diagram

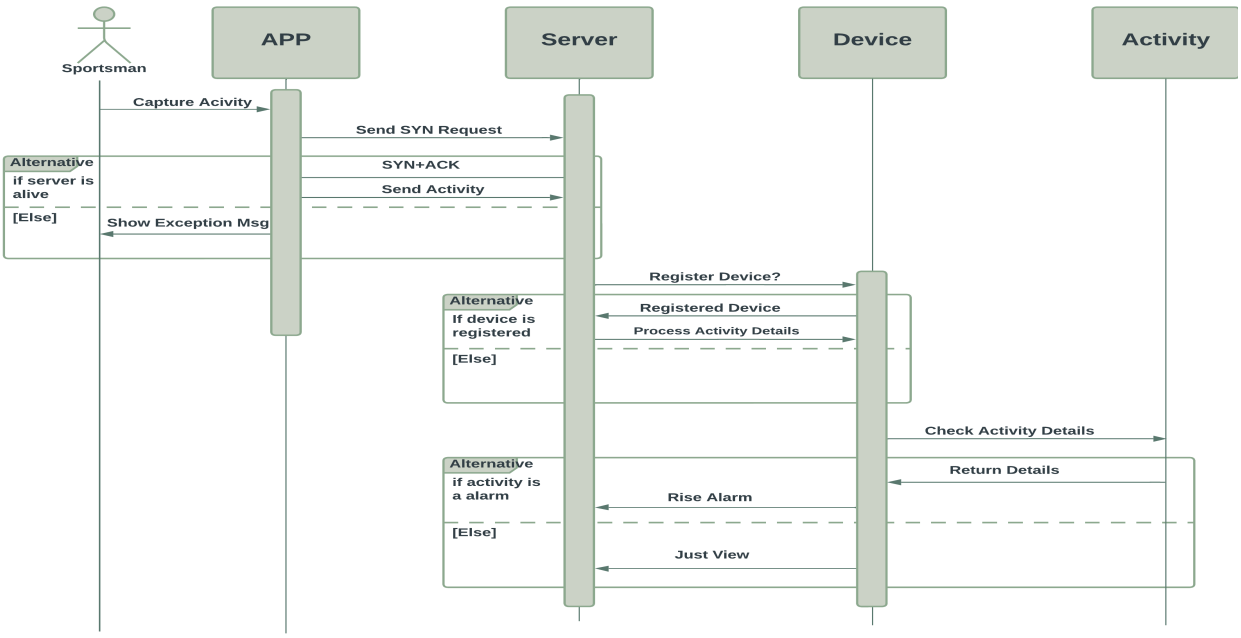

Figure 2: UML Sequence Diagram

5.2.3 Class Diagram

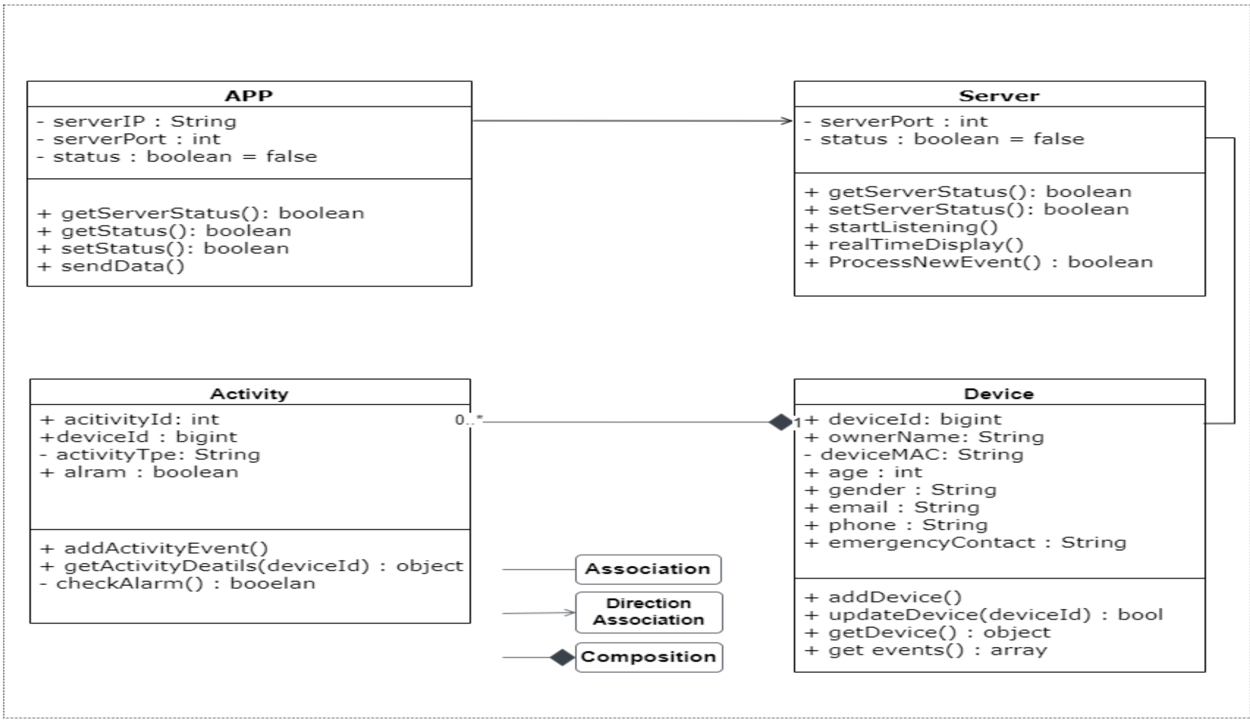

Figure 3 : UML Class Diagram

5.2.4 HMI Design

The overall structure of Long-Distance Sports Safety is given below:

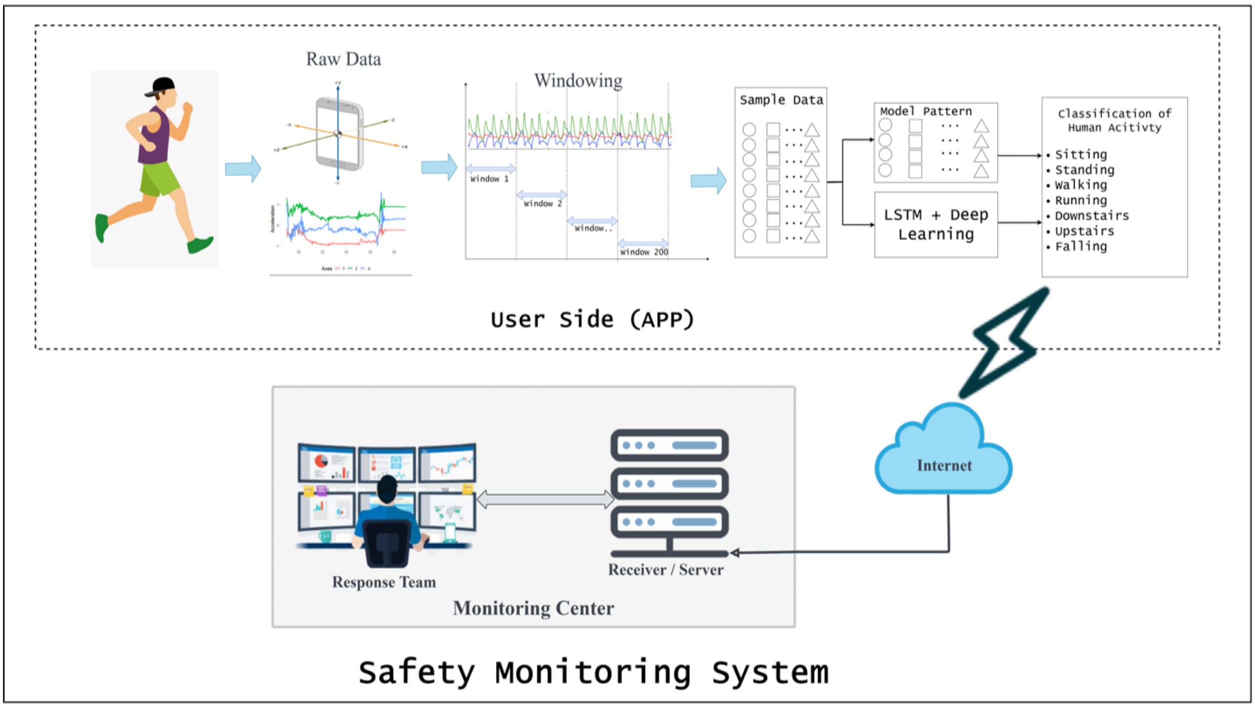

Figure 4: Architecture of Safety Monitoring System

5.2.5 Mathematical Algorithms:

$$\boldsymbol{Total\ Acceleration} = \sqrt{\boldsymbol{x^2 + y^2 + z^2}}$$

$$\boldsymbol{Gravity} = \frac{\boldsymbol{Total\ Acceleration}}{\boldsymbol{9.8}}\ \boldsymbol{ms^{-2}}$$

6 Software Plan

6.1 Software Tools

Software tools which are used to develop the project:

Mobile App Side	**Server Side**
OS: Android Programming Language: Java, TensorFlow, LSTM Model [5] IDE: Android Studio	OS: Open Platform/ Cross-Platform Programming Language: Java Database: SQL Server IDE: NetBeans

6.2 Process Model

In every software development, process models are used for planning, estimation, prediction, and validation purposes. It is the mechanism of dividing the development task into distinct phases to improve design and project management. Considering the scope, requirements, and project timeline, we have used V–Model XT in our project as it has well-defined structures, simultaneous verification and validation of each iteration also the ability to track down errors in the early stage of development. It is a best-fitting model where a project has limited time constraints and the project has to have the specified functionality. In this model, each iteration or sprint can be validated during the verification stages, which is a significant and prominent requirement of developing safety-critical systems. Since we are developing a Safety-Critical System for long-distance sports with high safety and reliability requirements that can be fulfilled through simultaneous verification and validation in every stages [6].

6.3 Resource Utilization

Table 2: Team members contribution

SL No	Project Tasks	Team Members Contribution				
		Nayem	Mohsina	Sayeed	Salma	Tarikul
1	Requirement Analysis	✓	✓	✓	✓	✓
2	Project Scope and Estimation		✓		✓	
3	Process Model			✓	✓	✓
4	Architectural Design Specification	✓	✓	✓		
5	Hazard Analysis	✓	✓		✓	✓
6	Modern Hazard Analysis	✓	✓		✓	
7	Implementation and Coding	✓		✓		
8	Testing	✓	✓	✓	✓	✓
9	Report and Documentation	✓	✓		✓	

6.4 Project Estimation

Based on the requirements of our application, we used COCOMO II model for calculating total function point, efforts and schedule.

1. Classify and Assign complexity levels of each Object

Measurement Parameters	Count	Weight	Functional Point Count
Screen	6(Medium)	6*2=12	2
Reports	2(Simple)	2*2=4	2
3GL	1(Difficult)	1*10=10	10

Total Functional Point = 12 + 4+ 10 = 26

We assume Developers Experience and case maturity capability is 7 and 4

Prod. (Productivity) = (7 + 4)/ 2 = 5.5

NOP (New Object Points) = [Functional points * (100 - %reuse)] / 100

= [26* (100 - 10)]/100

= 23.4

Effort = NOP/PROD

= 23.4 / 5.5

= 4.25 person-months = 5 person-months

So, we are 5 members in a group, so it is estimate to take us 1 month to develop. We analyzed that we have time to complete our project by the deadline 7 July 2022. This eased our group and relaxed us regarding the stress of the deadline.

6.5 Project Management (Trello.com)

Online project management tool "Trello" is used to manage our project.

7 Hazard Analysis Results

7.1 Failure Modes and Effects Analysis (FMEA)

Failure Type	Potential Impact	SEV	Potential Causes	OCC	Detection Mode / Current Process control	DET	RPN	Recommended Actions	Responsibility	Target Date	Action Taken
Failed to detect	serious injury to sportsman	9	Incomplete and missing data or Model	2	detection will be based on chunk of data set instead of a single set.	7	126	backup algorithm	System	immediate	
False Alarm	Dissatisfied & Annoyed sportsman	4	Natural issues or normal	5	The activity will be monitored in the next few times.	3	60	Pattern Analysis	Response Team	immediate	
Multiple alarm happens at a time, miss one or more to check	serious injury to sportsman	8	Not notice, ignore as false alarm, miss by mistake	5	manage alarm, will be in queue until takeover by any response team	6	240		Response Team	immediate	

Figure 5: FMEA

7.2 Modern Hazard Analysis: STAMP/STPA

STAMP (Systems-Theoretic Accident Model and Processes) is an accident causality model based on systems theory and concepts and it's developed at MIT by Prof. Dr. Nancy Leveson. STAMP incorporates causative elements such as software, human factors, and safety for

complex systems into engineering analysis. STPA (Systems-Theoretic Process Analysis) is a systems approach that uses STAMP to perform powerful hazard analysis techniques. [7]
We used STPA for hazard analysis in our project and discovered the following results:

Control Process Model:

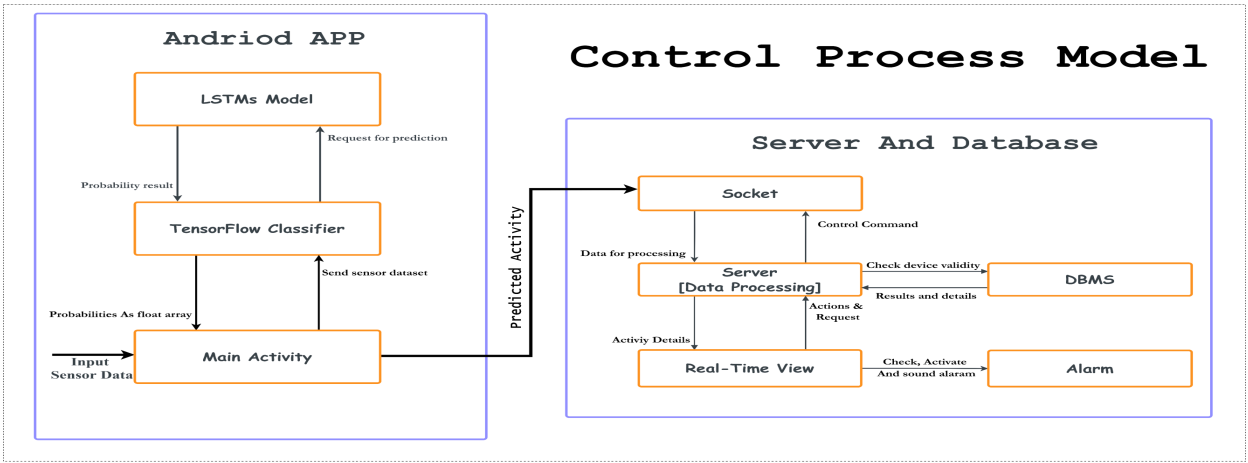

Figure 6 : Control Process Model

System-level Hazard	System-level Constraints
H1: Do not detect when aberrant situations occurred.	SC1: Need data from sensor
H2: Detect adverse situations in normal conditions.	SC2: Detect any activity with sensor data
H3: Delay to detect.	SC3: Need least amount of data
H4: Incomplete data will not give output.	SC4: Need all parameter data with least amount
H5: Received but is not displayed.	SC5 : Device must have activity information Server
H6: Activity is aberrant but does not active the alarm	SC6: Which activity will be abnormal for each device must be predefined
H7: Activity is normal but active this alarm	SC7: Active alarm when it is pre-defined only

8 Safety Plan

- ✓ Periodic check-up to find out which device wasn't sent any signal at a specific time.
- ✓ Real-time status display for each event on APPS
- ✓ For any kind of false alarm, team can view the live status of that specific device.
- ✓ Displaying the reason behind the alarm
- ✓ Log reporting for each exception and viewable to the team
- ✓ Use specific color coding for alarm
- ✓ Update the algorithm and be more specific on activity events that we sent

9 Security Plan

For security analysis(unsecure action) we are using STPA-SEC [8]

- ✓ Level of access, or what each user is allowed and not to do on the system
- ✓ Access control methods, or how users will access the system (login with id & password)
- ✓ Logging
- ✓ Registration system

10 Prototypes

The development of a system to monitor long-term sports safety is our goal. The planning and development phase will be substantial, according to our overall project idea. For the time being, we have developed our fundamental concept in order to demonstrate our entire notion.

Figure 7 : Prototypes

11 Testing

In testing phase, little minor issues found by testers which lead to a failure in some cases. After fixing those issues, software passed all tests and testing phases have been successfully completed.

12 References

Bibliography

[1] A. Bayat, M. Pomplun and D. A. Tran, "A Study on Human Activity Recognition Using Accelerometer Data from Smartphones," *Procedia Computer Science 34,* pp. 450-457, 2014.

[2] O. D. Lara and M. A. Labrador, "A Survey on Human Activity Recognition using Wearable Sensors," *IEEE communications surveys & tutorials,* vol. 15(3), pp. 1192-1209, 2012.

[3] S.-M. Lee, S. M. Yoon and H. Cho, "Human Activity Recognition From Accelerometer Data Using Convolutional Neural Network," *ieee international conference on big data and smart computing (bigcomp),* pp. 131-134, 2017.

[4] M. Kose, O. D. Incel and C. Ersoy, "Online Human Activity Recognition on Smart Phones," *Workshop on mobile sensing: from smartphones and wearables to big data,* vol. 16, pp. 11-15, 2012.

[5] N. Singh, R. Yadav, H. K. Singh and S. Agarwal, "HUMAN ACTIVITY RECOGNITION USING SMARTPHONE SENSORS," *International Journal of Information Sciences and Application (IJISA),* vol. 11, 2019.

[6] THE V-MODELL® XT, DEUTSCHLAND: BUNDESREPUBLIK DEUTSCHLAND, 2004.

[7] N. G. LEVESON and J. P. THOMAS, STPA HANDBOOK, 2018.

[8] W. Young and P. Reed, System-theoretic process analysis for security (STPA-SEC): Cyber security and STPA, STAMP Conference, 2017.