HARMFUL CHILD ACTIVITY DETECTION AND PREVENTION ASSISTANCE

Project ID : 2021-115

Individual Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology
Specialized in Data Science

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Declaration

We declare that this is our work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or institute of higher learning, and to the best of our knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Student Name	Student No.	Signature
Prathapa D.M.J	IT17167710	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

..…… ……..

Signature of the supervisor Date

..…… ……..

Signature of the co-supervisor Date

Acknowledgement

This project themes were a dream at the beginning when it accidentally planted on my mind. And how this tiny seed has been grown until a plant is a great work of the dedicated and acknowledgeable team.

I would like to express my great appreciation to my research supervisor, Mr. Prasanna Sumathipala. He gave me solid guidance by showing me the way to narrow down the research area to make it a more compelling thesis project.

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Finally, I would greatly appreciate the assistance given by my team members as and when it was needed.

Abstract

Preventing serious falls is a major problem for a working mother as well as for a caregiver as and when they are keeping a watchful eye to look after their young kids all the time at home. During our daily activities at home, some of the frequent types of falls areas fall from high tables, windows, chairs, and stairs. As such it is important to prevent fall-related injuries happen at home to keep your children safe. To do that parents are used to hiring babysitters, caregivers commonly these days supervise them closely as they believe that no safety system can take the place of your watchful eye. But as data science undergraduates now we are very confident enough to challenge that common perspective on people by offering a much more sophisticated and realistic system. It is our prime goal of this research dissertation.

As the research project it is proposed to implement a solution as "harmful unsafe child activity detection and prevention assistance, and quick reporting surveillance system "to manipulate the hardest role that is the role of a mom by taking care of her toddler or pre-school kid. Features of communicating the monitored behavior modified to capture even a single move that is performed and reported real-time would make the system outperform and provide promising results structuring a secure environment for end-users and their minors.

Keywords: Fall detection, video surveillance, Computer vision, Injury prevention, Climbing behavior.

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List of Abbreviations

Abbreviation	**Description**
GMM	Gaussian Mixture Model
SVM	Support Vector Machines
YOLO	You Only Look Once

1 INTRODUCTION

1.1 Background & Literature survey

Globally, the number of dual-income families has increased in recent years. Toddlers as well as the young children in double-income families must wait alone for their parents at home after school, which bothers both of them with their busy lifestyle. It is essential to reassure them, especially children who are left at home alone [1].

With the modern environment in the real world, parents are concerned about the welfare of children. It seems that the parents need their children to live in a safe environment where they can spend their time and minds without worrying about the children. However, half of them is generally dealing with a slew of problems [2].
Among the many concerns regarding the children, one major thing is to ensure that children are distracted from climbing or reaching heights that would result in dangerous situations.
Regarding this problem, one major source of morbidity, disability, and health-care use in accidents related to falls. The ability to predict falls incidents unsupervised will contribute to better outcomes for victims of falls. The unsupervised falls incidents prediction ability will contribute to a better result for victims of falls. Even though there are much wearable accelerometry and gyroscope-based fall detection devices on the market, unacceptable false-positive rates of those devices have become a considerable problem. [3].

Figure 1.1 - Climbing Behavior

Figure 1.2 - The Action of Falling

Visual monitoring now offers more detail about human activity, such as fall even [4]. Therefore, the motive of the proposed component is to monitor child behavior and to ensure child security is guaranteed by notifying parents of any actions related to reaching unsafe heights amalgamating visual surveillance, algorithms, and analytical knowledge to deliver promising results.

Fall detection and Climb detection.

Many systems have been implemented in climb and fall detection due to the high demand, high commercial value, and social importance of climb and fall detection systems and technologies. In recent years, several technologies have been developed. They are classified into two approaches based on how they detected and track the action: wearable sensor based (Figure 1.3), and vision-based approaches (Figure 1.4).

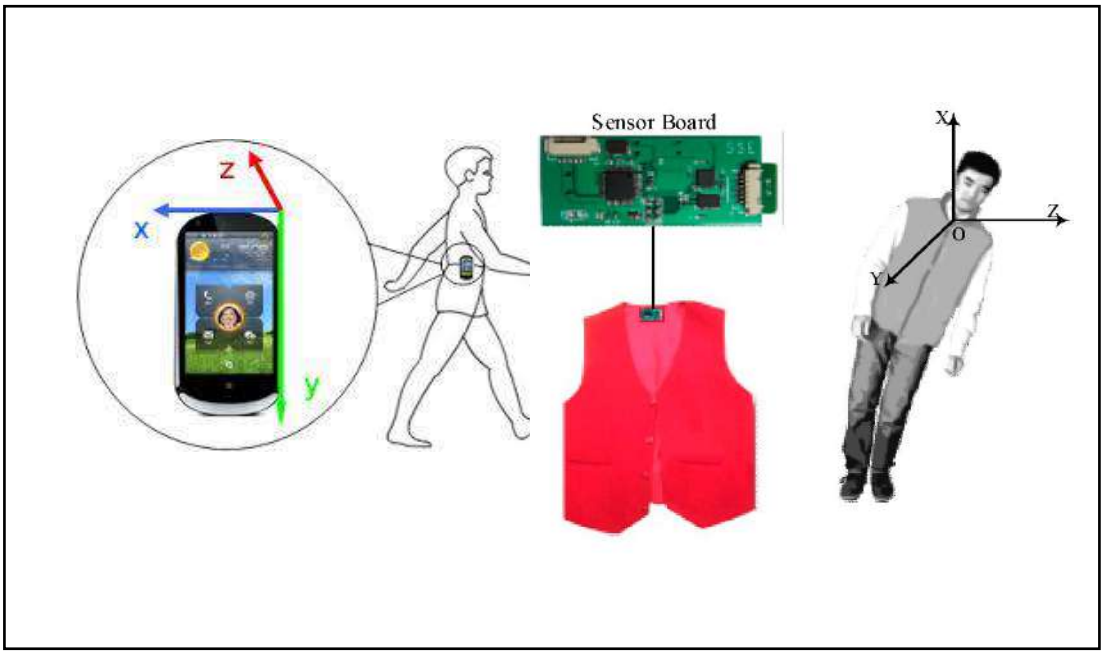

Figure 1.3 - Wearable sensor approach

Figure 1.4 - Computer Vision Approach

- Wearable Device Approach

The wearable device approach entails holding certain devices or wearing a certain garment with an integrated sensor to monitor the wearer's behavior and movements of the human body and using classifiers to recognize suspicious dangerous activity such as climb and fall [5][6][7][8][9][10][11][12][13][14][15].

In the last few years, increased attention to climb and fall detection has led to the development of many approaches to climb and fall detection [12][13]. Some techniques are commonly based on details collected by sensors such as vibration and acceleration sensors [12]. These approaches use echo, vibration, and body movements and gestures for climb and fall detection [14][15].

Petelenz et al [11] invented a system and device for detecting elderly falls. This device, like the previous one, collects motion data using accelerators. The difference is that this system often helps to differentiate between threatening falls and threats to one's life.

Depeursinge [7] has patented a system for monitoring a person's movement and detecting falls.

Doukas et al [8] designed a wearable sensor to track patient falls, which collects data from multiple accelerometers and uses an SVM and GMM to differentiate between falls and non-falls.

Hasen et al [9] introduced a method for detecting falls in the elderly. Three accelerators (sensors) and a processor make up the system. Three sensors gather motion data, which the processor analyzes to detect falls by discriminating between fall and non-fall patterns of motion data.

Willianms et al. [10] developed a smart sensor for detecting falls/slips and tracking activity. The sensors are designed to evaluate the effects of a fall. It also determines whether an alarm is needed by assessing the faller's condition.

Patrick Boissy [23] introduces a technique to detect falls and drops by utilizing fuzzy logic, and their experiment results in a high success rate for fall and drops detection, but the false detection rate of non-fall activity needs to be decreased, and Xiuxin Yang[24] discover Naive Bayes as the best algorithm in terms of efficiency and accuracy.

So, the theory of climb and fall detection in the above devices or systems is that a fall and climb have a different pattern of motion data from other activities. The approach to wearable devices has its benefits. For starters, apart from wearable garments, most wearable sensors, devices for fall, and climb detection are inexpensive. Second, wearable climb and fall monitoring systems are simple to set up and use.
And also, has several drawbacks. For instance, those method suggests that the worn device retains a fixed relative relation with the wearer and this condition can easily be broken. As a consequence, this method is prone to generating a high number of false alarms. Another major drawback of the wearable system is its intrusiveness.

- Camera-Based Approach

Surveillance Cameras are gradually being used in in-home assistance systems due to their various benefits over wearable sensor-based approaches, and the price of CCTV cameras decreases rapidly [16].

One of the most common and widely used fall detection and climb detection approach is to examine the bounding box (Figure 1.5) representing the human [17] in the frame. But this approach is only effective when the camera is positioned sideways, and it may fail due to occluding objects. To avoid the occlusion of obstacles and to provide more realistic situations, the camera should be in the higher position of the room.

Visual fall detection has a high rate of false positives and what seems to be a fall is not really a fall. In other words, most existing approaches [18] [19] [20] are unable to differentiate between a real fall action and an incident in which a person suddenly sitting down or lying.

Human falls have also been detected using the person's 2D (image) velocity [21][22]. Nevertheless, an issue with the 2D velocity approach is that 2D velocity is high when the human is close to the camera so that it is hard to define the thresholds to differentiate falls from a human sudden sitting action.

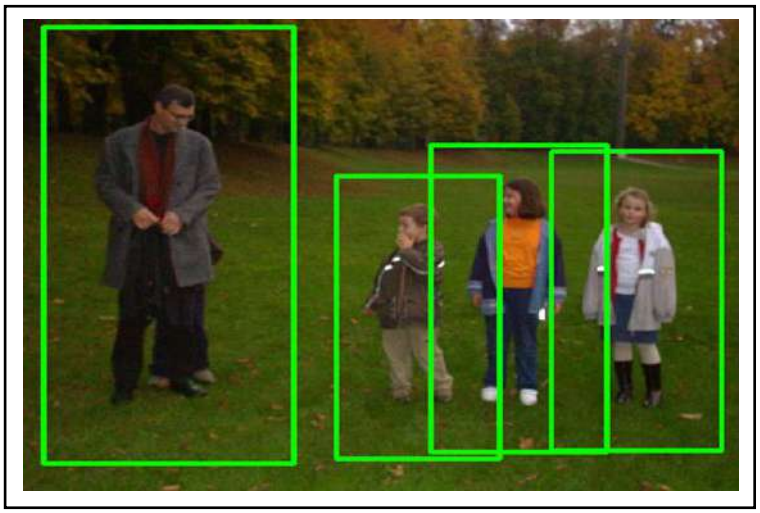

Figure 1.5 - Bound Box method

Child detection and Boundary Breach Detection

Many human detection and trespassing algorithms created the use of skin coloring. These [25] [26] algorithms are inaccurate because of the difference in skin color among humans.

In [27], child recognizing from their face image has been carried out and this approach fails when child is facing away from the camara.

The other approach [29] obtains an area of a moving target by measuring the difference of time-sequential images. This approach has the issue of failing to track a moving object based on the target object's moving speed or size [30].

All of these approaches detect a moving object on an image. When there are obstacles in front of the target, it becomes hard to identify the target moving object. To address the problem, detection methods using several cameras are being developed [31][32]. These approaches, however, require a much cost to set up the system.

1.2 Research Gap

Child climbing to a dangerous position, leaving the safe zone boundary of the room, and fells are the most leading cause of accidental injury to young children. Some falls can result in death or long-term disability.

To deal with those problems, various types of approaches have been taken. One option is to wear a sensor that detects the acceleration of the falls and these Wearable fall detectors are the most affordable and widely used form of fall detectors. These Wearable devices are selected for their low cost and higher efficiency.

However, if the parent forgot to wear the sensor to the child, no falls can be detected even when the incident happened. So, this approach fails to address user's acceptability issues [5][6][7][8][9][10][11][12][13][14][15].

To address these challenges, computer-based vision approaches can be used so that do not require the child to wear anything. Another reason for using a computer-based vision approach is that a Surveillance camera can grant more data and accuracy than the accelerometer in the motion of a child's actions.

Over the past years, some developments have been carried out on computer vision-based fall detection. Those systems are unable to differentiate between a real fall action and an incident in which a person suddenly sitting down or lying[18][19] [20][21][22].

The research aims to develop a system to Capture safety zone boundary breach and spot unsafe heights from the current position, effectively and accurately, and taking prompt responsive actions to avoid danger. By utilizing multiple computer vision-based techniques, such as Child detection, climb detection, fall detection, and pose estimation, and this system is planned to exceed all existing climb/ fall detection and prevention systems.

Product	[21][22]	[7] [8] [9] [10] [17][18][19][20]	[27][38][40]	Proposed solution (AI Care)
Fall detection algorithm	✓	✓	✓	✓
Climb detection algorithm	✗	✗	✓	✓
Taking prompt responsive actions to avoid danger (alerts)	✗	✓	✓	✓
Child detection	✗	✗	✓	✓
Capture safety zone boundary breach	✗	✗	✗	✓
Differentiate between a real fall and an incident in which a child is lying or sitting down abruptly	✗	✗	✗	✓
Calculate child midpoint & Calculate the average safe height of the room.	✗	✗	✗	✓
Height and hazard segmentation	✗	✗	✗	✓

Table 1.1 - Comparison of Former Research

1.3 Research Problem

Nowadays human lives accelerate at an unbelievable speed forcing everyone living in this generation to live with the pressure of engaging in numerous activities within a time frame of 24 hours narrowing down one's leisure time to a negligible figure. The role of a working mom is no brainer but an obvious victim of the explained situation as her life is sandwiched between the two roles: the role of a mom and a wife's role. Due to the pandemic situation, most of the corporates changed their rosters and working plans to work from home. It is given that with the current situation, safety plays a huge role but due to the current working arrangement followed by most offices, mothers are forced to balance office work along with balancing the two roles mentioned earlier which can be hectic.

Generally, young children like to climb on everything, including consumer commodities, like tables, highchairs, and cupboard, etc that are not designed to be climbed on. As a result, children are at risk of severe injuries. Some falls can lead to death or permanent disability.

Given the scenario is such, a babysitter sounds like a good idea but then again leaves us with a question mark on how safe it is. As a solution to the issue explained above, it is proposed to implement a solution as "harmful unsafe child activity detection and prevention assistance, and quick reporting surveillance system "to manipulate the hardest role that is the role of a mom by taking care of her toddler or pre-school kid.

The main goal of this research is to Capture safety zone boundary breach and spot unsafe heights from the current position. effectively and accurately and taking prompt responsive actions to avoid danger.

2 OBJECTIVES

2.1 Main Objectives

The main objective is to ensure the safety of children in the early development stages by tracking their movements and prevent them from reaching cautious heights that could result in injuries. The proposed solution will be implemented with the explained motive by indicating the caretakers or parents of such behavior and to prevent or diminish harm to minors as the solution makes sure to notify the relevant parties subsequent to detecting menacing actions as described.

Following specific objectives needs to be attained to archive the main objective.

2.2 Specific Objectives

Specific Object 1*: Detect whether the actions were caused by an adult or a child.*

The core objective backing up the main objective would be to detect whether the actions were caused by an adult or a child. As the research project is focused on child behavior this is an important objective in order to accomplish the main objective

Objective Object 2: *Calculate the mid-point of the captured child and calculate the safe height range of the room utilizing computer vision.*

The next specific objective is to first calculate the mid-point of the captured child and since it differs from child to child due to the variation of height, an average mid-point should be calculated. Based on the calculated statics a threshold consisting of a safe height range utilizing computer vision should be positioned to aid further analyzing procedures.

Objective 3 : *Capture and detect safety zone boundary breach and spot unsafe heights from the current position.*

Thereafter a safe zone should be illustrated covering both horizontal and vertical areas centralizing the child and based on the laid-out margins, to indicate in a situation where the borders of the defined zone are breached is the next specific motive after reconfirming that the actions were caused by the child itself segregating child's behavior from adjacent individuals.

Objective 4 : *Height and hazard segmentation*

In an instance the defined zone is breached as explained above next objective is to real-time analyze the height reached and based on the facts to provide the end-users a brief idea about the height whether it is low, moderate, or high indicating the severity of the situation. Also, the camera angle, area to be covered by the camera may differ and to achieve the reflected specific motive by handling the drawbacks is where the focal point is set in this objective.

Objective 5 : *communicate the incident efficiently to the parent or caregiver to avoid danger.*

The next objective is to amalgamate the previous motive along with the feature of detecting the action of falling over and to communicate the incident efficiently to the parent or caregiver. The action of falling over would be defined as an instance where the calculated mid-point is gravitated within a defined period of time breaking through the safe zone.

3 METHODOLOGY

Detection

As the focal point is on monitoring child behavior and preventing them from facing injuries caused due to reaching cautious heights, the first step is to detect whether the actions were caused by an adult or a child. In order to perform the mentioned segregation, YOLO would be utilized to capture each video frame and accomplish object detection.

Tracking

Simultaneously to track child actions, the Deep Sort algorithm would be used as it tracks extending features of simple online and real-time tracking with a Deep Association Metric capturing activities not only in a single frame but also ensuring to sum-up and track child activities performed in multiple frames.

Calculating child mid-point and safe height

The next most important step would be to work out the point around which the force of gravity appears to act. The proposed solution will be based on an algorithm that would use pixels per ratio-metric to calculate the center of mass as well as the safe height of the room for a given child.

Defining the boundary

To ensure that cautious incidents are triggered and prevented as the next step a boundary would be defined and based on the boundary fixed actions breaching the boundary resulting in hazardous consequences can be monitored. The boundary would be defined using OpenCV and to capture the action of breaching the border confirming that the action was caused by a child would be supported by Open Pose and Deep Sort mainly.

Prevent interruptions caused by surrounding objects

The objects in the background (i.e., chairs, tables) might hinder the process by interposing in the procedure of capturing child actions that could result in disruptions and also convey false results. The explained situation would be handled using Kalman filter implementation.

Hight and Hazard segmentation

Using the calculated midpoint and safe height range, the reached height would be real-time-analyzed and segmented as is low, moderate, or high indicating the severity of the situation. OpenCV will be used to perform the mentioned segregation backed by vision-based distance.

Alarming cautious behavior

Two speakers would be located. One within the reach of the parent or the caretaker and the other nearby to the child. In an instance where the child breaches the calculated boundary, the parent or the caretaker would be notified. Also, if the child reaches cautious heights the speaker reachable to the child would be utilized to warn the child regarding her or his behavior using a customizable recording which facilitates the users to record audio clips in their own voice and alarm children preventing injuries. Additionally, the parent or the caretaker would be notified regarding the same.

3.1 System Architecture

The system architecture is shown in figure 3.1.

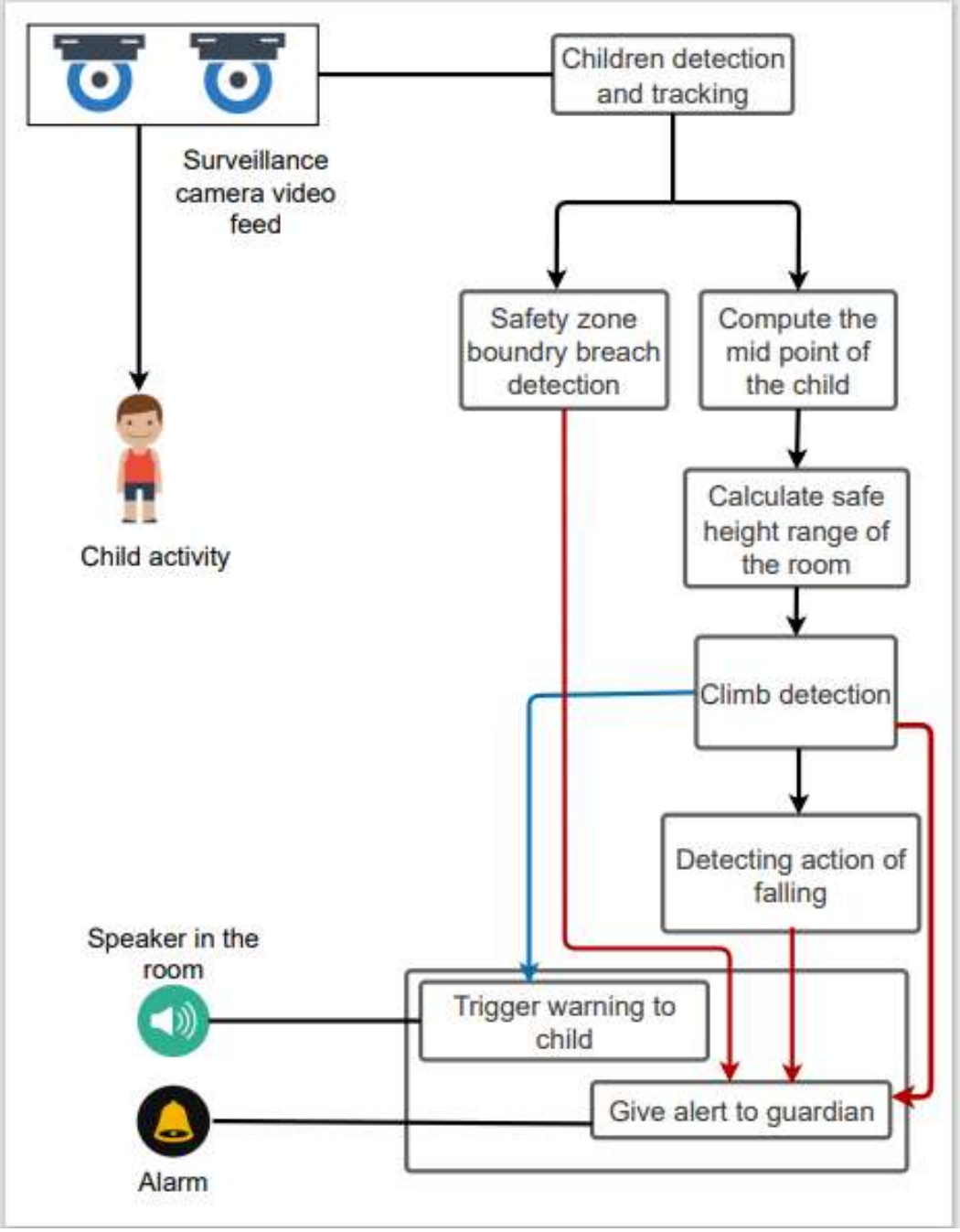

Figure 3.1 - High-level Architectural Diagram

3.2 Tools & Technology

The following technology domains will be used for this proposed system implementation.

- Computer Vision
- Machine Learning
- Deep Learning

Moreover, the below list contains the specific methods, libraries, and technologies that will be used in the proposed system.

- Python
- TensorFlow
- Yolo
- OpenCV
- Open Pose
- JavaScript/HTML/Bootstrap4

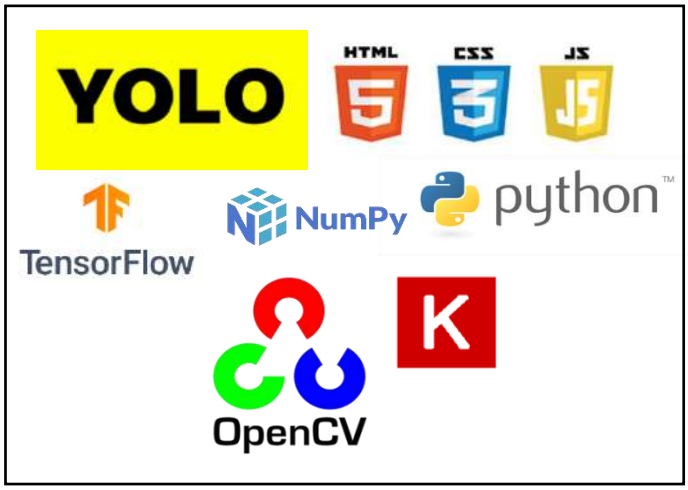

Figure 3.2 - Tools and Technologies

3.3 Work Breakdown Structure

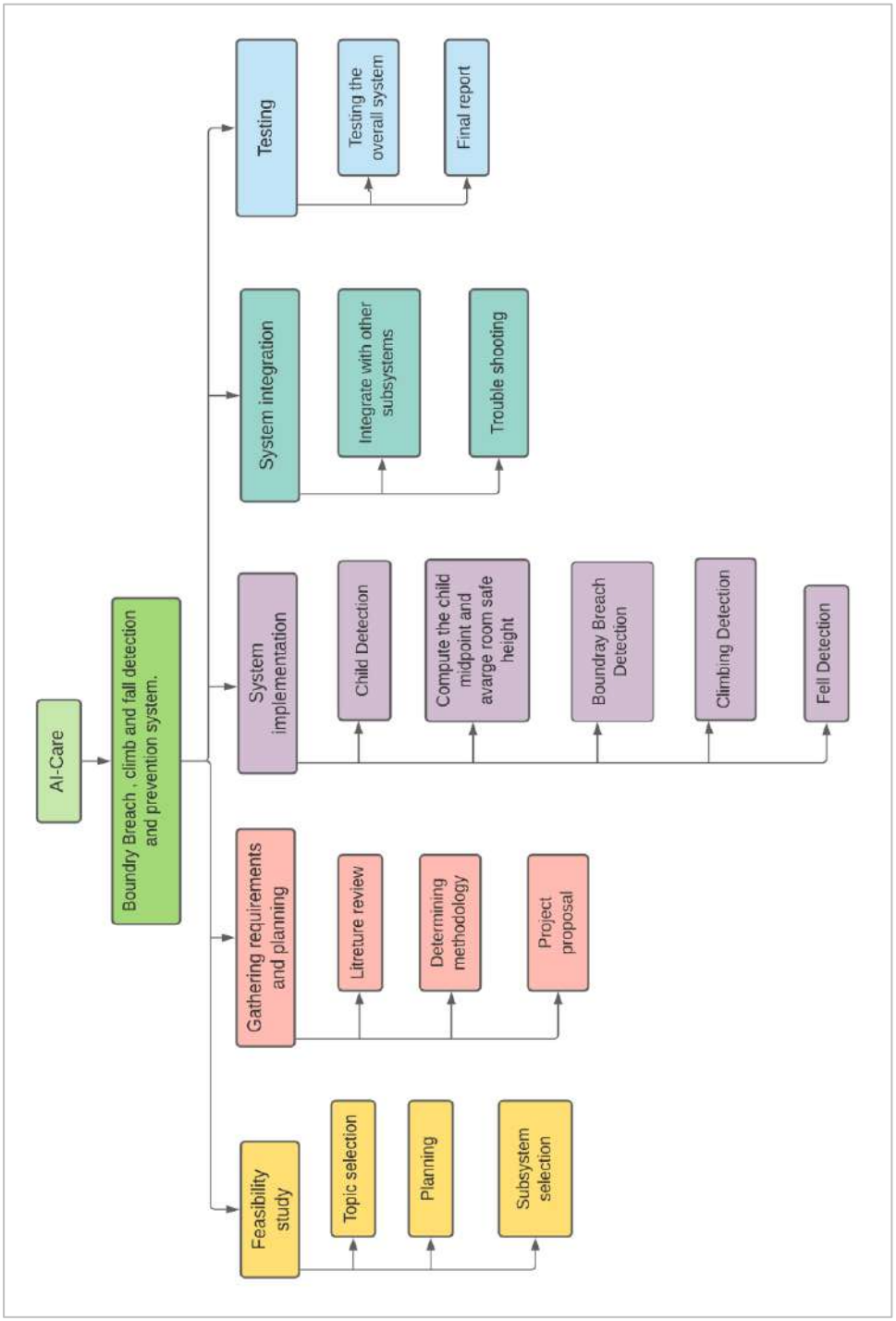

Figure 3.3 - Work Breakdown Structure

3.4 Functional & Non-Functional requirements

Functional Requirements

- Should have a method to detect whether the actions were caused by an adult or a child.
- Should have a method to calculate child mid-point and the safe height range of the room.
- Should have a method to Capture safety zone boundary breach and spot unsafe heights from the current position.
- Should have a method to detect the action of falling.
- The system should be able to discriminate between a real fall and an incident in which a person is suddenly sitting down or laying.
- Should have a method ay to communicate the incident efficiently to the parent or caregiver.

Non-Functional Requirements

- Response time and net processing time.
- Efficiency
- Availability
- Maintainability
- Capacity
- Serviceability: the system should be able to fulfil its function adequately
- Usability: The system has to be user-friendly and easy to use

Personal Requirements

- Parent/Guardian should be available.
- Child should listen to the warnings.
- Parent/Guardian should react to the alerts.

Hardware Requirements

- There should be a way to configure the speaker to the system.
- There should be a way to configure the camera to the system.

3.5 Comparison of Data Set

Fall Dataset	Scene	Object	Action	Sensor	Data
University of Rzeszow fall Detection (URFD) [33]	Indoor (office)	Single person (designate)	Fall Activities of daily living	Depth and RGB camera + accelerator	PNG 16 format and RGB images and accelerometric date
Fall Detection Dataset (FDD) [34]	Indoor (office/home/coffee room)	Single person (designated)	Fall Activities of daily living	RGB camera	RGB image
Multi-cam video dataset [35]	Indoor (office)	Single person (designated)	Fall Confounding events	RGB camera	RGB images
Postures of Fall (PoF) [36]	Indoor (campus corridor/subway station); outdoor (bus stops/streets)	Single or multi-person (random)	Fall walking Running standing	RGB camera	RGB images
SisFall: A Fall and Movement Dataset [37]	Indoor	Single person (designated)	Fall Activities of daily living	RGB camera + accelerator	RGB images

Table 3.1 - Comparison of Datasets

4 COMMERCIALIZATION

Child safety has become a great concern in the contemporary world due to many reasons and it would continue to grow further throwing child safety to wolves. Domestic accidents can be identified as a significant part of child safety and as the proposed solution is addressing issues of child safety caused due to accidents taken place at home or immediate surrounding, that alone can be utilized in commercialization as it is providing an inordinate answer to a public health matter that requires attention without a doubt.

Also as explained earlier the suggested functionality consists of main functions such as:

- Capturing safety zone outperforming all the solutions available
- Differentiating the action of falling accurately delivering promising results
- Segmentation of height and hazard

that can be straightforwardly used in commercializing the solution as there is no product available encapsulating the functionalities provided for users which ensures potential market opportunity as it is serving critical key requirements in the modern world.

As explained the novelty of the system along with the features embedded in the function providing promising results to end users outperforming all the readily available solutions in the market can be highly commercialized initiating potential for entrepreneurship.

5 GANTT CHARTS

The Gantt chart of the development process is as depicted in Figure 5.1.

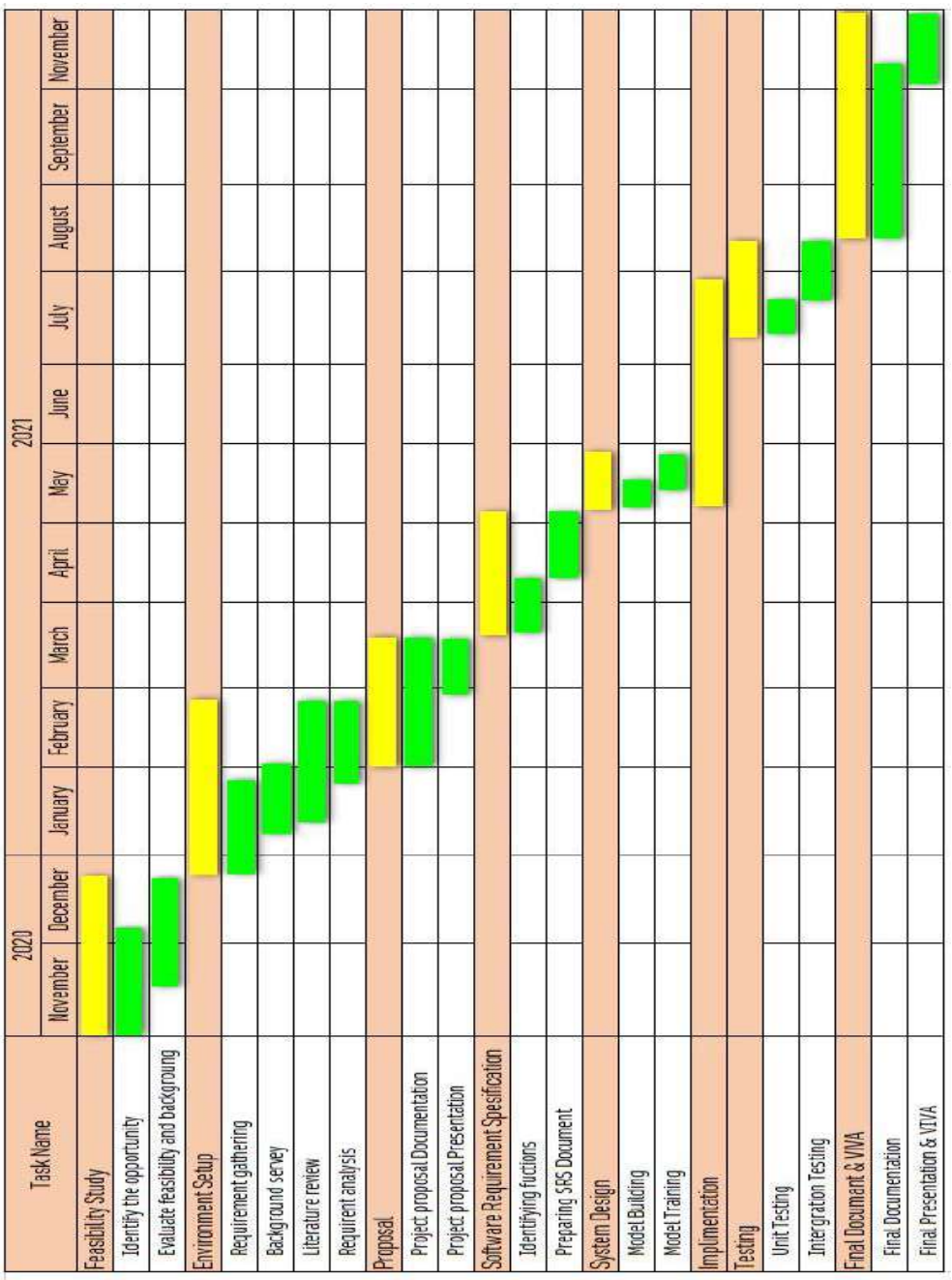

Figure 5.1 - Gantt Chart

6 BUDGET AND BUDGET JUSTIFICATION

Hardware Resource	Quantity	Estimated Price
Surveillance Camera	2	Rs 7000 *2
Speaker	2	Rs 1000 *2
Touch Sensor	1	Rs 300
Total	5	Rs 16300 /=

Table 6.1 - Expected Budget

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