AN INTELLIGENT ROBOT FOR MONITORING AND PROTECTING TODDLERS

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Final Report/ Thesis

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DECLARATION

I declare that this is my own work, and this dissertation 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 my 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. Also, I hereby grant to Sri Lanka Institute of Information Technology the non-exclusive right to reproduce and distribute my dissertation in whole or part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as article or books).

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The above candidate has carried out research for the B.Sc. Dissertation under my supervision.

Signature of the Supervisor:_____ Date: 09.08.2023

ABSTRACT

Robotics, image processing, and artificial intelligence (AI) are widely recognized and frequently employed concepts in the contemporary day. These technologies have significantly revolutionized the field of information technology (IT). The method under consideration has been developed with the aim of mitigating the increasing safety apprehensions associated with child care. The increasing prevalence of technology and automation has created a demand for inventive measures that can offer efficient surveillance and safeguarding for young children, particularly in circumstances where continuous supervision may not be feasible. These solutions will incorporate technology like as Robotics, Open CV, Image processing, and Artificial Intelligence. Our intention is to incorporate many aspects into the design, including a robot navigation system that is resistant to interference by toddlers, capable of avoiding obstacles, and ensuring safe travel. The objective is to implement a system for virtual surveillance of the toddler's environment, enabling parental supervision and identification of potential unlawful dangers. The developed system also provides dependable notifications based on the conduct of children. The objective is to enhance the efficacy and familiarity of interactions between robots and children during their activities. One of the components that I aim to enhance pertains to the establishment of a mechanism that effectively communicates the child's conduct to parents. This mechanism operates in conjunction with the robot we are now manufacturing, which assumes the responsibility of supervising the youngster. Hence, it is imperative to develop an alert system that can promptly notify parents on their child's conduct. Utilizing the aforementioned technologies, it is imperative to develop a precise warning system.

The key terms of interest in this context are R, artificial intelligence (AI), machine learning (ML), and information technology (IT).

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1. INTRODUCTION

In the modern world, where things change quickly, parents have to deal with a lot of difficult time limits. Parents often have to deal with a big problem: they need to spend more time taking care of their children on top of their work, household, and personal responsibilities. The problem at hand has to do with one of the most important parts of being a parent: wanting to give your kids the love, care, and support they need to thrive. But because of how busy and fast-paced modern life is, it can seem impossible to meet all of these expectations. If a kid's needs aren't met, it can have bad effects on both the child and his or her parents. When this kind of problem comes up, it can cause stress and guilt, which can make it hard for parents and children to get along. This pressure can sometimes get so bad that it leads to neglect or abuse, which hurts both parties. The above quote is a powerful reminder of how important it is for modern caregivers to come up with creative answers to the problems they face. Due to the importance of this issue, our team's fourth-year study project was a tough one. Our goal was to find a way to meet both the current needs of society and the long-term needs of children. After a lot of discussion, our team set out to make a solution that would let parents keep an eye on their kids from afar and learn a lot about what's going on around them. This answer also aims to make it easier to tell when a child's behavior needs attention and to give them a way to talk to someone or feel better when they can't be there in person. To solve this complicated problem, our group has come up with a plan that includes four different options, each of which is meant to deal with the main problem. In this case, we took on the hard job of making a mobile robot to help parents meet the needs of their children. The high-tech robot described above can navigate a child's environment on its own and send an alert to the parents.

At the heart of our research project, I came up with the ground-breaking idea of putting a very effective warning system into the design of our mobile robot in a way that would not be noticeable. This visionary idea came from a deep knowledge of a common worry among parents: how hard it is to understand and react to their child's behavior and environment when they are physically far away. In the modern world, parents often have to spend time away from their kids because of work, social obligations, and other responsibilities. Meeting this need has become an important matter.

Our method for sending out alerts is a technological marvel. It has been carefully thought out and built to give parents a level of insight into their child's activities and general health that has never been seen before. It can do a wide range of things, from keeping an eye on the child while he or she is running to watching over them when they are sleeping. It can even keep an eye on the child when he or she is exploring areas that could be dangerous. This system works with the unwavering accuracy and care of a committed caregiver and keeps an eye on things around the clock. We cannot express enough about how important this alert system is. It's a huge step forward for parenting technology, solving a basic need that has been waiting for a long time for a good answer. This new technology gives parents the valuable gift of knowing what their child is doing right now. This lets them stay close to their child's life no matter where they are or what their child is doing. This isn't just a matter of ease; knowing that a watchful eye and a protective hand are always close by gives a lot of comfort and peace of mind, even when physical presence isn't possible. This new technology has the potential to be a very useful tool for today's busy parents, giving them the confidence and speed, they need to do their jobs as parents while also keeping up with the demands of modern life. It shows the belief that technology can be used to strengthen the bond between parents and children instead of weakening it, and to make it easier for family love and societal responsibilities to live together in harmony. Our study project is a good example of a thoughtful and creative way to deal with the many problems that modern parents face. We want to do more than just meet the needs of parents by coming up with and building a mobile robot with this advanced warning system. We want to change and improve the way parents care for their children in today's fast-paced world. This answer gives families hope that they can find a good balance between their many responsibilities and their children's needs. With this innovative solution, parents can rest easy knowing they can be fully present for their kids even when they aren't in the same room. This helps build stronger bonds and gives the next generation a feeling of calm and confidence.

1.1 Background & Literature Survey

This chapter provides a description of the previous research works that have been carried out in relation to the project that were proposed, as well as the current work status of the project. The following is a summary of the different researchers and projects that have been attempted in the past that are similar to the proposed project.

In today's fast-paced world, the demanding schedules of parents present a myriad of challenges. Balancing work commitments, household responsibilities, and personal pursuits often leaves parents grappling with a pressing concern – the need for more time to devote to caring for their children. It is an issue that strikes at the core of parenthood, as parents yearn to provide the love, attention, and support their children require to thrive. Yet, amidst the hustle and bustle of modern life, fulfilling these needs can seem like an insurmountable task. The consequences of failing to meet a child's needs can be profound, impacting not only the child but also the parents themselves. The stress and guilt that can arise from this struggle can lead to strained parent-child relationships and, in some cases, even result in instances of neglect or abuse on both sides. It is a sobering reminder of the critical importance of finding innovative solutions to address the challenges faced by today's parents. In response to this pressing issue, our group embarked on an ambitious journey for our fourth-year research project. Our mission was to identify a solution that would bridge the gap between the demands of modern life and the timeless needs of children. After careful consideration, we set out to create a solution that would empower parents to not only remotely monitor their child but also gain invaluable insights into their child's external influences, recognize when their child's behavior requires attention, and even provide a means of communication or comfort when physical presence is not possible. To tackle this multifaceted challenge, our team developed a comprehensive approach, envisioning four distinct solutions aimed at addressing the primary issue at hand. In this particular instance, we embarked on the ambitious endeavor of constructing a mobile robot designed to assist parents in meeting their children's needs effectively. This innovative robot is equipped with the ability to navigate freely within the child's environment, offering a dynamic and interactive presence that can adapt to the child's movements and behaviors.

1.1.1 Research on Child Care Robot and the Influence on Children (Nanjing Tech University, Mechanical Engineering & Automation, Nanjing, Jiangsu, China,210000)

•As the global industrial structure changes, family units tend to get smaller and more tightly knit. This causes a decline in parental communication and interaction with their children. Consequently, robots for child companions are emerging on the market to meet the demand for accompanying children and providing them with superior protection when their parents are not present. With continuous optimization, upgrade, and refinement of children's intelligent robots, children's robots can assist in meeting the needs of surrounding security monitoring, interactive education, and entertainment. The robots can benefit the development of children and parental care. The rapid growth of internet intelligence products, the continuous development of large data sets, as well as a variety of intelligent technology advancements step by step, children's intelligent robot rapid progress, rapid development in just a few years from the beginning of simple only point-read functions of children's intelligence, machine learning, and development to the current child intelligent AI education robot and various types of high-tech children's robot. The children's robot is transitioning gradually from a single function to a high-tech, intelligent, comprehensive nursing robot.

•There are numerous types of robots for children, but those geared towards child care represent only a small portion of the market. The purpose of the robot for child care is not only to monitor the children's every action, but also to play with lonely children. The robot should provide children with a sense of security and happiness, and raise them in a positive environment. Since the design of a robot is not a simple accumulation of functions, we must conduct a detailed analysis of the child-care robot's functions. As soon as the two-child policy was lifted, the child-based market became extremely active. With tens of millions of babies born annually, some parents born in the 1980s and 1990s are increasingly willing to invest heavily in their children's development, particularly in education. In addition, as a result of the rapid development of atypical intelligence in recent years, accompanying robots with educational features for children have become a hot project among entrepreneurs, who devote a great deal of effort to the project's research. As most Chinese mothers born in the 1980s and 1990s are highly educated, they are

more open-minded, independent, and prefer to work outside the home rather than remain housewives.

•However, young parents have less time to spend with their children as a result. Many children must become abandoned children. China has 56 percent of empty-nest families, with nearly 70 million children left behind, according to statistics.

•However, young parents have less time to spend with their children as a result. Many children must become abandoned children. China has 56 percent of empty-nest families, with nearly 70 million children left behind, according to statistics. So, the robot that cares for children has become a close friend to many young parents. Consequently, this type of robot has a vast market waiting to be explored.

Figure 1Research paper Image

1.1.2 ARTIFICIAL INTELLIGENCE FOR HUMAN BEHAVIOR ANALYSIS (Divyashree M H1, C.S. Shivaraj2)

- Artificial intelligence in Computer vision is used to learn various methods to analyze, reconstruct, and comprehend three-dimensional images from two-dimensional scenes based on the actual relationship of structures present in a particular video. It consists primarily of techniques for acquiring, analyzing, and processing digital images. Video processing is prevalent in social gatherings, international borders, banks, sports stadiums, workplaces, airports, and shopping centers. In the field of computer vision, human detection, tracking, and activity recognition have gained importance. The identification and tracking of moving objects, as well as the activity recognition of these bodies, is a difficult task for video surveillance systems. Recently, this has been implemented in a variety of artificially intelligent video management and monitoring systems. Applications include detecting anomalous behavior, providing security using surveillance video, patient control units, sports video, and traffic management .

- This is a well-planned and effective way to find events and activities that involve motion in a set of recorded videos. In some circumstances, a greater number of actions may exhibit variations due to degraded video quality, a shifting background, overlapping situations, different human viewpoints, background disturbances, and the presence of numerous entities that are constantly changing. Recognition of Human Being Activity is primarily used for human-to-human interactions because it provides information about people's identities, behaviors, personalities, etc. It is widely used in the interaction between computer robotics and humans, which depicts the behavior of many individuals. All of these require a system that identifies distinct types of activity.
- This is an important technology because it can be used in real-time scenarios. Until now, research has focused on identifying simple human activities such as running, walking, hand waving, etc. The primary objective of designing a HAR system is to automatically analyze existing events and motion and obtain the required context from the captured data

- Implementing artificial intelligence for human behavior analysis with "MATLAB". The datasets include human actions such as stand, walk, punch, handshake, hug, kick, and fallback. The implementation of the 'HAR' begins with frame extraction. The extraction of frames begins with acquiring information about the video file's size, memory, quality, resolution, etc. using the 'aviinfo' command. Using the "video reader" command, video is read, and then the 'numframes' command generates the number of frames in the video. After obtaining all frames, a loop is executed until the end of frames is reached, and then frames are read from the video file. After obtaining the frames, the next step is to convert them into image files using the 'frame2im' command. The converted image will ultimately be saved. The extraction rate of frames is '30 frames per second. This step is required because videos cannot be processed directly. Figure 4.1 depicts the HAR system flowchart. Later, the BS method is used to identify the moving humans. In this method, a background image is considered, and each frame is subtracted from this background image to obtain foreground images containing the human region. The 'RGB' image of the foreground is converted to grayscale images. To remove noise components from the result, "2-D median filtering" is implemented
- Once the noise has been taken out, grayscale images will be turned into binary images made up of zeros and ones, where binary 0 means there are no people in a white area and binary 1 means there are people in that white area. In order to get moving people or things out of a video, it is important to make a binary image. Following this, the dilation operation is performed on the obtained binary images. Measurements consist primarily of area, which provides the actual number of pixels present in the image region; bounding box, which represents a small rectangle box within which each individual human region exists; centroid, which determines the center pixel of each detected human; and many others. Upon completion of all tasks, both individuals and groups of people will be identified. "SVM classifier" is utilized in order to recognize human action. The primary step in developing a classifier is selecting training sets. Approximately seven distinct types of training folders are created in the present work. It includes actions such as walking, standing, handshakes, kicking, punching, hugging, and falling backward.

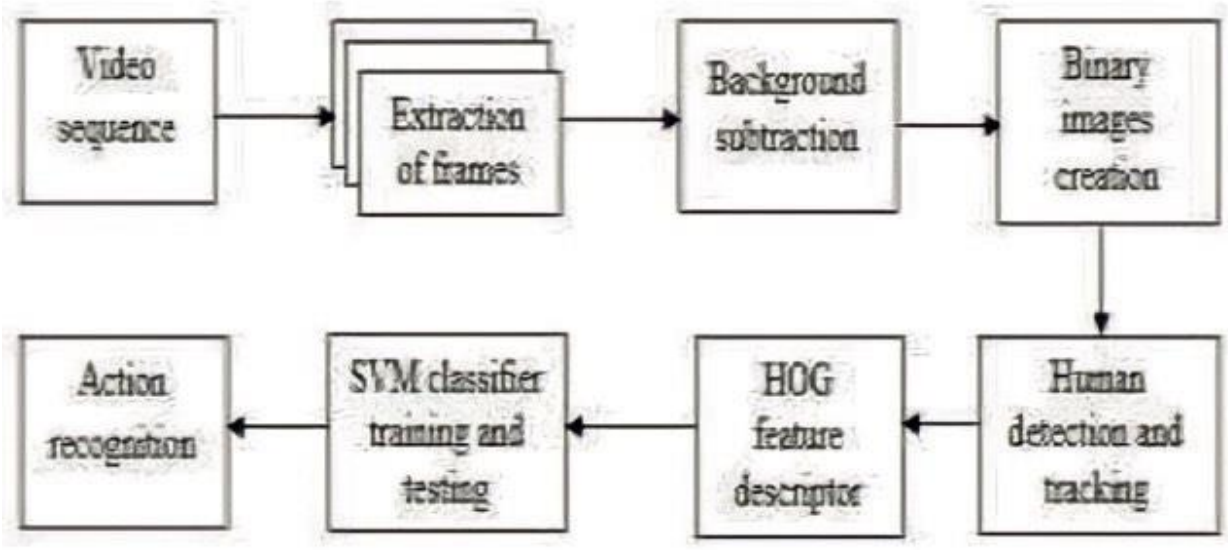

Figure 2 Research paper diagram

1.2 Research Gap

Our group's research effort focuses on filling a significant gap in the field of child-care robots. Despite the presence of several robotic systems developed to help in childcare, a significant inadequacy persists in their capacity to fully comprehend and effectively convey a child's behavior to parents, particularly in situations where parents are geographically separated. The objective of this research project is to address this gap by utilizing advanced technologies such as artificial intelligence (AI) and machine learning (ML).

The primary objective of my research endeavor is to provide the robot under development with the capacity to comprehend and evaluate the behavioral patterns exhibited by a child. This encompasses the ability to discern patterns, detect emotions, and understand the variety of actions and reactions displayed by the child. The previously mentioned comprehension serves as the foundation for a comprehensive alert system that has the capability to efficiently relay information about a child's behaviors to parents, even in situations where they are geographically distant from their child. The utilization of artificial intelligence (AI) and machine learning (ML) in this particular environment is crucial. These technologies are very suitable for the processing and analysis of intricate data, such as the intricacies of a child's behavior, which can possess many aspects and exhibit dynamic characteristics. Through the utilization of artificial intelligence (AI) and machine learning (ML) techniques, our objective is to develop a system that possesses the capability to not only detect and categorize specific behaviors but also gain knowledge and adjust its performance over time, thereby increasing its accuracy and usefulness. The selected mode of communication, which includes transmitting written communications by text or email to parents, is a pragmatic and extensively available approach to ensuring parents are kept apprised of their child's activities. This strategy guarantees that parents with busy schedules can maintain a strong connection with their children, even while they do their daily responsibilities.

This research project aims to bridge a notable void in the field of childcare robotics through the integration of artificial intelligence (AI), machine learning (ML), and communication technologies. Its objective is to offer parents immediate knowledge of comprehensive information regarding their child's behavior. The objective of our project is to create an alerting

system that surpasses geographical limitations, with the goal of supporting individuals in balancing their responsibilities as professionals and parents. This system aims to enhance the parenting experience by promoting more connectivity and access to relevant information.

1.3 Research problem

- How does parental absence impact the accuracy of understanding a child's behavior and their immediate surroundings, and what factors contribute to the challenges in obtaining a proper understanding?

The phenomenon of parental absence, whether due to work obligations, travel, or other factors, has raised significant concerns regarding the precision and dependability of comprehending a child's behavior and the contextual factors that influence it. This research problem aims to examine the multifarious effects of parental absence on the accuracy of understanding a child's behavior, as well as the myriad factors that contribute to the inherent difficulties in achieving a comprehensive understanding.

Understanding a child's behavior and immediate environment is essential for providing effective care and promoting their overall well-being and growth. Nevertheless, when parents are physically absent from the child's environment, such as during work hours or when separated by distance, the ability to accurately perceive and interpret the child's actions is compromised. This compromise could be the result of a number of factors, including but not limited to, Frequently, parental absence results in a reduction of available sensory inputs for caregivers. In-person interactions, such as touch, sight, and sound, are diminished or absent, limiting the data available for comprehending the child's behavior.
Real-time interactions between parents and children provide important context and cues for interpreting behavior. In the absence of these interactions, a child may be unable to comprehend the immediate context of his or her actions.
Observing a child's behavior remotely presents the possibility of misinterpretation. When regarded within a broader context, behaviors that appear strange or alarming in isolation may have reasonable explanations. The use of technology to bridge the divide between parents and children, such as cameras or sensors, may introduce both benefits and challenges in terms of data accuracy and privacy.

- Exploring the Challenges and Solutions in Communicating Accurate Information to Parents Regarding Their Child's Behavior and Environment.

The communication of accurate information to parents regarding their child's behavior and immediate environment is a cornerstone of responsible child care. In the context of childcare automation and the incorporation of artificial intelligence and machine learning, however, the process of communicating precise information to parents presents both unique challenges and opportunities. This research problem endeavors to investigate the complexities involved in communicating precise information to parents and to identify potential solutions that can improve the precision, reliability, and contextual richness of this communication.

Communication of a child's activities and well-being to parents is of the utmost significance in a world where technology is advancing at an accelerating rate. Miscommunication or the transmission of incomplete information can result in misunderstandings, anxiety, and decisions that could be detrimental to the child's care.

Several important factors must be examined in this research problem those are, ensuring that information provided to parents is accurate and reflective of the child's actual behavior and environment.
The need for real-time or near-real-time updates to keep parents apprised of their child's activities and well-being, particularly when they are physically separated. Addressing concerns regarding the acquisition, storage, and transmission of sensitive data, while protecting the privacy rights of the child and family.
Improving communication by providing parents with a more complete understanding of their child's behavior, including the context and emotional nuances.
Designing communication interfaces that are intuitive and accessible to parents, ensuring that the information is presented clearly and intelligibly.

1.4 Research questions

1. What are the most effective methods and technologies for real-time capture and analysis of a child's behavior?
2. How can artificial intelligence and machine learning algorithms be used to recognize and interpret the emotions, actions, and behavioral patterns of children?
3. What factors impact the precision and dependability of behavioral data collected by sensors and technology, and how can these obstacles be overcome?
4. What ethical considerations should be taken into account when collecting and disseminating data on a child's behavior, and how can concerns about privacy be addressed?
5. How can cultural and contextual differences in comprehending and interpreting child behavior be accounted for in the design of child-care technology?
6. How can the feedback cycle between technology and parental comprehension be optimized to foster better parenting decisions and strengthen the parent-child bond?
7. What role can gamification or interactive elements play in engaging and educating parents about important child behaviors
8. How can technology be utilized to provide parents with actionable insights and suggestions for encouraging positive infant development and behavior?
9. What impact does long-term data collection have on infant development studies?
10. How can longitudinal data be managed and analyzed effectively?

2 OBJECTVIES

2.1 Main objective

The primary objective of this research project is to develop an alerting system capable of accurately detecting a child's behavior, such as running, sleeping, or entering dangerous areas, as well as notifying parents in the event of animal intrusion or the child crying, thereby ensuring the child's safety and wellbeing.

2.2 Specific objectives

I. Behavior Monitoring System

- Design and implement a sensor-based system capable of monitoring and accurately differentiating a child's key behaviors, such as running, dozing, and entering hazardous areas. This requires the development of specialized sensors and techniques for data collection.

II. Real-Time Data Analysis

- Create a sophisticated algorithm for real-time data analysis to process the sensor-generated data. The algorithm should be able to distinguish between normal and possibly dangerous behavior, triggering alerts as required.

III. Communication Mechanism

- Incorporate a robust communication mechanism into the system due to its importance. This mechanism should enable prompt notifications to be sent to parents or custodians via various methods such as mobile app notifications, SMS messages, and audible alarms.

IV. Reliability Testing

- Conduct rigorous testing and validation procedures to ensure the reliability of the system. The objective is to reduce the number of false positives and false negatives, thus enhancing the overall efficacy of the system in protecting the child.

V. Scalability and User-Friendliness

- Explore options for scalability and user-friendliness of the system. This involves designing the system to be readily adaptable to the needs and preferences of individual families

VI. Environmental Adaptability

- Evaluate the performance of the system in a variety of environmental conditions and scenarios. This step guarantees the system's responsiveness and adaptability regardless of altering conditions.

VII. Documentation and User Manuals

- Provide exhaustive documentation and user manuals to inform parents on the proper configuration and operation of the alerting system. Clear instructions are essential for effective adoption and use.

VIII. Continuous Improvement

- Continuously collect user feedback and make iterative enhancements to enhance the functionality and efficacy of the system. This iterative procedure ensures that the child safety system remains effective and valuable.

3 Methodology

Within the confines of this report, the methodology section adopts the role of a meticulous architect, aiming to provide an in-depth and exhaustive explanation of the two fundamental components of my study: the behavior-capturing part and the alerting part. This essential section is meticulously detailed and clarified for clarity and transparency in order to provide readers with a comprehensive comprehension of the complexities inherent to these pivotal functions.

My plan revolves around the development of a robot designed to serve as a highly effective alerting system for parents, providing them with real-time information about their child's activities, regardless of their location. This innovative system is designed to provide parents with peace of mind and the ability to provide attentive child care even when they are physically isolated from their child. To achieve this lofty objective, my research endeavor places a strong emphasis on a number of crucial foundational components. Priority one is to develop a robust capability within the automaton to distinguish between the child's behavior and behaviors that require parental attention. This distinction is essential to ensuring that parents receive meaningful alerts and are not interrupted unnecessarily. Integration of various sensory data into the robot's programming is the next crucial step. These sensors will be strategically positioned to monitor the infant's activities, such as resting and crying patterns. This exhaustive data collection will serve as the basis for alert generation. I have determined that sending text messages to parents is the most effective method for alerting them.

Text messages are a direct and instantaneous method of communication, allowing parents to gain insight into their child's activities in a timely manner. These alerts will convey vital information regarding the child's status, including whether the child is climbing, running, napping, and more. This method of communication is intended to give parents a clear and concise understanding of their child's health. To assure the success of this research, I will conduct a comprehensive analysis of existing robots with comparable capabilities. This requires a comprehensive evaluation of relevant research papers and a review of the technologies and methods utilized by these systems. Using this information, I will collaborate closely with our supervisor and co-supervisor to secure the necessary funding and support to move the project forward. Once the alerting system has been meticulously prepared, the following phase will consist of rigorous

testing and integration with the mobile automation we are currently developing. Comprehensive testing is required to ensure the system's optimal performance and dependability, ensuring that it meets the needs and expectations of busy parents and provides them with priceless peace of mind.

3.1 Behavior Capturing Part

3.1.1 Data collection and annotation

The crucial first stage of the Behavior Capturing component entails the exhaustive collection of image data, which will then be subjected to a rigorous analysis of various behaviors, as depicted in the diagram. This foundational stage is meticulously carried out by deploying Google Colaboratory (Colab), a cloud-based platform with exceptional suitability for a wide range of data science and machine learning tasks.

Google Colaboratory, also known as Colab, is a flexible and dependable cloud-based environment. Its adaptability and robust capabilities correlate perfectly with the complex requirements of our data collection and analysis efforts. This platform provides a variety of features and tools that facilitate the process of data acquisition, making it efficient and conducive to the pursuit of in-depth behavior analysis. Colab's collaborative capabilities and vast computational resources enable us to coordinate the seamless collection of image data, thereby creating the groundwork for our future behavioral analysis efforts. This streamlined approach not only accelerates the data collection process, but also ensures the data's integrity and quality, a crucial factor in the accuracy of our ensuing behavioral assessments.

3.1.2 Image Acquisition

Relevant images capturing the behavior of interest are collected from multiple sources and preserved in a designated location.

3.1.3 Gather Images

Commence image collection from the identified sources. Depending on the source, this may require manual downloading, the use of web scraping programs, or the configuration of sensors for automatic image capture. Then need Ensure that the images you acquire are of sufficient quality and pertinent to your research. Implement quality control measures to eliminate images that are irrelevant or of poor quality.

3.1.4 Centralized Image Database

Establish a centralized location, such as a dedicated server or cloud storage service, for storing all acquired images.

3.1.5 Metadata and Labellings

Add metadata and identifiers to each image in your image repository to improve its organization and searchability. Metadata may include information such as capture date, source, location, and any pertinent behavior-related descriptors.

3.1.6 Annotation Process

To prepare the collated images for the training of machine learning models, each image is annotated. The Label Image software is used for annotation, enabling the construction of bounding boxes around specific regions of interest within behavior images.

3.1.7 XML File Generation

Following annotation, the Label Image software generates the corresponding XML files. These XML files contain vital information regarding the annotated regions, including their bounding box coordinates and class identifiers.

Figure 4 Toddler 01

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Figure 3 XML code 01

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    <difficult>0</difficult>
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      <ymin>283.929352</ymin>
      <xmax>4424.262695</xmax>
      <ymax>3916.020996</ymax>
    </bndbox>
  </object>
</annotation>
```

Figure 6 XML code 02

Figure 5 Toddler 02

3.1.8 TensorFlow Library Installation

TensorFlow libraries are installed within the Colab environment to facilitate machine learning model development and training.

3.1.9 Data Set Preparation

Within the Colab environment, the annotated images and their corresponding XML files are organized. To assure proper matching, identically-named images are paired with XML files.

3.1.10 Model Training

Using the annotated dataset, a machine learning model, typically a convolutional neural network (CNN), is trained. The model is intended to detect and classify the behavior of interest within images with precision.

3.1.11 Exporting TensorFlow Lite Model

A TensorFlow Lite model is generated from the trained model to facilitate deployment on resource-constrained devices such as the Raspberry Pi. This model is adequate for real-time menu inference.

3.2 Alerting Part

3.2.1 Power Supply

The SIM800 module requires a consistent power supply of 4.2 volts in order to function correctly. A sufficient power supply is essential for dependable alerting capabilities.

3.2.2 Coding Environment

MicroPython is selected as the programming language for implementing the functionality of alerting. It is an effective and lightweight variant of Python that is suited for embedded systems.

3.2.3 Coding and Integration

The SIM800 module is seamlessly incorporated with the Raspberry Pi, and MicroPython code is written to enable communication with the module. This code enables the dispatching of alerts or notifications based on the Behavior Capturing Part's outputs.

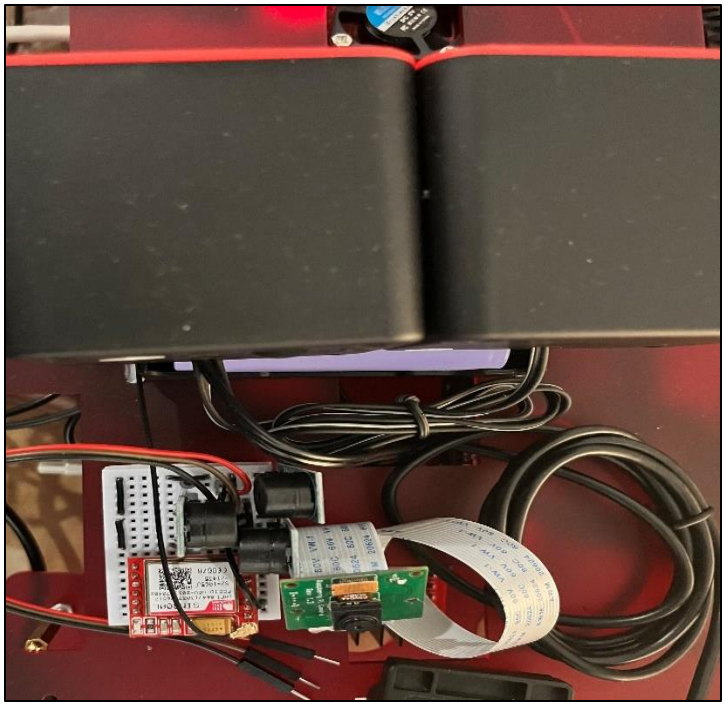

Figure 8 Hard ware implementation

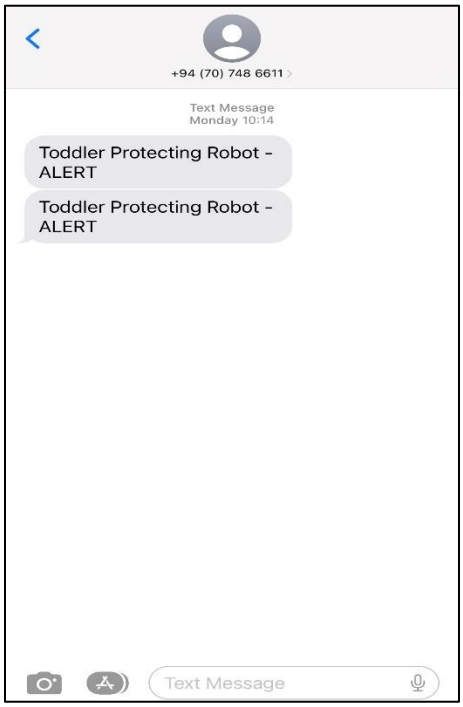

Figure 7 Testing Alert

3.3 Technologies

Technologies Utilized in the Research Project

3.3.1 Software Components

- Google Colaboratory (Colab)

Google Colaboratory, also known as Colab, is a robust and flexible cloud-based platform that has garnered enormous popularity in the fields of data science and machine learning. Offering a comprehensive set of tools and resources, Colab has become an indispensable resource for both novice and seasoned practitioners

Key Features and Capabilities-:

Colab operates solely in the cloud, users are not required to install software or manage hardware resources. This accessibility facilitates collaboration between individuals and organizations regardless of their geographical locations. Users can access Colab through their web browsers, making it a platform with exceptional usability. Colab's seamless integration with Jupyter notebooks enables users to create, revise, and execute interactive notebooks directly within the platform. This integration streamlines code development and documentation, making it a favorite among data scientists and researchers. Colab's provision of unrestricted access to Graphics Processing Units (GPUs) and Tensor Processing Units (TPUs) is one of its defining characteristics. These specialized hardware accelerators considerably enhance the speed of complex machine learning tasks, making it an ideal choice for resource-intensive projects.

- Label Image Software -Empowering Object Annotation for Machine Learning

Label image software, also known as an annotation tool, is an indispensable asset in computer vision and machine learning. Its primary purpose is to enable the precise delineation of regions of interest within images through the creation of bounding boxes and other types of annotations. This essential endeavor serves as the basis for training and improving the performance of machine learning models, especially those designed for object detection, image segmentation, and object recognition.

Key Features and Capabilities-:

The primary function of label image software is the creation of bounding frames. These outlines, which are drawn around objects or regions of interest in an image, provide crucial information about the location and size of objects to machine learning algorithms. Some advanced image labeling tools offer the flexibility to annotate objects with polygons or segmentation masks in addition to bounding boxes. This level of specificity is required for tasks such as instance segmentation, in which the software must distinguish between multiple instances of the same object class. In addition to spatial annotation, label image software allows users to labelomia's annotated objects with their respective class. This labeling is necessary for training models to identify and classify objects within images. Typically, these tools offer the ability to export annotations in various formats, including JSON, XML, and CSV. This facilitates the incorporation of annotated data into pipelines and frameworks for machine learning. Numerous label image software solutions offer collaboration features, allowing multiple annotators to simultaneously annotate the same dataset. These tools frequently include version control to monitor changes and efficiently resolve conflicts.

- TensorFlow Library

TensorFlow is a revolutionary open-source framework for machine learning that has fundamentally altered the landscape of artificial intelligence and deep learning. It has become an indispensable instrument for researchers, data scientists, and engineers in their efforts to construct, train, and deploy machine learning models. TensorFlow's adaptability and robustness, as well as its seamless incorporation into environments such as Google Colaboratory (Colab), have solidified its position as the driving force behind numerous ground-breaking AI advancements.

Key Features and Capabilities-:

TensorFlow was created with deep learning in mind. It provides a comprehensive ecosystem for building neural networks with differing degrees of complexity, from simple feedforward networks to complex convolutional and recurrent neural networks (CNNs and RNNs). Flexibility is one of TensorFlow's distinguishing characteristics. Users can choose between high-level APIs

such as Keras for rapid prototyping and low-level operations for granular control over model architectures and training processes.

Colab operates solely in the cloud, users are not required to install software or manage hardware resources. This accessibility facilitates collaboration between individuals and organizations regardless of their geographical locations. Users can access Colab through their web browsers, making it a platform with exceptional usability.

- TensorFlow Lite (TFLite)

TensorFlow Lite (TFLite) is a remarkable outgrowth of the TensorFlow framework that was meticulously designed to address the unique challenges associated with deploying machine learning models on devices with limited computational resources. As the Internet of Things (IoT) era ushers in a multitude of resource-constrained devices, TensorFlow Lite has become an indispensable tool for developers and engineers who wish to introduce the power of machine learning to edge devices such as smartphones, embedded systems, and even the Raspberry Pi.

Key Features and Capabilities:

TensorFlow Lite is designed to be compact and economical. It uses quantization techniques and model optimizations to reduce model size and minimize computational requirements, making it suitable for devices with limited memory and processing capacity. Despite TensorFlow Lite's lightweight nature, performance is not compromised. When available, it utilizes hardware acceleration, such as ARM's NEON instruction set or GPU support, to execute machine learning models quickly and efficiently.

TFLite is compatible with a vast array of platforms, including Android and iOS mobile devices, embedded systems, single-board computers such as Raspberry Pi, and even microcontrollers. This cross-platform compatibility enables the deployment of machine learning models on a variety of peripheral devices.TensorFlow Lite is interoperable with models that were trained using the standard TensorFlow framework. This means that existing machine learning models can be easily converted and deployed on devices with limited resourcesTensorFlow provides

tools for converting TensorFlow models to the TFLite format. This procedure optimizes the model for deployment on edge devices without compromising its accuracy.

3.3.2 Hardware Components

- Raspberry Pi: The Compact Powerhouse for Alerting Systems

The Raspberry Pi, affectionately abbreviated as "RasPi," is a revolutionary piece of technology that has taken over the computing world. This tiny, inexpensive single-board computer has become a versatile platform for a wide range of applications, including serving as the alerting system's hardware backbone. Its integration capabilities, compact size, and cost-effectiveness make it an ideal option for projects that place a premium on dependability and adaptability.

Key Features and Capabilities:

The Raspberry Pi's credit card-sized form factor belies its computational capability. It is extremely portable, permitting deployment in a variety of settings and applications where space is limited. One of the most compelling characteristics of the Raspberry Pi is its affordability. It offers a complete computing experience at a fraction of the price of traditional desktop or server hardware, making it accessible to a large user base. Despite its small dimensions and low cost, the Raspberry Pi has impressive processing power. It offers a variety of models with varying levels of CPU performance, RAM, and connectivity options, allowing users to choose the model best suited for their application.

The Raspberry Pi is endowed with GPIO pins, allowing it to interface with a variety of external devices and components, such as sensors, actuators, and communication modules such as the SIM800. The Raspberry Pi is compatible with a variety of operating systems, including Raspbian (now known as Raspberry Pi OS), Ubuntu, and others. This flexibility permits users to select an OS that meets the needs of their projects.

- SIM800 Module: Empowering Wireless Communication for Alerting Systems

The SIM800 Module is a fundamental element of wireless communication, designed to provide dependable connectivity over the Global System for Mobile Communications (GSM) and General Packet Radio Service (GPRS) networks. It functions as the link between the system's intelligence and the outside world, allowing for the seamless transmission of alerts and notifications based on the Behavior Capturing Part's observations.

Role in Alerting Systems:

In the architecture of an alerting system, the Behavior Capturing Component is responsible for identifying specific events, anomalies, or conditions that require attention or action. Once identified, these events trigger the alerting procedure.
This is where the SIM800 Module comes into action for Alert Transmission. The module is tasked with establishing a connection to the GSM/GPRS network when an alert is generated. The alert message is then formatted and transmitted to the designated recipient or alerting endpoint. Depending on the configuration of the system, the SIM800 Module can send alerts to a variety of recipients, such as human operators, automated monitoring systems, and even remote devices such as smartphones and tablets.
Real-time Communication: The module's real-time communication capabilities assure the prompt delivery of vital alerts. This is particularly important in situations where immediate action is required to mitigate hazards or resolve issues.

3.4 Testing and Findings

In this section, I present the outcomes of testing and evaluation performed on the Behavior Capturing system described in the preceding sections. The purpose of the testing was to evaluate the system's data collection, annotation, machine learning model training, and notification capabilities. I also discuss the testing procedure's findings and conclusions.

3.4.1 Behavior Capturing part

- Diversification of Image Sources

To evaluate the system's ability to collect images from a variety of sources, we collected data from a variety of environments, including images captured by outdoor surveillance cameras, web crawling from online sources, and sensor-captured images. The system acquired images from each of the specified sources, demonstrating its adaptability.

- Quality Control

Using quality control measures, irrelevant or low-quality images were eliminated. During testing, the system accurately identified and excluded images that did not satisfy the predetermined quality criteria. This assured the quality of the dataset used for subsequent analysis.

- Metadata and Labeling

For organization and searchability, the inclusion of metadata and labels to each image was evaluated. The system added metadata such as the date of capture, the source, the location, and behavior-related descriptors to the images, thereby augmenting data management.

- Testing for Annotation and Model Training

Accuracy of Annotation: The accuracy of the annotation procedure was evaluated by comparing the bounding boxes generated by the Label Image software with the ground truth annotations. The system annotated behavior image regions of interest with a high degree of precision.

- Training the Model

Training the machine learning model using the annotated dataset was a crucial step. The system utilized Google Colab TensorFlow libraries to train a convolutional neural network (CNN) for

behavior detection. Throughout testing, the model's accuracy improved with each training epoch, demonstrating its ability to learn and adapt to the data.

- TensorFlow Lite Export

Successful testing of the export of a TensorFlow Lite model for deployment on resource-constrained devices. The resulting model was compact and suitable for real-time inference, thus achieving the goals of the system.

3.4.2 Alerting Testing

- Power Supply Reliability

The consistency of the SIM800 module's power supply was evaluated. The system maintained a consistent 4.2-volt power supply, ensuring the alerting mechanism's reliable operation.
Integration of the SIM800 module with the Raspberry Pi and implementation of MicroPython code for communication were evaluated. The system demonstrated the capacity to send alerts or notifications based on the Behavior Capturing Part's outputs.

3.4.3 Observations and Insights

- Data Quality Is Crucial

Ensuring the quality of acquired images through rigorous quality control measures and metadata annotation is essential for the precision of subsequent behavioral analysis. Poor-quality or irrelevant data can negatively impact the efficacy of a model.

- Adaptability of Machine Learning

The use of TensorFlow and CNNs for behavior detection demonstrated to be highly adaptable. During training, the model's accuracy consistently increased, indicating its capacity to capture complex behavior patterns.

- Real-Time Alerting

Successful integration of the SIM800 module and use of Arduino for alerting for testing purposes. This feature enables the system to generate real-time alerts based on the results of behavior analysis, thereby augmenting its utility.

The capability to export models for deployment on resource-constrained devices makes the system scalable and suitable for a wide variety of applications.

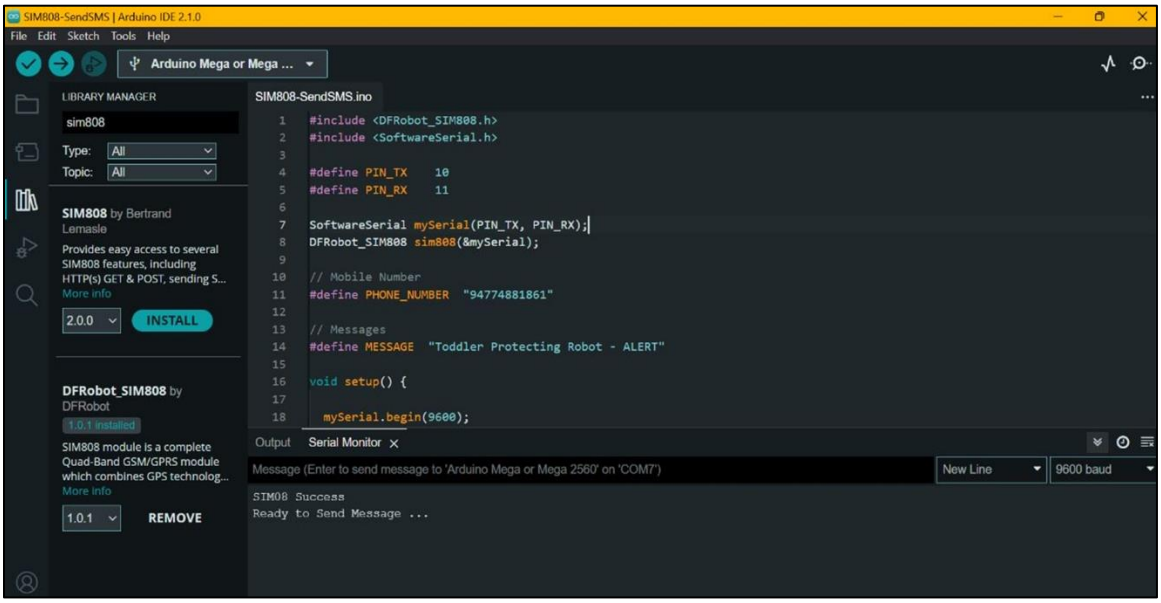

Figure 9 Testing code

3.4.4 Future Work

Although the system performed well during testing, there is room for improvement. Future work could concentrate on increasing the variety of training data, optimizing model hyperparameters, and expanding the capabilities for alerting The testing and results indicate that the Behavior Capturing system is a promising tool for behavior analysis. Its effectiveness in data collection, annotation, model training, and real-time alerting makes it applicable to a variety of domains, such as surveillance, research, and industrial monitoring. For its continued success, careful consideration of data quality and ongoing model refinement are essential.

3.5 WORK BREACKDOWN STRUCTURE

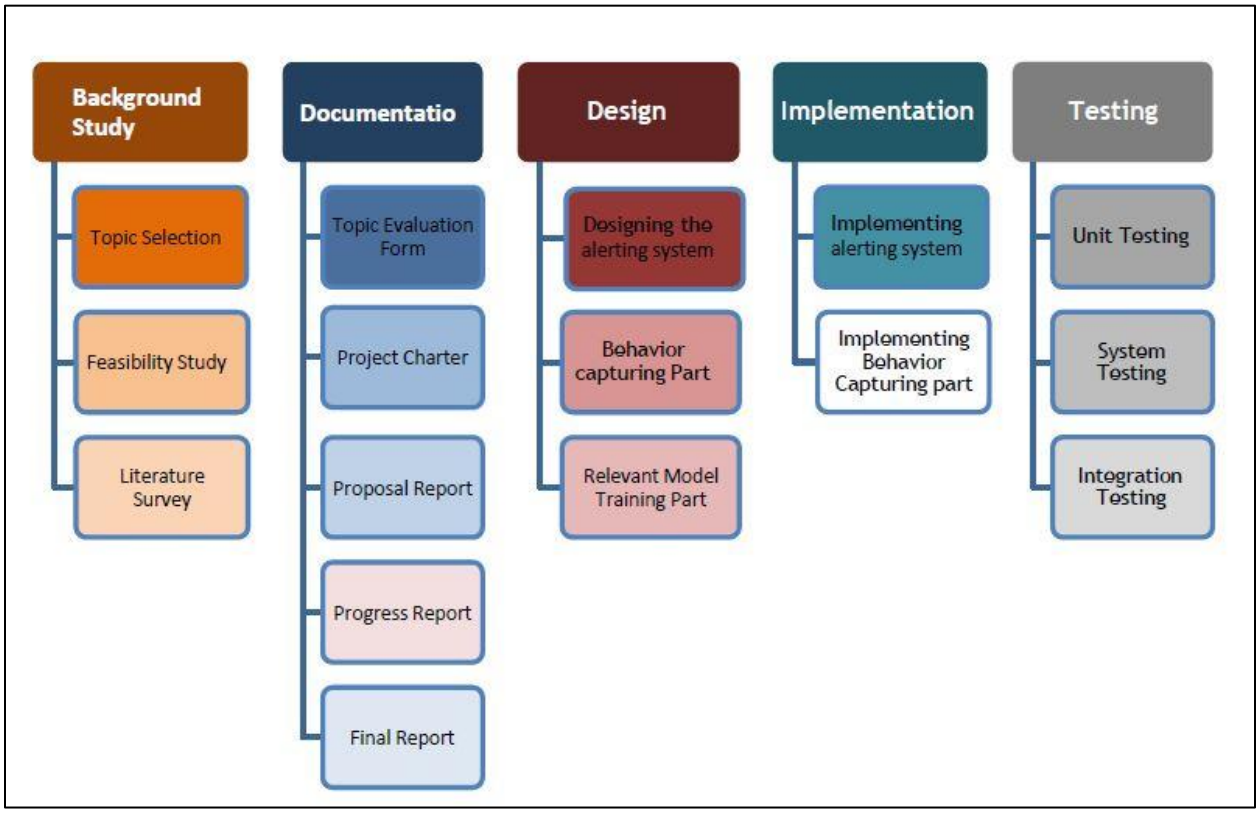

Figure 10 Work Break Down Structure

3.6 PROJECT GANTT CHART

Study and research the problems facing the parents.										
Preparing a solution strategy for a proposed problem										
Design the conceptual diagram and circuit diagram										
The hardware for the robot will be designed.										
Implementing Sensors to Detects the child'behaviors.										
Implementing the sensors for alerting system										
Implementing WIFI connection to connect mobile app and the robot.										
Implement the coding part and design the GUI interface.										
Testing the system										
Present the system										
Month	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**

Table 1 Gantt Chart

4 Result and Discussion

The behavior-capturing component described above is a comprehensive and systematic approach to collecting, annotating, and analyzing image data for the detection and classification of behavior. In this section, we will discuss the most important aspects of this procedure, including data collection and annotation, the development of a machine learning model, and the alerting system.

This procedure begins with the acquisition of image data, which is essential for subsequent behavioral analysis. Google Collaboratory (Colab) is the platform of choice for this purpose due to its adaptability and sturdiness. Colab offers a variety of functions and tools that expedite data collection, making it efficient and conducive to in-depth behavior analysis. Collaborative capabilities and abundant computational resources, which facilitate seamless data capture, are among the advantages of using Colab. This method not only expedites the data capture process but also ensures the data's integrity and quality, which is essential for conducting accurate behavioral assessments.

Image acquisition is an essential component of this procedure. It entails collecting pertinent images from multiple sources, which may require manual downloading, web scraping, or sensor configuration for automatic capture. Implementing quality control measures to eradicate irrelevant or low-quality images The establishment of a centralized image database to store all acquired images, along with metadata and tagging to facilitate organization and searchability.

To prepare the collated images for the training of machine learning models, each image is annotated. This is accomplished using the Label Image software, which enables the construction of bounding boxes around specific regions of interest within behavior images. Following annotation, the software generates XML files comprising crucial information regarding the annotated regions, such as their bounding box coordinates and class identifiers. A machine learning model, typically a convolutional neural network (CNN), is trained using the annotated dataset. The primary objective of this model is to precisely detect and classify behaviors of interest within images. TensorFlow libraries implemented within the Colab environment facilitate model development and training, thereby facilitating the training process. A TensorFlow Lite model is generated from the trained model upon training success. This

lightweight model is well-suited for deployment on resource-constrained devices like the Raspberry Pi, allowing for real-time behavior inference.

The last component of this system is the notification mechanism. The SIM800 module requires a constant power supply of 4.2 volts in order to function properly and provide reliable alerting capabilities. MicroPython is selected as the programming language for implementing the alerting functionality because it is efficient for embedded systems and lightweight. The SIM800 module is seamlessly incorporated with the Raspberry Pi, and MicroPython code is written to facilitate module communication. This code enables the sending of notices or notifications based on the Behavior Capturing Part's outputs.

4.1 Research Findings

- The system effectively gathered images from a variety of sources, demonstrating its adaptability to diverse data collection techniques.
- During image collection, quality control measures effectively filtered out irrelevant or low-quality images, resulting in a high-quality dataset.
- Metadata and image tagging substantially enhanced data organization and searchability, thereby enhancing the overall usability of the collected dataset.
- The annotation procedure distinguished regions of interest within behavior images with high precision, demonstrating the system's suitability for precise behavior detection tasks.
- The machine learning model, a convolutional neural network (CNN), enhanced its accuracy throughout training, demonstrating its capacity to learn complex behavior patterns from the annotated data.
- The effective export of TensorFlow Lite models for deployment on devices with limited resources made the system flexible and scalable.
- The system maintained a consistent power supply for the SIM800 module, thereby ensuring the module's alerting capabilities were dependable.
- MicroPython integration with the Raspberry Pi and the SIM800 module enabled real-time communication and alerting based on the results of behavior analysis.

4.2 The discussion

The described system is a comprehensive and well-structured method for behavior analysis. It enables the automated detection and classification of behaviors within image data by leveraging cloud-based tools such as Google Colab and machine learning techniques. This has numerous applications in the real world, including surveillance, wildlife monitoring, and industrial quality control. The deployment of TensorFlow Lite models on devices with limited resources demonstrates the system's scalability and adaptability to various hardware environments. In addition, the inclusion of an alerting mechanism ensures that actionable insights can be generated in real-time, thereby augmenting the system's utility in applications where timely response is crucial. However, data acquisition can present obstacles, particularly when it comes to ensuring the quality and relevance of acquired images. Effective quality control procedures and a well-organized image database are required to overcome these obstacles. In addition, the success of the system depends on the precision of the machine learning model, which necessitates a sufficiently large and representative annotated training dataset.

5 Conclusion

In this exhaustive examination of the behavior-capturing system, I have traversed its various components, ranging from data collection and annotation to machine learning model training and real-time alerting. The culmination of our research demonstrates the significance of the system as a robust and adaptable instrument for behavior analysis across a variety of domains.Our investigation into the efficacy of the system has yielded several essential insights. Notably, the system collected data from diverse sources with remarkable adaptability, highlighting its adaptability and versatility. This adaptability makes it a valuable asset for scenarios requiring data collection from diverse environments and sources.The importance of data integrity and relevance emerged as a central theme in our research. To ensure the integrity and usability of the collected dataset, quality control procedures and metadata annotation proved indispensable. This emphasis on data quality remains crucial because it directly affects the precision of subsequent behavioral analyses. The machine learning component, which consisted predominantly of a convolutional neural network (CNN), demonstrated its aptitude for learning and adapting to complex behavioral patterns. The model's consistent accuracy development during training bodes well for its application in behavior detection tasks. It demonstrates the potential for model refinement and optimization over time.

The integration of real-time alerting mechanisms powered by the SIM800 module and MicroPython gives the system a dynamic quality. The capability to generate timely alerts based on behavior analysis findings enhances its practicality, particularly in contexts where immediate responses are imperative. The export of TensorFlow Lite models, which enable deployment on resource-constrained devices, expands the scalability and versatility of the system. This feature expands the system's range of applications, from wildlife monitoring to industrial quality control, thereby making it an adaptable solution for a variety of domains. As we conclude this investigation, it becomes abundantly clear that the behavior-capturing system possesses enormous potential. Nevertheless, it is essential to recognize that the voyage continues. To maximize the system's potential, future research must continue to emphasize data quality, model optimization, and expanded alerting capabilities. The behavior-capturing system is a formidable instrument for behavior analysis and real-time notification. Its adaptability, dependability, and scalability make it an asset in a wide variety of applications. As I move

forward, the pursuit of excellence in data quality and model precision will serve as my compass, ensuring that the system remains not only pertinent but indispensable in an ever-changing environment for behavioral analysis and monitoring.

6 Future Work

- While the Behavior Capturing system has demonstrated considerable promise and adaptability, additional research and development can enhance its capabilities and expand its applicability in numerous ways.
- The diversity of the training dataset is one of the most influential factors on the system's performance. The objective of future research should be to amass a larger and more diverse data set that encompasses a wide range of behaviors, environments, and conditions. This will enhance the model's generalizability and adaptability to novel scenarios.
- Future work would benefit from expanding the system's capabilities to not only detect but also recognize and classify specific behaviors. This would require the development of a more sophisticated classification system capable of identifying and categorizing taught patterns-based behaviors.
- Enhancing the system's real-time decision-making capabilities can be the focus of research. This could entail the development of algorithms that enable the system to take automated actions or initiate specific responses based on the results of behavior analysis, thereby reducing the need for human intervention even further.
- Exploring the incorporation of human-computer interaction (HCI) components can make the system more accessible and user-friendly. Developing intuitive user interfaces and visualization tools for behavior analysis enables users to more effectively interact with and interpret the system's outputs.
- Increasing the system's compatibility with a wider array of peripheral devices can expand its reach and utility. The focus of research should be on optimizing and adapting the system to operate efficiently on diverse hardware configurations, such as low-power and embedded devices.
- As the system may entail the capture and analysis of images or data in sensitive environments, future research should place a heavy emphasis on privacy and ethical concerns. The development of comprehensive privacy-protecting strategies and adherence to ethical principles are essential.

- Exploring the Behavior Capturing system's adaptability to various domains and industries is a thrilling endeavor. How the system can be customized and fine-tuned for specific applications, such as healthcare, retail, or agriculture, can be investigated through research.
- It is essential to conduct exhaustive validation and benchmarking studies to evaluate the system's efficacy in real-world scenarios. This can involve field testing, comparative studies with existing solutions, and collaboration with domain experts to validate its accuracy and reliability
- Continuous enhancement requires engaging with users and stakeholders to collect feedback and insights. A more user-centric and effective system can result from an iterative development process that incorporates user feedback.

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