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A Comparative Study Between GSM and CNN to Develop Gesture Detection Based Alert System for Women's Safety

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Abstract

Women's safety is a pressing issue in today's world, and technology plays a crucial role in addressing it. This project introduces a facial expression recognition device that uses convolutional neural network (CNN) technology and develops its comparison with an expression system with the use of GSM. Unlike traditional methods that rely on manual activation or dedicated devices, this system instantly reacts to threatening situations by recognizing predefined gestures and ensuring swift alerts without drawing attention. The device collects a large dataset of labeled facial images that may include various facial expressions, emotions, and other facial features. Facial analysis software maps out the facial features, converts them mathematically, and stores them as 'faceprints' or other representations. Through the use of supervised learning techniques, the model is taught to identify certain face features and the labels or categories that correspond with them. As the camera of the device captures a face, the CNN springs into action, comparing features with what it has learned to pinpoint potential threats. The device's dynamic alert system, specifically designed for women's safety, unleashes auditory cues upon detecting a potential threat and ensures immediate user notification. To respond quickly in emergencies, users can also assume control by manually triggering alarms. The device facilitates seamless communication with selected contacts, allowing women to notify others promptly about detected threats. The synergy between CNN technology, user control, and communication features creates a powerful tool for women's safety. In the comparative study, it is found that the alert system developed with the aid of CNN is more effective and reliable compared to an alert system developed with the aid of GSM modules.

Keywords: Facial expression recognition, convolution neural network (CNN), women's safety, threat detection, GSM modules

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INTRODUCTION

Background

The world is plagued by violence against women (VAW), which robs people of millions of conventions and accomplishes gender equality. In terms of math, this translates to 243,000 women and girls losing their virtues annually, or almost one death per hour [1]. However, discrimination is still ongoing because men are harassing and stalking 818 million women worldwide, robbing them of their freedom and sense of security [2]. They represent the reality of millions of women who go about their daily lives taking care of their families, all while battling daily threats and living in constant fear of being violently harmed [3, 4]. There is no denying the existence of effective methods for addressing these problems. In this project, we propose the creation of a device that leverages the power of Convolution Neural Networks (CNNs) to address this pressing issue. The device utilizes CNNs to analyze facial expressions and body language, enabling it to identify patterns associated with inappropriate or threatening behaviors. By integrating this technology into a compact and user-friendly device, we aimed to provide women with a tool that enhances their sense of security and empowers them to navigate their surroundings confidently. To achieve this, we began by training the CNN model using a dataset of labeled images representing various expressions and behaviors.

This training process enables the CNN to learn and recognize patterns indicative of potential threats. Once trained, the CNN is seamlessly integrated into the women's safety device, which captures and analyzes images in real time. Additionally, the device features a manual control option that allows users to activate a GSM mechanism for immediate assistance from authorities or notify their loved ones if they feel unsafe. By combining cutting-edge CNN technology with user empowerment, this project aimed to provide a comprehensive solution for women's safety. The ultimate goal is to create a device that not only enhances personal security but also instills a sense of confidence and freedom in women in their daily lives.

Research Problem

Women are not safe anywhere and are more at risk when they travel alone on desolate highways. When a woman senses danger, she must intervene to activate handheld devices that are currently available for her safety. For example, he/she must shake the device or press a button. However, for some reason, the function of the safety device remains unfulfilled if a woman is in danger and cannot activate it in time. Women's safety is seen as one of the most crucial concerns in a nation like India, where the incidence of crime—which includes rapes, murders, burglaries, and many other crimes—is thought to be higher than the pace of the population increase. India has the highest rate of child brides worldwide and is considered one of the world's most dangerous countries for women, according to Thomson Reuters Foundation analysis. Over 39,000 rapes were recorded in 2016. To address the issue of women's safety and the drawbacks of current gadgets, this proposal suggests a gesture-based alert system.

Motivation

The inception of this project was catalyzed by a profound recognition of the alarming statistics surrounding violence and harassment against women globally. Drawing inspiration from the growing discourse on women's safety and the imperative for actionable solutions, we embarked on a journey to develop a tangible response to this societal challenge. Through extensive research and consultation with experts in various fields, we gain insights into the multifaceted nature of the problem and the potential role of technology in mitigating its impact. Armed with a sense of purpose and a commitment to innovation, we set out to create a device that not only detects threats but also empowers women to take control of their safety [5–7]. Recognizing the urgency and complexity, our team thoroughly researched various contexts and scenarios in which women face safety risks. By consulting experts, we gained a comprehensive understanding of the challenges and gaps in safety measures.

This team effort guided our design, ensuring that our solution met the unique needs of women in different environments. Leveraging advancements in artificial intelligence, machine learning, and sensor technology, we developed a device capable of accurately detecting and responding to potential threats in real time, thereby we aspire to create a future where every woman can live free from fear and insecurity, empowered to pursue her dreams and aspirations without compromise.

Objectives

This study aims to develop a gesture detection based alert system for enhancing safety and security measures.

The objectives of the project are as follows;

- To detect potential threats by analyzing facial gestures in real time.
- To stop threats, physical attacks, sexual assaults, and other types of harassment and violence.
- To give women a quick and covert means of requesting assistance during an emergency. To enable women to send alerts to emergency contacts or authorities without drawing unnecessary attention.
- To give women control over their safety and encourage independence.
- To design a user-friendly device for women from all backgrounds, including those with disabilities.

MATERIALS REQUIRED

Raspberry Pi Model B

An image processing algorithm was used to train the Raspberry Pi system. In this instance, a Raspberry Pi 4 Model B is used, which has a powerful 64-bit quad-core processor that operates at 1.5 GHz, a GPIO header for connecting sensors, dual-display support via two micro-HDMI ports supporting resolutions up to 4 K, hardware video decoding at up to 4Kp60, up to 8GB of RAM, and the ease of adding an external microphone or camera. Raspberry Pi has a dedicated camera input port that allows users to record HD videos and high-resolution photos. The output voltage was 5V/3ADC and was connected via a micro-USB connector. Bluetooth and dual-band wireless LAN have been certified for modular compliance. The Raspberry Pi as shown in Figure 1 was connected to a GSM module, buzzer, and camera [8].

SIM 800L GSM Module

The SIM800L GSM module illustrated in Figure 2 is a versatile and compact device commonly used for communication in various applications, such as the Internet of Things (IoT), remote monitoring, and tracking systems. It integrates GSM/GPRS functionality, enabling it to connect to mobile networks for data transmission and communication. Owing to its small form factor and low power consumption, the SIM800L is popular for projects requiring reliable cellular connectivity in constrained environments. Its features include support for SMS, voice calls, GPRS data transfer, and compatibility with standard Trip Unit rating commands for easy integration into various projects and systems [9].

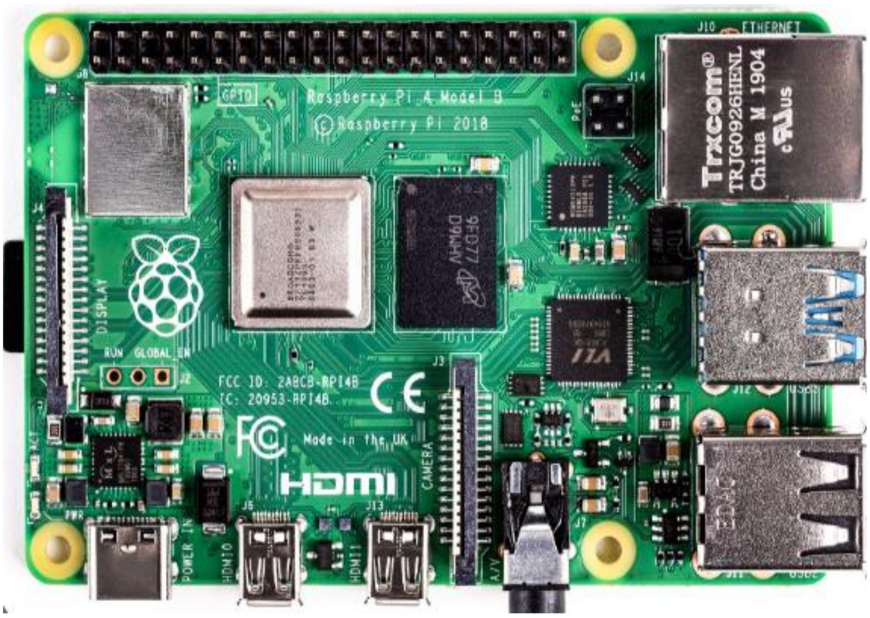

Figure 1. Raspberry Pi.

Figure 2. GSM model.

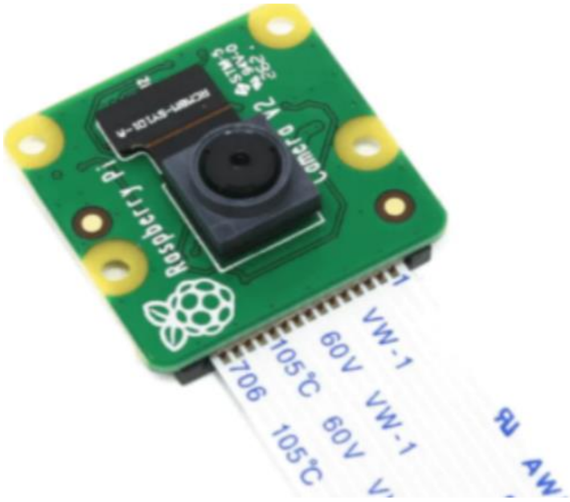

Figure 3. Raspberry Pi Camera.

PI Camera V2

The Raspberry Pi Camera with a fixed focus lens is shown in Figure 3. Module v2 is an add-on board specifically built for Raspberry Pi, which houses a high-quality 8-megapixel Sony IMX219 image sensor. It can produce static images up to 3280 × 2464 pixels and can handle videos at resolutions of 1080p30, 720p60, and 640 × 480. One module that can be used to capture images and high-definition films is the Pi camera module. The Raspberry Pi board has a dedicated CSI (Camera Serial Interface) to which the Pi cam can be attached using a 15-pin ribbon cable [10].

Buzzer

An electrical gadget that uses piezoelectric phenomena to produce sound is called a piezoelectric buzzer, as shown in Figure 4. Certain materials, such as quartz, ceramics, and certain crystals, exhibit this effect when mechanical stress is applied to them because it generates an electric charge. Conversely, applying an electric charge to these materials causes deformation, producing mechanical vibrations and sound waves [8].

Figure 4. 2D model buzzer.

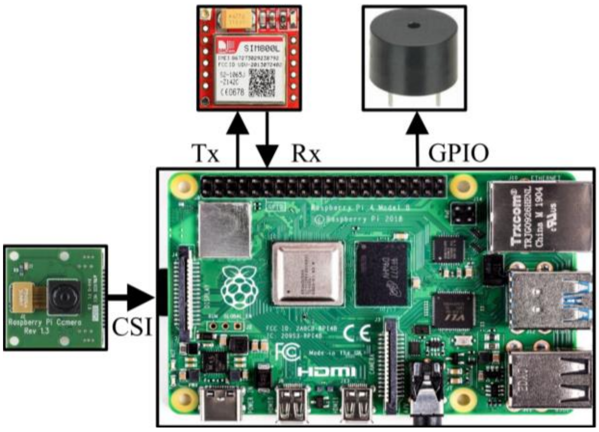

Figure 5. Circuit diagram of the proposed system.

Circuit Diagram

The hardware setup of the circuit diagram is shown in Figure 5.

WORKING

The system performs binary classification of inputs using a CNN by analyzing the facial expressions of input images and classifying them into one of two possible categories (threatening or non-threatening). It begins by feeding the input image into the CNN, which consists of multiple layers of convolution and pooling operations. These layers help the network extract meaningful features from the facial expressions. Following their extraction, the features are routed through fully connected layers that classify data using the features that have been learned. The probability distribution over various facial expressions is the output of the network. During the training phase, the CNN was trained on a large dataset of labeled facial expressions to learn the patterns and features associated with each expression, the CNN is iteratively optimized using backpropagation and gradient descent algorithms to minimize the classification error and improve its ability to distinguish between threatening and non-threatening facial expressions. Validation data were used to assess the model's performance and guarantee its generalizability. In real-time applications, the system can capture live videos or images, process them using a CNN, and provide real-time predictions of a person’s facial expression. This capability allows for immediate response and intervention in potentially threatening situations, thereby enhancing overall safety and security measures. By continuously analyzing and interpreting facial expressions, the system can provide valuable insights into the emotional state of individuals, aiding in the early detection of potential risks, and facilitating timely assistance. A flowchart of the test is shown in Figure 6.

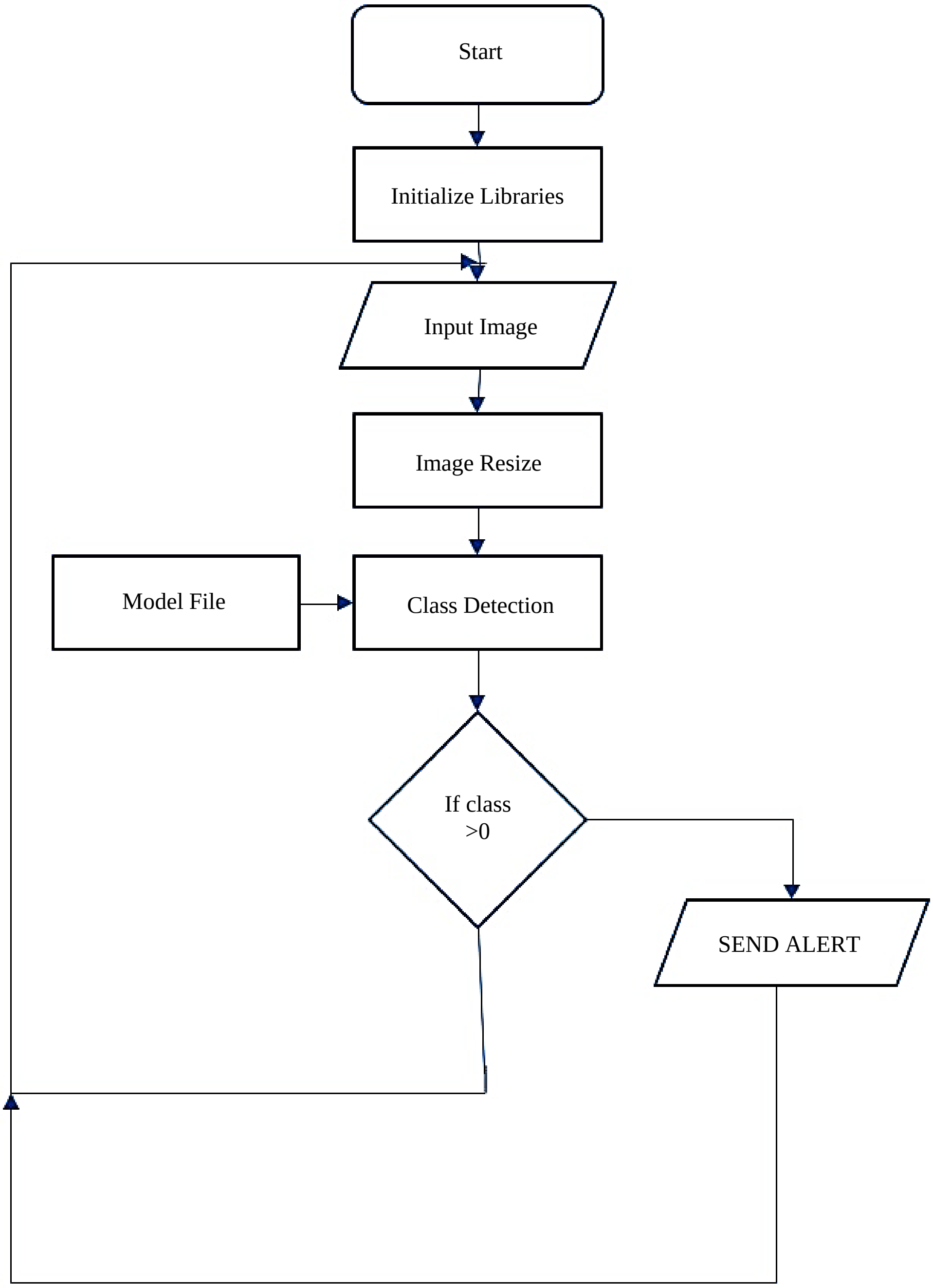

Figure 6. Flowchart of testing.

CONCLUSION

In a comparative study, it was found that an alert system developed with the aid of a CNN is more effective and reliable than an alert system developed with the aid of GSM modules. The proposed female safety device marks a significant advancement in leveraging technology to address societal challenges. The demonstrated effectiveness of CNN in facial expression recognition underscores the system's potential to enhance safety protocols and facilitate rapid responses in critical situations. With its ability to provide immediate alerts and seamless communication with authorities, this system offers a crucial layer of protection to women, empowering them to navigate their environments with greater security and confidence. The development of an alert system can be more innovative if the use of a CNN in addition to an ESP 32 microcontroller and IoT is used to create a hybrid alert system, which should be considered in future studies.

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