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Women & Child Safety Glove based on Raspberry Pi and Machine Learning

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Abstract: ***Women safety has become a matter of utmost concern in the current times. Most cases of women harassment occur due to the lack of proper help at the right time to the victim. Technology like smart watches, mobile applications have been used in the past to combat this issue, however, nearly all of them have the following three problems.***

1) ***They depend heavily on smartphones***
2) ***They depend on some kind of Human Interaction to work***
3) ***Due to the dependence on phones, they cannot be used by school going children***

In this paper, I propose the solution to these problems, a device that provides absolute security while also taking care of the problems faced by other devices.

Figure 1 Women Safety Smart Glove

Keywords: Artificial Intelligence, Emotion Recognition, Sound analysis, pulse detection, GSM, women safety, lists, Raspberry Pi, Smart Glove, Machine learning.

I. INTRODUCTION

The device is a Smart Glove, which has a Raspberry Pi, Pi camera module, a microphone, force sensors, pulse sensors, ultrasonic sensor and GSM module embedded in it. The Glove uses AI algorithms to detect danger based on Multi-Sensory Inputs from the above mentioned faculties. The Glove automatically detects danger and sends an SOS response without the victim having to trigger the device to do so. Moreover, it is a self-sufficient device, i.e.; it doesn't need a phone or Wi-Fi to work. The GSM module connects to cellular data and transmits SMS when triggered by the Pi to do so. Here is a brief description of all the faculties and how they sense danger. (All the faculties return "True" when they sense danger).

Pi Camera: Performs real-time emotion recognition and weapon detection for visible threats. Outputs "True" if emotion detected is angry, fearful, or sad and if weapons are found in the vicinity

Figure 2 Pi Camera

1) *Microphone:* Performs real-time audio analysis to listen for screaming etc. Returns "True" if ambient sound is beyond a particular frequency and amplitude threshold.
2) *Pulse Sensor:* Scans for increased heart rates as a person's heart rate increases abnormally during a panic situation and stays like that as long as the danger is there. The sensors check whether an erratic heartbeat persists over an interval of time and ignores momentary increase in heart rates. If the heartbeat is beyond a threshold the sensor Returns "True".

Figure 3 Pulse Sensor

3) *Force Sensor:* Scans for the change in pressure applied on the device which might happen during strangling of the victim by the attacker OR when the attacker tries to break/harm the device. The sensor returns "True" if the pressure applied is beyond a threshold value.

Figure 4 Force Sensor

4) *Ultrasonic Sensor (HC-04):* Scans for people. If multiple attackers try to surround the victim, the sensor senses their presence and reports danger. Returns "True" if the attacker comes inside the circle of a threshold radius value

Figure 5 Ultrasonic Sensor

5) *Accelerometer:* Detects change in the orientation of the Glove. If the Glove is violently made to move about the 3 coordinate axes very frequently in a very short period of time, the accelerometer would interpret it as mishandling of the Glove, which could be a possibility during an attack. For example, when the attacker tries to take out the glove and throw it away. Returns "True" if the above happens.

Figure 6 Accelerometer

6) *GSM SIM800L Module:* (Requires working SIM card) Connects to Cellular Data and sends SMS to the police and the relatives of the victim along with the images and location of the victim and the attacker after the Pi has predicted danger.

Figure 7 GSM SIM800L

The Pi takes the final decision of whether the person is actually in danger by collecting reports from all the faculties. If most of them return True then only it returns the final verdict of whether a person is actually in danger or not. The device is fool-proof as it triggers the distress signal only when most of the faculties have categorized their respective stimuli as potential threats and this is possible only when an actual situation arises.

7) *Related Work:* Projects similar to mine have been developed in the past, for example, in paper [1]. I improvised their concept by, using a Raspberry Pi instead of an Arduino and I used AI concepts like Haar Cascades and Fast Fourier Transform for object recognition and audio analysis respectively.

II. METHODOLOGY

High rate of crime against women and children is the main motivation behind this project. The Raspberry Pi is the core of the Safety device. The programming has been done in Python 3.6 and the primary libraries used are Tensorflow, Keras, Pandas, NumPy and PyAudio. When the Pi is powered with a 10W power supply, a python applications begins running which starts the surveillance process. The camera module begins scanning the surrounding for weapons and the face of the wearer for his emotions. These two processes happen alternatively and scan for 10 seconds each. After every 10 seconds the respective service reports the danger status to the Pi. Meanwhile simultaneously the microphone picks on ambient sound and analyses the frequency and amplitude of the sound. It reports danger to the Pi only if the frequency and amplitude are beyond a threshold value. Simultaneously the Ultrasonic sensor, force sensor, and pulse sensor monitor their respective stimuli (refer to “Introduction” section above”). All the faculties report potential danger only when

1) The stimuli they receive is beyond their respective thresholds
2) The stimuli is consistent and not momentary

I programmed it this way so as to reduce false positives triggered due to the momentary provision of the required stimuli.

A. *Practical working of the Device*

When the wearer is attacked by an attacker, due to the natural reflex, he/she tends to scream and does so as long as the danger persists. This screaming is picked up by the microphone, which after the analysis, reports danger to the Pi. The face of the victim also looks troubled and most of the times, the emotions are – Angry, Fearful, Surprised and Sad. The face is scanned by the camera, which reports danger if any of these emotions are detected.

In case the attacker is armed, the camera picks that up and reports danger. If the attacker tries to catch hold of the victim and grabs the hand, then the force sensor detects the large amount of force required by the attacker to maintain a grip. It reports danger in such a scenario. The heart rate of victim suddenly increases to supply more blood to the brain; this pulse is recorded by the Pulse sensor and danger is reported. After every faculty has given its report, the Pi decides whether the person is actually in danger or not. Based on the result, if the person is in danger the Police and the relatives of the victim are made aware of the situation along with the location and images of the situation. This is facilitated by the GSM module, which is responsible for connecting to the internet and SMS.

B. Working of the Primary Algorithm

I will explain the functioning of the algorithm using the example of the microphone. The microphone constantly listens for surrounding noise in real-time and analyses it to determine its frequency and amplitude. After every 30 pairs of the two, it stores these pairs in a python list. Then, using the statistics module, the program computes the mean of the frequencies and the amplitudes. If the mean is beyond the threshold value for frequency and amplitude, it outputs a True or False Value depending on the mean value and stores it in another list. This process is repeated on every 30 recordings of frequency and amplitude each. When the length of the list containing the output predictions from the recordings becomes 10, mode is calculated of this new list containing "True" and "False". If the mode is "True" then the program gives a final prediction that according to audio analysis the person might be in danger. The opposite happens when the mode comes out to be "False". Similarly all the faculties rely on this statistical prediction to give their respective final predictions. All these predictions are compiled by the main program and stored in a list. The mode is again calculated on this list containing "True" (In Danger) and "False" (Safe). Finally if the mode is "True", it means that most of the faculties have indicated danger, and the program triggers the Camera module to click pictures and the GSM module to send the necessary information to the concerned people.

C. Working of the Subsidiary Algorithms

Here I will explain the working of the algorithms which facilitate the functioning of the faculties.

1) *Camera:* Emotion recognition works using a Convolutional Neural Network (CNN) which was trained on FER-2013 dataset. First the OpenCV module is used to stream the video from the camera to the Pi. The Haar Cascade XML file works upon the video capture to detect faces in the video stream resizes the face area to 48*48 and passes it to the CNN. Based on the model's training, it predicts the emotion and predicts danger accordingly. The weapon detection feature also uses the OpenCV module to stream video from the camera and uses the Weapon Haar Cascade to detect weapons in the video stream.
2) *Microphone:* The Audio analysis mainly depends on the Aubio and PyAudio libraries of python. PyAudio enables the microphone to stream sound at a buffer size of 2048 and sample rate of 48000. The Audio stream is passed to Aubio which determines its Frequency.

D. Experimental Data

In order to test the glove, I had to provide the necessary stimuli to the sensors. Here are some images.

1) For weapon detection, I showed it an image of a gun on my smartphone. The algorithm uses OpenCV to draw the rectangle around the object. The list shown below consists of "1" which corresponds to the "Danger Detected" ("True") value, (refer "Working of Primary Algorithm").

Figure 8 Weapon Detection

2) The image showed below, is for the audio analysis feature of the Glove. The "100" is the confidence the algorithm has in determining the frequency whereas the other values correspond to the frequency of the ambient sound. The threshold is set to 80, beyond this value; any sound will be considered a shout. The Glove was tested on frequencies ranging between 800Hz to 1000Hz.

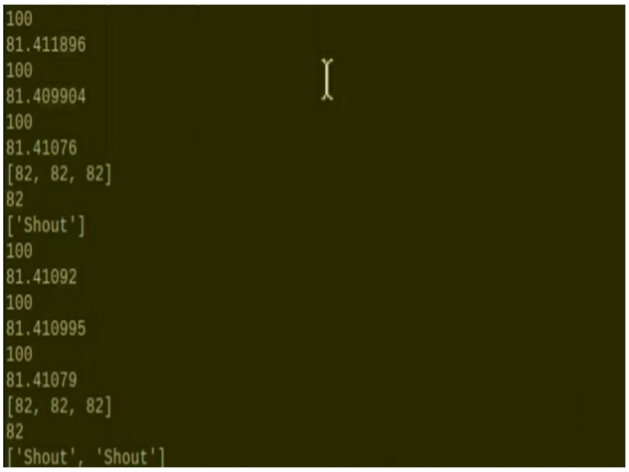

Figure 9 Sound Analysis

3) Being a wearable, the device has to be extremely light

Figure 10 Raspberry Pi 51g

Figure 11 Pi Camera 3g

Figure 12 Ultrasonic sensor 8g

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Figure 13 Glove 53g

The net weight with all its components comes to be 150 grams.

4) The image shown below is the proximity analysis by the ultrasonic sensor

[DANGER]3	[SAFE]42
[DANGER]3	[SAFE]43
[DANGER]3	[SAFE]43
[DANGER]3	[SAFE]42
[DANGER]3	[SAFE]42
[DANGER]3	[SAFE]43
[DANGER]3	[SAFE]43
[DANGER]3	[SAFE]42
[DANGER]3	[SAFE]42
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[SAFE]880	[SAFE]42
[SAFE]880	[SAFE]43
[SAFE]880	[SAFE]42
[SAFE]	[SAFE]43
	[SAFE]

Figure 14 Ultrasonic sensor data

The threshold set is 10 inches. If the person came inside the 10 inch radius, the program would interpret it as a threat and classify it as danger. In the left image, the person was just 3 inches away from the glove, which is indicated alongside the prediction whereas in the right image the person was 43 inches away from the glove.

5) The image showed below is the Emotion Recognition feature of the glove

```
################################ Angry
['Neutral', 'Neutral', 'Happy', 'Angry']
Fearful
Neutral
Neutral
Neutral
Neutral
################################ Neutral
['Neutral', 'Neutral', 'Happy', 'Angry', 'Neutral']
Neutral
Neutral
Happy
Neutral
Angry
################################ Neutral
['Neutral', 'Neutral', 'Happy', 'Angry', 'Neutral', 'Neutral']
Neutral
['Danger', 'Safe']
Neutral
Angry
Happy
```

Figure 15 Emotion Recognition

Emotion analysis works in the same way as mentioned above. One can see the list of emotions being created. The list containing the 30 emotions is being created. Meanwhile, the list of predictions is also being created whose maximum length is 10 and whose mode is calculated to determine the final state of the victim.

6) For the response, I programmed it to send a mail with the photo of the scene via mail. Here is the response it generated based on the stimuli it received as has been shown in the above points.

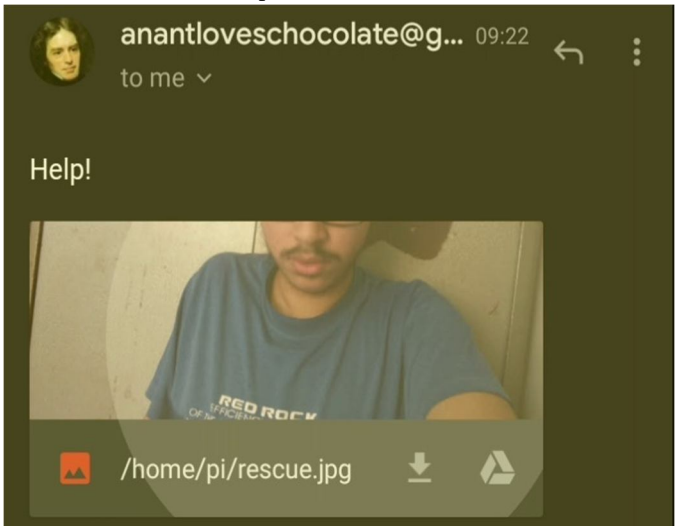

Figure 16 Response

Here the Glove uses Gmail but can be scaled up to SMS using the GSM module.

III. ACKNOWLEDGEMENTS

I would like to accredit this project to my robotics teacher Mr Priyank Shah and the entire Robotrix India, for igniting the passion of robotics and innovation in me. I would also like to thank my aunt Dr. Deepti Kumar for teaching me how to write an academic paper.

IV. CONCLUSION

This is not the first or the last project made to reduce crime, but, a mere enhancement, based on the development of many such projects before mine, towards this field. The issue which my Glove seeks to address is a pressing concern in the present times. The problem of women and child safety must be given a befitting reply using technology.

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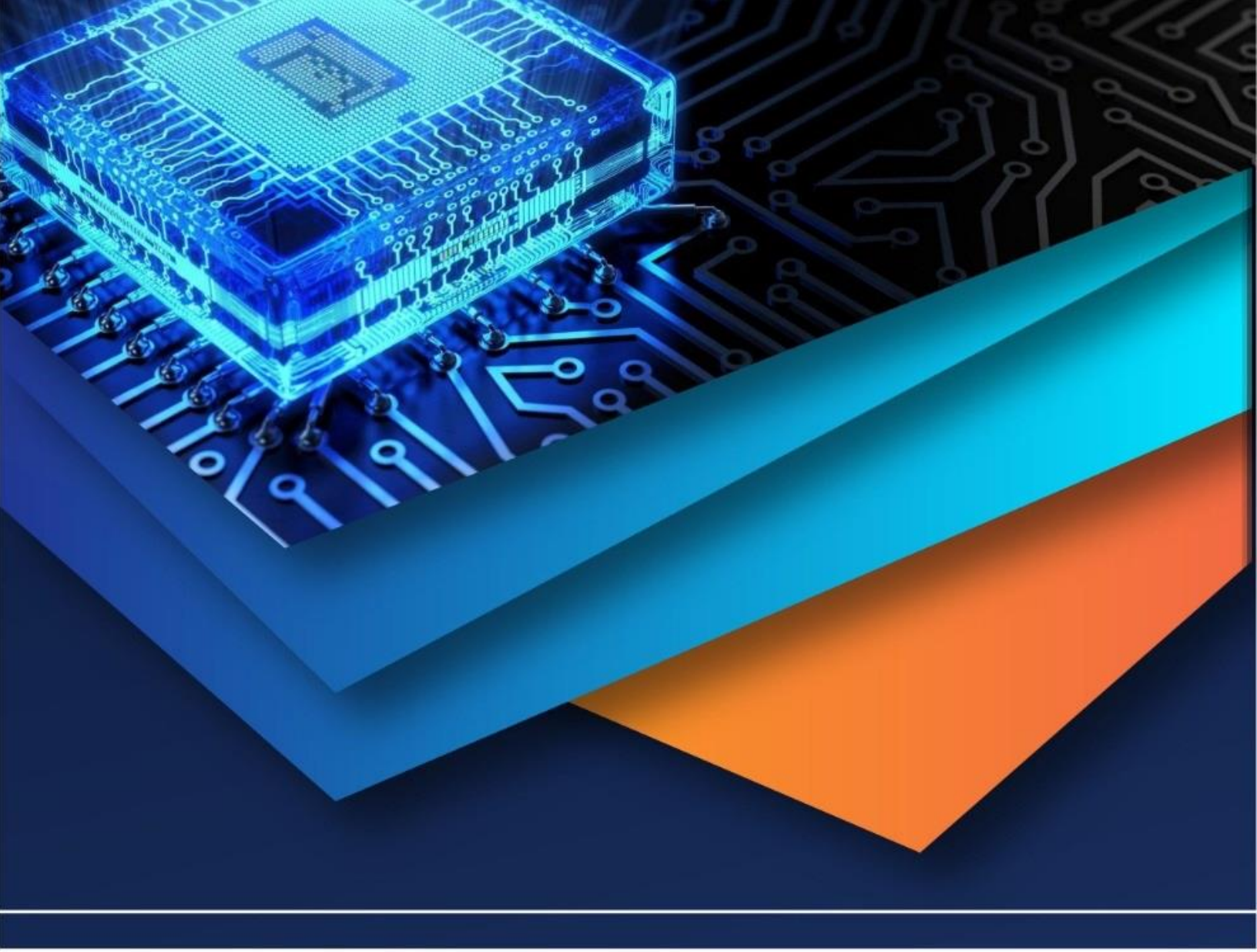

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