Intelligent systems to the rescue: Women's smart safety device based on IoT, ML and fog computing

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19BCS117 19BEC013 19BEC002 19BEC041
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***Abstract*— The most pressing issue in our community now is violence and discrimination against women, which seems to be only rising despite all awareness. Statistics show that India, which perceives itself as a promising superpower and industrial centre, is nonetheless enslaved by different patriarchal evils. As a result, women's safety has become a big concern, as they are afraid to leave their homes at any moment for fear of abuse or violence, and are trapped in spite of having huge potentials. In an attempt to combat such threat, we propose a novel technique to women's safety by harnessing the power of Internet of Things and Machine Learning.**

***Index Terms*— Women's Safety, GPS-GSM, Edge Computing, Fog Computing, Machine Learning**

I. INTRODUCTION

Today, in the current global scenario, the most pressing concern for every girl is her safety and security, especially in light of the recent surge in incidents of female harassment. Building a safety equipment that may function as a rescue and avoid harm in the event of a hazard is quite crucial, especially for women.

An advanced system can be built that can detect the location and health condition of a person that will enable us to take action accordingly based on electronic gadgets like GPS receiver, body temperature sensor, GSM, Pulse rate sensor. A number of sensors can be used to precisely detect the real time situation of the women in critical abusive situations. The heartbeat of a person in such situations is normally higher which helps make decisions along with other sensors like motion sensors to detect the abnormal motion of the woman while she is victimized.

The idea to develop a smart device for women is that it's completely comfortable and easy to use as compared with already existing women security solutions such as a separate garment, bulky belts and infamous mobile apps that are just very abstract and obsolete. The Smart band integrated with Smart phone has an added advantage so as to reduce the cost of the device and also in reduced size.

The main objective of this project is to build a smart security device for women using the Internet of Things. It is a system that is designed merely to serve the purpose of providing security to women so that they never feel helpless while facing such social challenges.

II. LITERATURE SURVEY

A. Background

Women safety is a major issue not in just India but across the globe. There have been many attempts to create a device or software that would help women in the time of need. Having this concern in mind many developers have come up with creative applications.

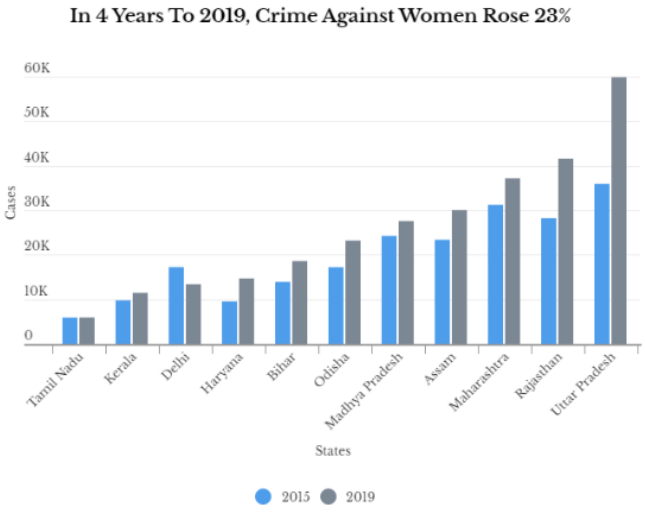

Fig. 1. Flow of data

B. Literature Review

VithU App as the name suggests it is always with you. VithU App is an initiative launched by a popular show broadcasted by Channel V 'Gumrah'. The main goal of this app is to provide security for women. In this app, if a woman is in a dangerous situation, she can send an alert

message to her close contacts with the help of a tap.[1] The co-founders of ILA security, have designed three personal alarms that can shock and disorient potential attackers and hence safeguard the victim from perilous situations.[2] SHE (Society Harnessing Equipment) is a garment embedded with an electronic device. This garment has an electric circuit that can generate 3800kV which can help the victim to escape. In case of multiple attacks it can send around 80 electric shocks.[3]

Most previous devices [4][5][6][7] that have come up with smart safety devices for women focus on the GPS-GSM module as it provides ubiquitous access from everywhere without much complication. The common protocols that are used in these devices are Bluetooth and Zigbee, while features include, shock waves, buzzers, recording help messages and temperature-pulse sensors. The common drawbacks range from the devices not being completely automated and oftentimes giving misleading results due to use of linear and static machine learning algorithms.

Using edge, fog and cloud computing combination for applications in devices are also researched extensively.[8] With the advent of smart cities and smart streets, the growth of fog based applications to make life easier and more efficient becomes evident. Cloud storage allows not only the necessary data storage but also easy access and means for additional analytics. It further provides high fault tolerance. [9] In addition, fog computing for wearables are picking up pace as the rise of wearable sensors, such as fitness trackers and smart watches, has led to an increasing demand in processing sensor data, such as activity recognition based on accelerometer and gyroscope readings. The data have to be sampled at relatively high frequencies to derive meaningful activities, needed with low latency settings and hence the use of fog computing. [9] Utilizing the benefits of fog computing and the strength of machine learning based algorithms have led to a variety of use cases like motion guides [10][11][12], street light management [13][14], scream detection [15] among many others. This project draws inspirations from some of these and comes up with a novelty in the field of women's safety.

III. METHODOLOGY

A. Public survey

The project conducted a public survey of 100 women, to obtain essential information about the needs of women regarding the proposed device. There were some interesting findings in the survey ranging from inclusion of pepper spray/electric shock in the device to the use of voice recognition. Such suggestions were also taken into consideration while outlining the design for the project.

B. Objectives

The system is designed in a way to include the following:

- Alerts family and police: By sharing the location of the woman in danger
- Automatically turning the device ON: This is done by monitoring the values of different sensors used
- Records audio and video evidence: In case any evidence is needed during court trials, this will come in handy
- Fog computing: Use the surroundings and smart street lights as intelligent devices for ensuring safety
- Scream recognition: Activating the device via scream
- Machine Learning approach: Harnessing the power of ML and DL to automate the detection of danger

C. Project flow

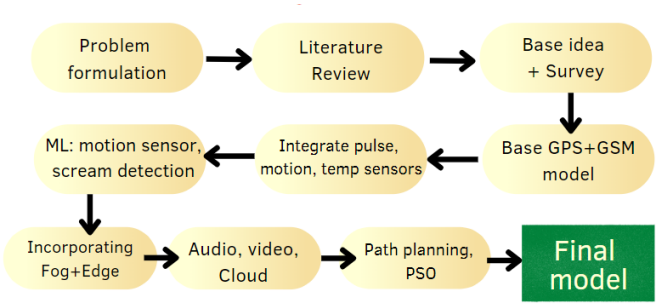

Fig. 2. Project flow

D. Approach

In addition to the inherent capabilities of the device itself, the environment, the surroundings itself can be utilized to ask for support and push for more safety. The crux of this project lies in configuring the street lights as smart fog computing devices. The considerations to be made include: time delay for authorities/other people to arrive, alerting people in the surroundings, causing delay of the danger in the scenario itself. The device considerations include: cost effectiveness, power consumption, authorized access and confidentiality, size of the device, possible locations for the device to be concealed. Further, other aspects include, placement of the fog computing devices, internet requirements and connectivity protocols. The safety device, modeled as a wristband, has several components: location module using GPS, messaging using GSM, motion sensor, pulse rate sensor and temperature sensor module, scream detection module, voice recorder and camera modules.

E. Fog and Cloud computing

The approach behind the fog computing concept stems from the fact that it is composed of fog nodes/servers, which allow the deployment of distributed, latency-aware applications and services. Street lights are almost ubiquitously present in every street. In the described scenario, the street lights can be configured as fog computing nodes. The capabilities of the fog computing node would include: Alarm on being triggered by the user (siren, flashing lights), ability of video recording, path finding and

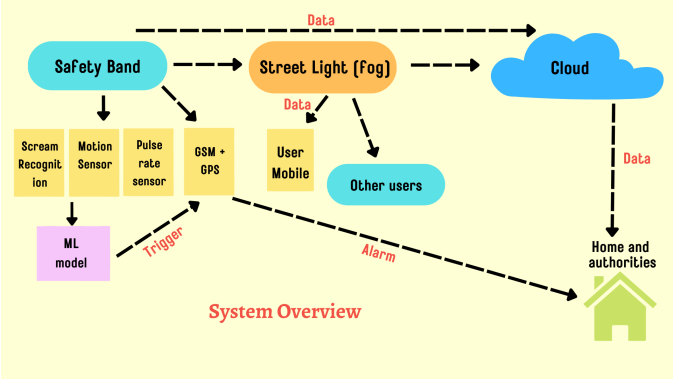

Fig. 3. Flow of data

routes with higher density and required machine learning algorithms.

Fog computing was considered in this scenario for its real-time interaction, heterogeneity support, contextual location awareness and low latency features. It also offers mobility support, as the user would be in a dynamic state, and the predominance of wireless access. Fog layer, the streetlights, are closer to the edge, safety bands, source of information, and guarantee lower latency than cloud. Fog is also distributed, connected through various protocols and failsafe. Cloud layer is for the data storage purposes: audio, video evidence.

F. Proposed system

The band contains two levels of abstraction. The initial state gets triggered into use only when the user activates it. It is based on UART full duplex communication. When the user will turn on the device, all modules will be launched simultaneously. On clicking the first button, the motion, pulse rate and temperature will start being monitored. On passing a certain threshold, an automatic alert would be sent to the family and friends of the user: "Hey! I'm at location and my phone number is . Could you call and check up on me?" The first button also triggers the fog computing mechanism, where the user will be notified on nearest women, shortest path, etc. The other users will also be notified of the person in distress.

The second button is manual or also can be triggered by scream recognition. This is the definitive alarm and will immediately alert the authorities in the location, surrounding users and also the family-friends. Audio recording and camera captures will also be started for gathering evidence against the perpetrator. The fog devices, i.e. the street lights will also be triggered, lighting up as an SOS signal, flashing different colored lights, blaring siren alarms and also video recording.

G. Hardware requirements

- **Arduino UNO**: open source hardware component that can process and analyze data collected from sensors connected to it and make the data useful for the user

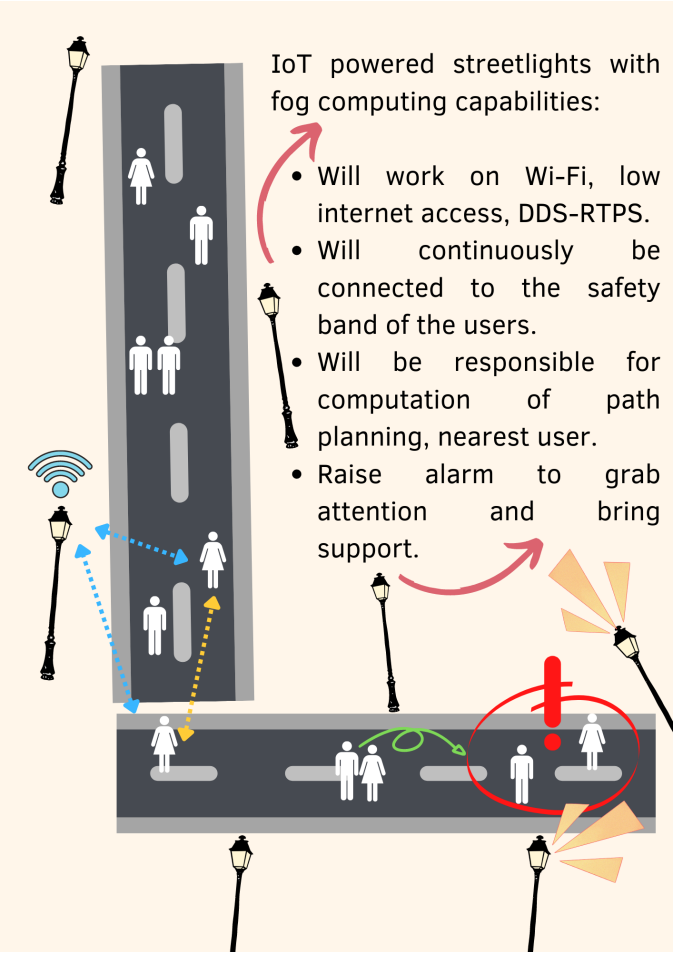

Fig. 4. Scenario description

- **GSM module**: communication module which connects to GSM mobile telephone technology to provide a data link to a remote network .We have used a GSM module in this project in order to send a warning message to the women's guardians or parents so that they can react or take action immediately. GSM is used to send data from control unit to base unit.
- **GPS Module**: Global Positioning System (GPS) is a satellite-based system that uses satellites and ground stations to measure and compute its position on Earth. So, we have incorporated a GPS system in our project so that whenever a woman has triggered the button that she is in distress ,location coordinates of her are sent to the guardian /parent or nearby police station so that action can be taken accordingly. GPS is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from various satellites to reach the receiver.
- **Heartbeat sensor**: Open Source heart rate monitor(optical heart rate sensor) which is considered as a PPG device used to monitor the non-invasive heart rate. It measures the real- time heart beats and calculates BPM with the aid of algorithms implemented

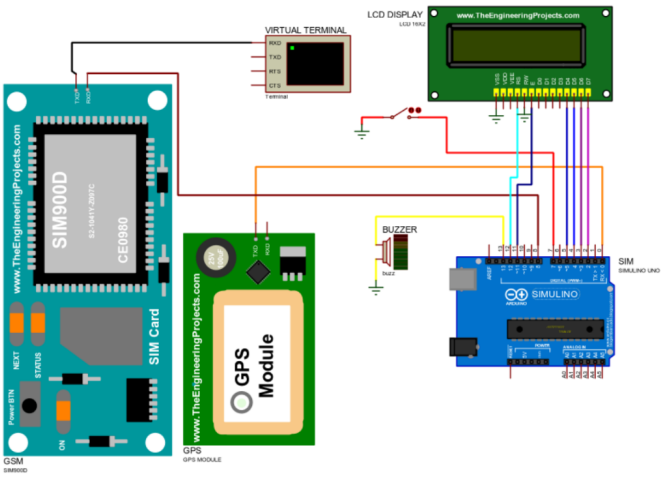

Fig. 5. Proteus simulation

by Arduino. The normal operating voltage is +5V or +3.3V and current consumption of 4mA. The sensor has two sides, one side consists of an LED with an ambient light sensor and the other side contains circuitry which amplifies the signals and filters the noise.

- **Voice recorder**: The Voice Recorder and Playback Module can also be used in Security based projects. When an intruder is detected a voice message is played/recorded endlessly.

The sensors used in this project are:

- GSM Module : SIM900D
- GPS Module: NEO 6M
- HeartBeat Sensor: SEN-11574
- Microcontroller: ARDUINO UNO
- Voice Recorder: MAX 9814

There are efficient alternatives to these components too. There are some Gsm modules called GSM800 and GSM900d and GSM900A but the most effective ones for these open projects is GSM900d. There are alternatives for Arduino UNO such as Node MCU and ESP8266 microcontrollers with inbuilt wifi and other features. The MAX4466 is quite classical and has an integrated op-AMP and gain can change from 25x to 125x while the MAX9814 has an automatic gain control.

H. Simulation

Firstly when it gets triggered the information from the gps module will be sent to Arduino, simultaneously message will be popped on the lcd screen displaying “women in danger” in order to make sure that the device is working fine. After which that information will be transmitted to gsm module, where in it sends the SMS to her close people and police with given template which includes message – “I’m in danger!” and followed by message which includes longitude, latitude and the google map link.

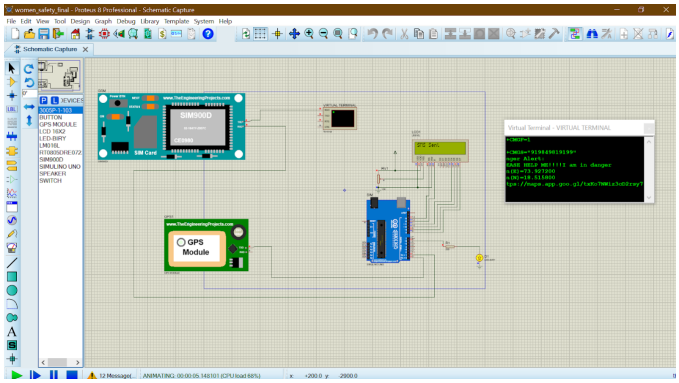

Fig. 6. Circuit diagram for simulation

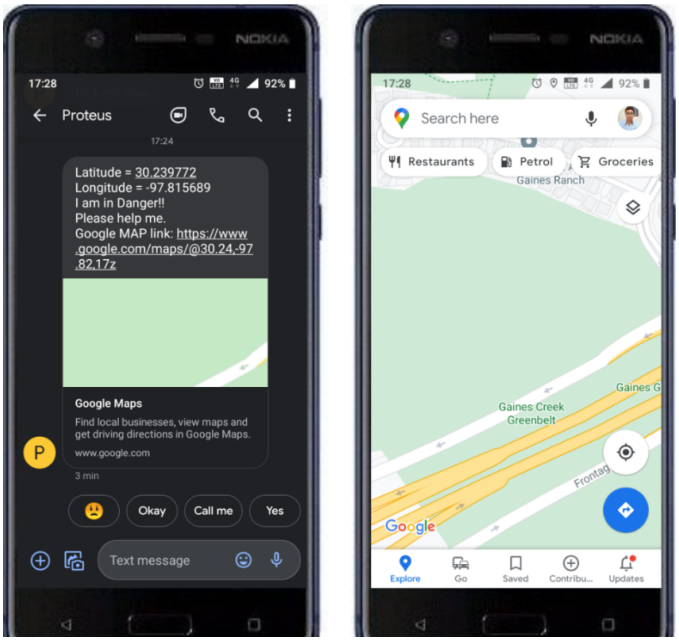

Fig. 7. Example of GSM message

IV. ALGORITHMS IMPLEMENTED

A. Motion sensor detection

When the user activates the device, data will be continuously monitored using an accelerometer and gyroscope. This ensures that any sudden movements by the user can be taken into account, and auto alerts can be triggered. Time series can be applied on this data. The proposed algorithm is based on a typical long short term memory model which uses position-time variation. It takes in a stream of input sequence and maps it to an output value (in this case, it is many-to-one, many time streams, to a classification prediction.) The experiment performed here used data from "MotionSense Dataset for Human Activity and Attribute Recognition" by Malekzadeh et al. The data describes 6 states, including walking to running, and the coordinates are dynamically captured at every time step. The model was fed a frame of 2.5s datapoint (20Hz frequency) and 80% overlap between frames to consider

temporally continuous data.

The model was built on this dataset and it can be emulated in real time by getting direct data from the sensors on the safety band. The algorithm returns an accuracy of 94% on this dataset.

B. Scream recognition algorithm

For the purpose of setting off based on voice and scream recognition, a deep neural network based model was experimented. It extracts speech signal features using Mel-Frequency Cepstrum Coefficients (MFCC) and plots it as a vectorized real time data. The DNN uses this data for classification. The model gives an accuracy of 92% on a dataset of size 4000 samples.

C. Path finding algorithms

The requirement for this to find the shortest path to another user or to a safer place. Time is of the essence in this scenario and will help the user find support faster. This has to take place at the fog computing level as this is a search algorithm and is computationally expensive. Search space is modeled by a graph, where each node corresponds to a location of a smart node, and the links can connect edge devices and allow access. Some typical algorithms from literature include single source multiple destination traveling salesman problem and Maintaining Connectivity and Coverage Maximization (MCCM).

V. RESULTS AND ANALYSIS

This project proposes an innovation over existing ideas by utilizing the powers of the fog computing layer. The implemented algorithms further strengthen the use case. The project is based along the Smart City lines and holds immense power in principle. A summary of the experiments are represented below:

Component	Improvement	Outcome
Simulation of band	Audio-video recorder, edge-fog computing approach	Proposed innovation over existing devices
Motion state recognition	Concept: LSTM approach	Accuracy: 94%
Scream detection algorithm	Concept: MFCC technique	Accuracy: 92%

Fig. 8. Results

VI. FUTURE SCOPE

Being a project of social welfare, there can be numerous future improvements looking at several directions. Some of the future tasks that we have identified are:

- Use of a wake word: the band can stay active, on low battery, to recognize the user's voice with a certain wake word, in case of sudden danger
- Fingerprint sensor: the band will be composed of a fingerprint sensitive material. Only authorized fingerprints will be recognized. If any attacker's fingerprint is encountered, then there will be a vibration on the user's band. There will be a 1 minute buffer after which an alert will be sent.
- Ability to book cab nearby automatically: depends on the cab service provider
- Individual bands that the user wears are being cast as edge computing nodes, which are connected to the fog and cloud.
- Scream recognition, motion detection in various cases: has to be customized and trained for every user, once at the start
- Bands powered by solar power (sustainability) with battery back up
- Internet balloons or StarLink for ubiquitous internet access
- LoRaWAN gateways and Device-to-Device communication

VII. CONCLUSIONS

We realize that there is a pressing need for developing an efficient safety device. We aim to design a flexible, economical and easily concealable device that provide security to women so that they never feel helpless while facing such social challenges. This project proposes a novel approach to safety by utilizing the prowess of intelligent IoT systems, edge, fog and cloud computing, and machine learning algorithms. We hope this idea can be implemented at the highest level for the welfare of the society and it proves vital to develop future implementations for the safety of women in the global perspective.

ACKNOWLEDGMENT

We would like to thank Dr. Jagadeesha R Bhat for his valuable comments and guidance to improve the quality of the project with new innocations. We are also grateful to him for inciting our curiosity towards applications of IoT for welfare of society and sustainability.

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