Crime Prevention on the Edge: Designing a Crime-Prevention System by Converging Multimodal Sensing with Location-Based Data

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Abstract. Emerging technological innovations have been developed in recent years to prevent crime and enhance public safety. This paper evaluates the recent advances in ubiquitous sensing and pervasive computing to ultimately propose a multimodal crime prevention tool which incorporates several technologies into a single wearable device. The crime prevention tool proposed combines Bluetooth Low Energy (BLE) technology to sense the social context of a person with a violent language sound-based detection system which aims at the real-time spotting of violent behaviours and threats to victims of domestic abuse. The system is currently being developed to safeguard and protect vulnerable individuals.

Keywords. Bluetooth Low Energy (BLE), Crime Prevention, Proximity detection

1. Introduction

Ubiquitous computing for the purpose of crime prevention is a constantly improving subject with a huge impact on society's security and safety. Through the development of edge computing tools and methodologies, cities and the people that live in them can be made even safer through the integration of unobtrusive novel technologies.

The use of technology in crime prevention has been explored in a variety of work, for example applications, such as the tracking of terrorist suspects to gain insights into their spatial and temporal behaviour, have recently been proposed by Griffiths, G et al (2017). Overall, as outlined by Belur, J et al

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(2020), electronic monitoring is an effective tool towards preventing recidivism, especially for sex offenders.

Despite the wider subject being explored by a number of researchers, our work focuses on merging the use of natural language processing and wearable devices.

Our system proposes a novel low-cost wearable device to equip vulnerable individuals with a tool to protect them against violent behaviours, by the use of a multimodal approach based on the evaluation of their social context with BLE technology and the detection of violent language by combining audio processing, machine learning and natural language processing (NLP) techniques. Our existing work has attempted to curate and process a natural language dataset to improve the identification and detection of harmful language. We are now looking to integrate this algorithm on-device alongside location-based sensor data to assist in the real time detection and prevention of violent or harmful language.

This paper is split into four sections, the next section presents the methodologies used throughout the study. *Section 3* is a discussion of the limitations and opportunities of the work. Finally, *Section 4* provides a conclusion and highlights the focus of future studies.

2. Methodology

The proposed system makes use of edge computing to enable onboard complex computations that support the safety of vulnerable individuals. By implementing multimodal data algorithms, including proximity detection using BLE technology and sentiment analysis techniques based on sound and language, the proposed system supports enhanced feedback and monitoring of potential threats and issues. Feedback and notifications are algorithmically triggered to alert authorities or designated contacts of an emergency while presenting the generated information for decisions to be made.

The wearable device includes proximity detection techniques to provide instant information about suspicious behaviour nearby. Along with this, the wearable also integrates violent language detection through Natural Language Processing (NLP) of relevant captured data to safeguard victims. The data generated through both sensing modalities are then combined to support further actions or decisions.

2.1. Proximity Detection

The two most used and known location-based technologies to track and monitor people include radio frequency and the Global Positioning System (GPS) (J. Tully, 2014). However, in recent years there has been an increase attention to BLE probe requests for crowd monitoring (Rekimoto, J et al, 2007) and social context analysis (Anderez D et al, 2020) (Woodward K, 2020).

Our current experiments with different technologies show the continuous broadcasting done by BLE transceivers is more convenient than the interception of intermittent probes sent by WiFi antennas. In line with this, we propose the use of BLE for proximity detection to ensure regular offenders keep their legal distance from the victims and an alert is triggered automatically if the victims are at risk. By monitoring offenders' approximate location to vulnerable individuals (using their phones or enforced tag) enables the detection of suspicious activities such as stalking. *Figure 1* shows how the alerts are sent out depending on the proximity of the devices of interest.

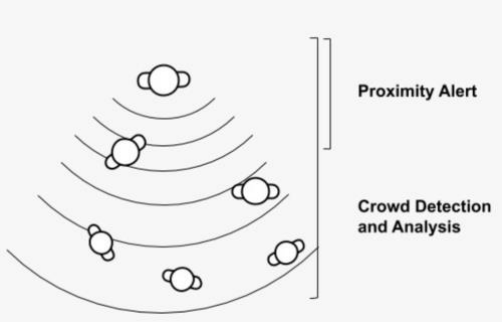

Figure 1. A diagram showing how the proposed proximity alerts will be sent.

3. Challenges and Opportunities

The collected dataset provides useful usability for the outlined purpose of the project; however, we identified a number of challenges that should be taken into consideration:

Privacy - There exist some concerns about data sharing and access to personal information. We propose to process the data locally and only communicate the output of the detection algorithms remotely (alert to police or a family member).

Battery Life - Battery life is another factor that is being tested as the project progresses as the higher the processing power required, the quicker the battery drains. This challenge can be overcome by incorporating adequate hardware for high processing computations.

Processing power - To preserve data we aim to process data locally on the device using edge-computing, however this can be challenging depending on the processing power required. Edge devices are evolving and making strong leaps in advancing its processing power.

4. Conclusion

In this paper we presented our work in progress research relating to the merging of on-device sensor data and a natural language processing algorithm to detect violent or harmful language. Our preliminary results highlight the importance of the multi modal approach as the combination of audio text and BLE for crime prevention has not been explored and the need to further research how this approach can be integrated into an environment like that. We hope to continue the development of our wearable device and further develop the idea behind using location-based technologies alongside Bluetooth and Wi-Fi sensing as part of the project.

The crime prevention system proposed combines different sensing technologies with signal processing and machine learning techniques for ensuring the safety of vulnerable individuals. The rationale of this project is certainly the need for a system of these characteristics, as expressed by several project collaborators (Police and victim support charities).

The research challenges and the limitations of existing technologies suggests that the use of edge computing embedded in unobtrusive wearable devices can help the society to live a better and safer life. Future work will be focused on the implementation and experimental evaluation of the system. The incorporation of additional sensing technologies will be also studied and evaluated.

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