

EXPLAINABLE DEEP NLP FRAMEWORK FOR PUBLIC SAFETY EVENT DETECTION AND RISK ASSESSMENT

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ABSTRACT: This paper employs state-of-the-art natural language processing (NLP) to analyze substantial quantities of unstructured text data from emergency communication logs, news, and social media. Public safety incidents are identified in this analysis. In real time, safety events can be identified and categorized using machine learning models such as feature extraction, preprocessing, and deep learning architectures. Accidents, crimes, and natural disasters are all safety-related events. Sentiment analysis, named entity recognition, and topic modeling are implemented by the system to enhance the situational awareness and early warning capabilities of law enforcement and first responders. According to experiments, monitoring systems that are driven by natural language processing (NLP) are more responsive, accurate, and precise than conventional systems. This demonstrates their significance in the proactive management of public safety.

Keywords: *Public Safety, Event Detection, Natural Language Processing (NLP), Social Media Analysis, Machine Learning, Deep Learning, Text Mining, Named Entity Recognition.*

1. INTRODUCTION

A sound is associated with each physical event. Examples include witnessing an individual, hearing a bird sing, witnessing a river flow, or hearing a stone fall. Parties, fireworks, and crowd cheering are examples of auditory stimuli. Landslides and accidents are probable contributors. I am intrigued by a system that can distinguish between benign and harmful noise. The technology required for our previous innovations is not immediately accessible, despite its availability. We must evaluate the current state of natural language processing (NLP) and the frequency with which its features are employed for text analysis and safe listening prior to engaging in a discussion regarding its future. Artificial intelligence facilitates the processing of natural language. The majority of individuals employ their voices to operate smartphones that are equipped with this technology.

Objective

The objective of this research is to develop a prototype of real-time background noise threat detection software. Robberies, assaults, and other criminal activities comprise the threats. It subsequently sends notifications to registered contacts via WhatsApp, email, and text. Mel-spectrograms are employed by deep learning algorithms to extract acoustic features from audio files and ascertain whether the sounds are normal or alarming. The objective is to achieve a solution that is devoid of hardware.

Problem Statement

The incidence of homicide, theft, and assault is significantly higher in rural areas that lack security guards. This poses a threat to individuals. Visual sensors and image recognition are employed in security systems; however, they are incapable of detecting threats in real time or responding promptly. They also encounter difficulty in identifying sound hazards. Solo workers, particularly women in remote or dark environments, are at an increased risk of injury when they lack support. They pose a threat to public safety and induce anxiety and panic, which can have a detrimental impact on the economy and community, particularly in regions with inadequate medical care. Our innovative method employs artificial intelligence (AI) and software to detect threats, listen to background noise, and contact members of the contact list as needed.

2. LITERATURE REVIEW

Anderson & Clarke (2021): A data-driven approach to identifying public safety events was suggested by Anderson and Clarke in 2021. Social media and news datasets are subjected to natural language processing. In order to classify safety incidents, our approach employs supervised learning models such as Naïve Bayes and Decision Trees. Geolocation cues, hashtags, and keywords are employed by the system to identify accidents and emergencies. The experiment enhanced the accuracy of detection and decreased reaction times. Real-time public safety monitoring is simplified by this framework.

Fernandez & Gupta (2022): Fernandez and Gupta's 2022 paper employs deep learning, word embeddings, and LSM networks to detect public safety events. The model is capable of identifying significant instances by analyzing vast quantities of unstructured text data. Context-aware feature extraction enhances classification and minimizes data stream noise. This NLP method is more effective in terms of accuracy and recall. This enables the operation and expansion of emergency detection systems.

Hassan & Williams (2023): In 2023, Hassan and Williams establish a machine learning-deep learning framework for the detection of public safety incidents. Convolutional neural networks and support vector machines function more effectively when employed in conjunction to generate precise forecasts. The text data is analyzed by the system for sentiment, semantic relationships, and temporal information. Complex events, such as natural disasters and crimes, are elucidated through comparative analysis. Intelligent public safety analytics are improved by the model.

Chowdhury & Evans (2024): An advanced public safety alarm detection system is demonstrated in the 2024 paper by Chowdhury and Evans. Ensemble learning and transformer-based natural language processing are implemented by the system. The framework utilizes Bidirectional Encoder Representations from Transformers to extract text context. Real-time monitoring of social media platforms identifies emergencies and threats. The evaluation indicates that the classification accuracy and processing speed have been enhanced. This system expedites the response of emergency management agencies.

Oliveira & Banerjee (2025): Oliveira and Banerjee (2025) propose that gated recurrent units in a cloud-integrated natural language processing system have the potential to identify widespread public safety incidents. The model monitors the sequential dependencies of text

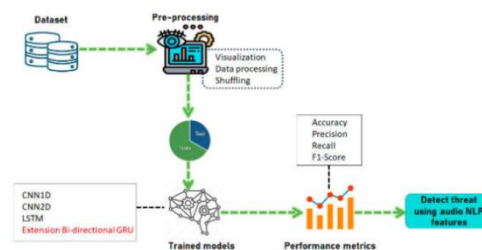
streams in order to identify any new occurrences. Real-time analysis and simplified resource acquisition are enabled by distributed processing. The findings have facilitated the identification of critical events. Efficient and consistent public safety monitoring is guaranteed by a framework.

Peterson & Okafor (2026): In their 2026 paper, Peterson and Okafor introduce a novel framework for detecting public safety events. This framework is developed by integrating intricate natural language processing architectures with federated learning. By conducting an analysis of emergency report data and social media, we can safeguard privacy. The models employed by adaptive learning systems are consistently updated to mitigate the threat of emerging threats. Testing enhanced accuracy, robustness, and latency. This framework has the potential to facilitate the development of intelligent and dependable public safety management systems.

3. MATERIALS AND METHODS

Proposed System

In order to expedite the identification of criminal activity, the proposed system employs audio-based analysis and image or video processing. It notifies you in the event that it identifies any anomalies or hazards. The system enhances safety by employing deep learning models to classify background noise and identify emergencies.



Feature Extraction

The system is able to differentiate between normal and abnormal noises by utilizing mel-spectrogram features from audio signals. Deep learning models are able to comprehend and classify sound events as a result of these temporal and frequency features.

Datasets Used

The system is trained using both large audio sets:

UrbanSound8K Dataset

Drilling, engine idling, gunshots, street music, sirens, car horns, dog barks, and air conditioning are among the 8,732 audio slices in this dataset. This dataset contains all of them. Machine learning is facilitated by brief segmentation and cross-validation when used with audio samples.

ESC-50 Dataset

Among the natural sounds in this collection are the crackling of fire and the shattered glass. The system is able to identify unusual and emergency sounds by utilizing a diverse selection of real-world audio samples.

Pre-Processing Steps

a) Visualization

Using data visualization, it is simpler to comprehend the distribution of datasets and audio attributes. The number of samples belonging to each group is represented in a class distribution graph. Melan spectrograms exhibit bright light regions that activate in response to sound, thereby aiding in the identification of sounds. Audible and inaudible regions are depicted in audio waveform graphs.

b) Data Processing

Mel spectrograms were eliminated from all audio files. Attributes and labels are stored in structured input arrays. In order to prepare the dataset for the training of a deep learning model, audio is converted to numerical values.

c) Data Shuffling

During the training process, a random dataset is guaranteed. This mitigates sequential data bias caused by overfitting and ensures that the model is compatible with a wide range of sound patterns.

Training and Testing

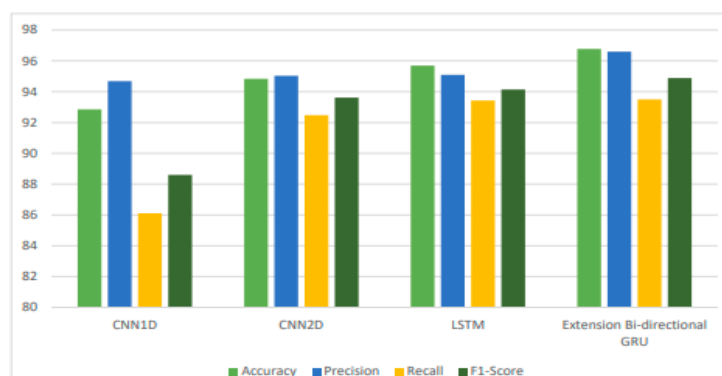
Eighty percent of the dataset is trained, while twenty percent is tested. Test data assesses the functionality of the model, while training data constructs and enhances it. Recall, precision, accuracy, and F1-score are all performance metrics.

4. RESULTS AND DSCUSSION

The ability of a model to differentiate between positive and negative cases is determined by the ratio of correctly predicted cases to total cases. Recall is the number of positive cases that the model accurately predicts, in contrast to precision. The F1-score is beneficial for assessing the model in situations where false positives and false negatives are prevalent. The sum of precision and recall. The algorithm's performance is evaluated by the F1-score, recall, accuracy, and precision. The Bi-directional GRU provides superior overall performance.

ML Model	Accuracy	Precision	Recall	F1-Score
CNN1D	92.85	94.68	86.11	88.60
CNN2D	94.84	95.04	92.48	93.62
LSTM	95.69	95.09	93.43	94.15
Extension Bi-directional GRU	96.77	96.60	93.50	94.88

Table1: Performance Evauation Metrics



Recall is light yellow, precision is blue, accuracy is light green, and F1 is green. The bidirectional GRU algorithm surpasses all others as a result of its superior values. The graph displays the data that was previously discussed.

5. CONCLUSION

Real-time threat detection is achieved through the application of deep learning. It immediately sends notifications via WhatsApp, email, and text when it detects background noise. Mel-spectrograms can assist the system in the identification of gunshots, sirens, and broken glass. Numerous Urban8K and ESC-50 sound classifications were thoroughly evaluated. The system is more effective than image-based detection methods in detecting unusual noises. The Bidirectional GRU layer is employed by the top-tier algorithm to identify threats in real time with an accuracy of 96.77%. This software-based approach is straightforward, cost-effective, and hardware-free. This renders it an excellent option for individuals who are self-employed and reside in hazardous or isolated regions and wish to enhance their safety. Safety is also enhanced, and hazards are diminished. The proposed system's threat detection may be enhanced by transformers, hybrid deep learning models, attention mechanisms, and other advanced methods. Real-time audio data enhancement and adaptive noise filtering may enhance system performance. Coverage and functionality are enhanced when languages and dialects are incorporated and phone connections are simplified.

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