Wearable Emergency Alerting Device

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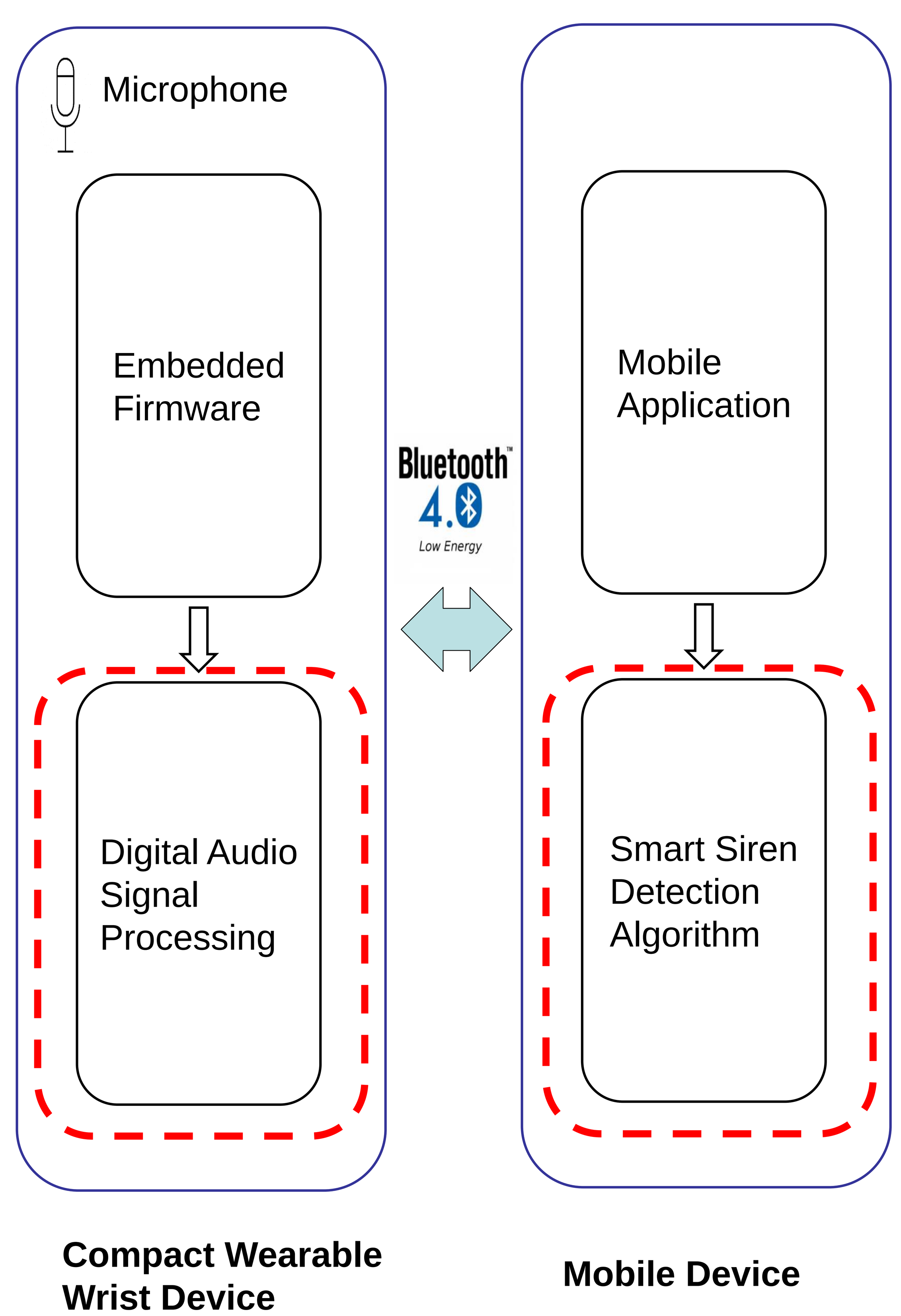
Alert Buddy

Background & Objectives

- Emergency alarms save lives. However, people who are hearing impaired may not be able to depend on existing solutions.
- Auditory alarms have almost no impact on the hearing impaired. And while there are other means of warning, such as bright flashing lights, vibrations, or exaggerated gestures, their potency can be seriously reduced in circumstances.
- Our project AlertBuddy, offers a smart solution in the form of compact wearable assistive device. It is easily configured using a smart phone and can reliably detect and alert the user of emergency sirens.

Solution Overview

Emergency Siren

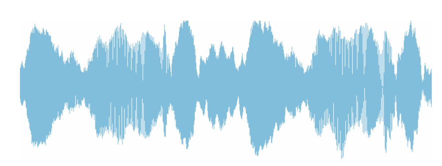


Siren Detection Algorithm

Has two steps:

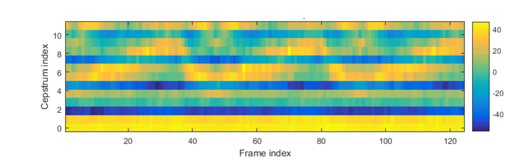
1. Training with known siren sounds

Audio training samples



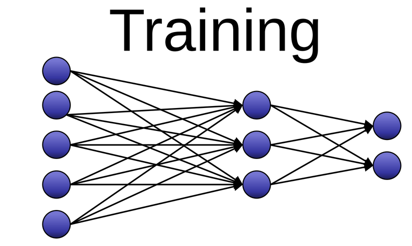
- 8KHz samples rate
- Use 1 sec sample and divide to frames of 16ms length with 50% overlap

Feature Extraction



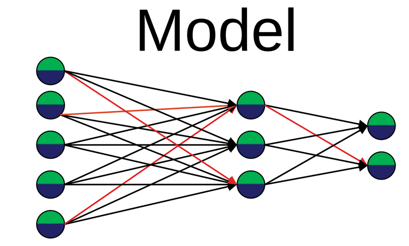
- Mel-Frequency Cepstral Coefficients (MFCCs)
- Uses Fast Fourier Transform (FFT) and Discrete Cosine Transform (DCT)
- Frequency scale as perceived by a human (Mel-scale)

Neural Network Training



- Multilayer perceptron
- The inputs are 12 MFCCs
- Uses scaled-conjugate gradient backpropagation training algorithm with cross-entropy error performance function

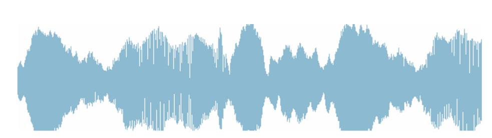
Classification Model



- Neural network with tuned weights for the connections
- Recognizes patterns and assigns corresponding output for each sound

2. Detection of new sounds

Unknown sound

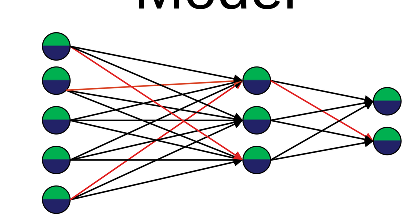


- Recorded 1sec sample using the microphone on wrist device

Feature Extraction

- MFCCs similar to training phase

Classification Model

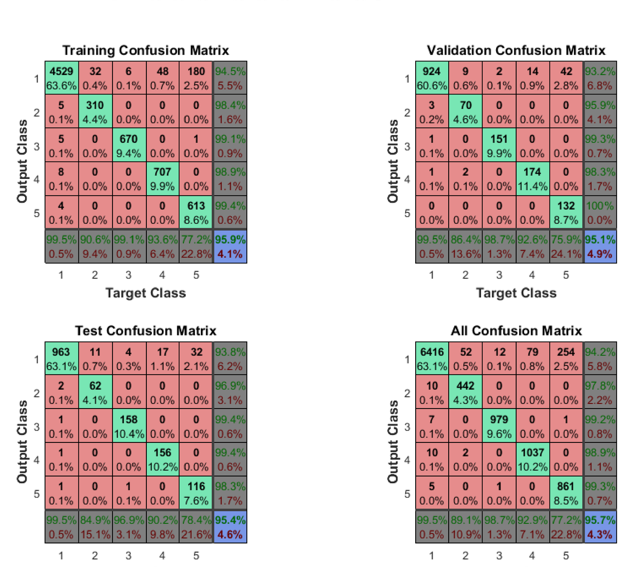


Detection Result

- This can be "Not a siren" or one of the known siren sounds

Results

- Neural net confusion plot for training with 5 types of sounds. Ambience, Fire Alarm, Police Siren, Smoke detector & Tornado siren. 95% overall accuracy obtained for these sounds.



- As the number of sound types increases, the accuracy decreases. It was not possible to obtain results above chance level for more than 5 sounds.
- The result also depends on special characteristics of emergency sounds. The approach is less accurate for other less similar types of sounds.

Discussion

- For feature extraction, parameters such as the frame duration and sample rate were selected base on available memory and CPU resources on the wrist device hardware.
- The neural network training was done on Intel® Core™ i7 CPU X980 @3.33GHz server using MATLAB Neural Network Toolbox™.
- For classification, the output of the neural network for each class is summed over the entire sample duration and the maximum is used to select the class.
- The prototype feature extraction algorithm was exported to C code using MATLAB Coder Tools™ and then later optimized to make use of hardware capabilities on the wrist device. The Neural Network was also deployed as C code to the Mobile Application and run using native interfaces.

Conclusion

- Using MFCC feature extraction and artificial neural networks, it was possible to detect and classify a specific set of emergency sirens.
- Satisfactory results were obtained when testing the algorithm with the wrist device and mobile application.
- Although a 1 sec sample is sufficient for the algorithm to detect the sound, it was found that including a sensitivity level to filter out occasional false positives will prevent unnecessary alerts to the user.
- It was attempted to implement the training part of the algorithm on the mobile application. But due to limitations on available libraries and frameworks, it was not possible to complete this.
- Since the wrist device has hardware provisioned for two microphones, the algorithm can be extended to also detect angle of arrival.
- MFCCs are frequency based features. Therefore, they have limitations in describing sounds with time based characteristics. This also makes MFCC based detection susceptible to noise. By combining them with time-frequency based techniques such as Matching Pursuit (MP) and Dynamic Time Warping (DTW), better results may be achieved.

References

- J. K. Selina Chu. Shrikanth Narayanan, "Environmental Sound Recognition With Time-Frequency Audio Features", IEEE TRANSACTIONS ON AUDIO, SPEECH, AND LANGUAGE PROCESSING, vol. 17, pp.1142-1158, 2009.
- R. G. F. Beritelli, "A Pattern Recognition System for Environmental Sound Classification based on MFCCs and Neural Networks," in Signal Processing and Communication Systems, 2008. ICSPCS 2008. 2nd International Conference on, Gold Coast, QLD, 2008.

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Digital Audio Signal Processing and Smart Siren Detection Algorithm