Radio-Frequency Based Detection of Unattended Children to Reduce In-Vehicle Heat Stroke Fatalities

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I. INTRODUCTION

A sad type of incident, which predominantly happens in warm and sunny seasons, is children dying of hyperthermia inside vehicles. In the US, there are, on average, 37 heat-related fatalities per year [1]. In about 70% of these cases, the child was either forgotten or intentionally left inside the vehicle.

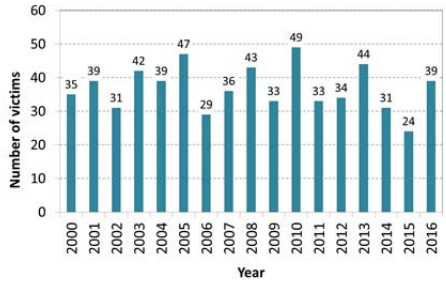


Fig. 1. In-vehicle heat stroke fatalities in the US

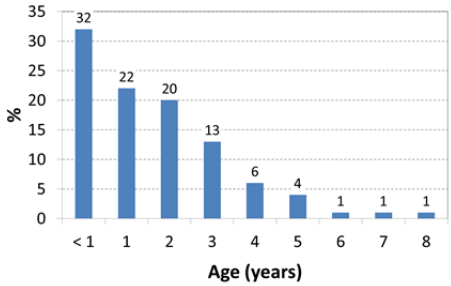


Fig. 2. Share of heat stroke victims by age group

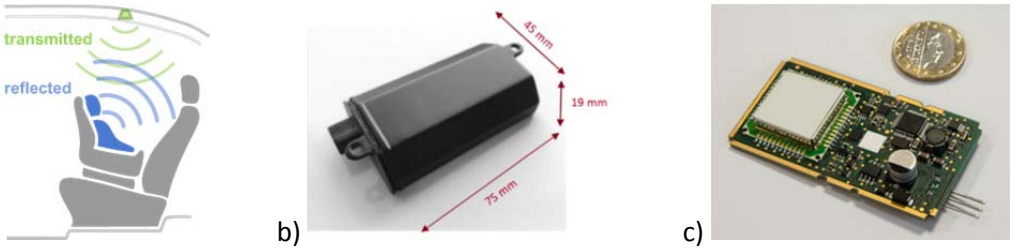
Temperatures rise very quickly in a car that is parked in the sun, and can reach a critical level within less than 20 minutes. IEE's VitaSense sensor, integrated behind the headliner of the vehicle, uses radiofrequency (RF) signals to detect the vital signs of a child. This type of vehicle-based sensing approach is the most promising, as it can potentially use all of the vehicle's available infrastructure to initiate various warnings or countermeasures.

For development, testing and demonstration purposes IEE developed a dedicated test tool, replicating the breathing pattern of a sleeping newborn.

II. METHODS

IEE has investigated various technologies (seat-based, thermal sensors, optical systems) for their suitability to detect unattended children, independent of whether they are installed in a child seat or not. But each of them had certain weaknesses that would not have allowed detection of a child in certain normal circumstances.

Radiofrequency-based detection has allowed IEE to overcome those hurdles. A sensor, integrated behind the headliner of the vehicle, uses radiofrequency (RF) signals to detect the presence of a child on the rear seat after the car has been parked.



a) b) c)

Fig. 3a-c). RF-module integrated behind the vehicle headliner, VitaSense ECU

IEE's VitaSense emits signals in the 24GHz ISM band, with a very low transmission power of 4mW, leading to a specific energy absorption rate more than 20 times below that of a cell phone. The electromagnetic waves can penetrate through sunshades and clothing. The sensor evaluates the reflected signal, and a specific algorithm filters the signals and allows detection of the vital signs of a human being. The system is sensitive enough to detect the small breathing movements of a sleeping baby.

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Human babies played a major role in the development of the system and the fine-tuning of the algorithm, however they are not always available. Therefore, IEE has developed a dedicated test tool to reproduce the breathing pattern of a sleeping baby. A baby doll has been fitted with a pneumatic bladder in the abdomen. The breathing pattern and amplitude reproduced by the bladder has been aligned with the weakest parameters that were identified in a real human baby. This dedicated test tool allows tests to be run whenever needed.

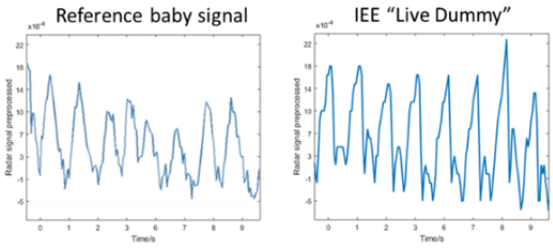
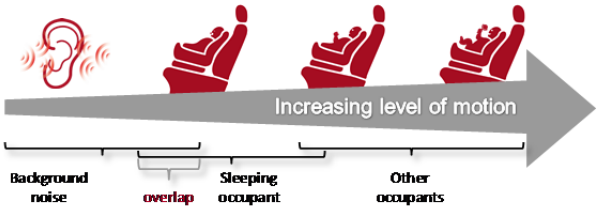
a)  b) 

Fig. 4a-b). Dummy reproducing breathing patterns, comparison to human baby

III. INITIAL FINDINGS

The continuous wave radar measures the movements of the child. Detection is possible within 1 to 2 seconds, if a significant level of motion is observed. This classification method is called *Global Motion Recognition*, and is usually triggered when the child is awake. Another classification method, discriminating small breathing patterns from background noise, is called *Sleeping Child Recognition*. It is usually triggered when the child is asleep. The reflected signals are analysed for the presence of a periodic motion (breathing). A robust decision is thus possible after 8-10 seconds, even if the reflected signals are so low that they could be background noise.

a) 

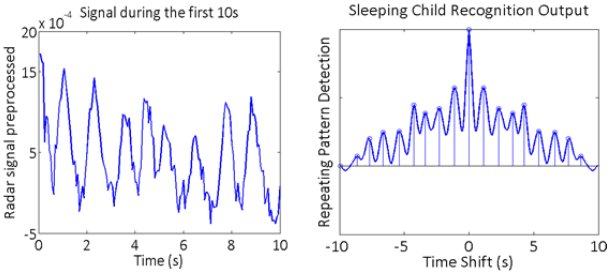
b) 

Fig. 5a-b). Signal depends on level of motion, Sleeping Child Recognition for 1-month old child

It is also important to design a system so that false alarms are avoided, therefore the regularity and periodicity of the signal is an important element to differentiate sleeping babies from other factors that increase the background noise level, such as rain falling on an empty car.

IV. DISCUSSION

On average, 37 children die of hyperthermia inside vehicles every year in the US. This can seem relatively low compared to the overall road fatalities, but the social consequences of heat stroke fatalities are often dramatic. The victims are very young and defenceless, the caretaker is often a parent or direct relative, and society seems to have little understanding about the memory failures that lead to the dramatic consequences.

A sensor, integrated behind the headliner of the vehicle, uses radiofrequency (RF) signals to detect the vital signs of a child, and is sensitive enough to detect the small breathing movements of a sleeping baby, even under difficult circumstances, such as through the sunshade of a rearward-facing child seat. Based on detection tests with human babies under various conditions, the RF-based detection method has been thoroughly tested and found to be robust. A dedicated test tool to reproduce the breathing pattern of a sleeping baby has been

created to support the development.

A vehicle-based sensing approach is the most promising, as it can potentially use all of the vehicle's available infrastructure to initiate warnings or countermeasures. Further studies on warning strategies may be needed to identify the most effective and acceptable ones.

V. REFERENCES

[1] Heatstroke Deaths of Children in Vehicles, http://noheatstroke.org/ [Date accessed April 25th 2017]