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Sensory Options for Earthquake Victim Recovery

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Summary:

This paper examines the feasibility of assembling a low-cost sensor device that could be used in case of an earthquake, building collapse or any structural damage to find humans stuck inside the debris. Several experiments in various scenarios were performed to evaluate different sensors individually and three sensors were selected to build a device capable to detecting humans behind an obstacle. After obtaining a result from the sensory elements used for the device, the probability of finding a human is estimated. The results have been tabulated for different detection ranges of the individual sensors and for the preferred sensor in each collapsed building scenario.The device was tested against two laboratory scenarios witha success rate of 93 percent.

Keywords: Body detection, Victim Recovery, Thermal Vision Camera, Gas sensor.

Background, Motivation and Objective

In case of an earthquake or a structural damage a high-risk challenge is generated in searching and saving lives stuck in the debris. According to medical science an injured casualty has a time of 72 hours to survive, given that they get help on time [1], and time becomes a very crucial factor in discovering the victims inside the rubble.

Conventional devices and methods used in such disasters are mobile video camera, sniffing dogs, and audio devices, but could be time consuming in potentially dangerous situations. Also a prototype from NASA called FINDER has also been very useful in finding people stuck in rubble, but is not available commercially [2]. The objective of this paper is to design a cost- effective system to measure the feasibility of different sensory options that can be implemented to search for human body stuck inside debris of a collapsed building. For this purpose, standard sensors were selected and evaluated to detect typical attributes of a living human body such as odor, heartbeat, sound, motion, breathing and heat signature[3].

New Method

The new device combines the readings of three low-cost sensors for an increased probability of finding human body stuck in debris.

Description of the System

Three candidate attributes were selected for victim detection by cost-efficient market-available sensor: a) motion (*RCWL-0516, Doppler Effect based digital motion sensor*), b) heat signature (*AMG8833,8x8 pixel infrared thermal camera*), and c) breathing (*T6-713,non-dispersive infrared CO_2 sensor*). The three selected sensors were integrated into a system consisting of an Arduino MEGA processor, a Raspberry Pi, 800x480 HDMI color display and a Bluetooth module HC05.

Experimental Setup

The Experimental setup was broadly divided into the following parts:

(**SN1**) Individual testing of sensors:

The CO_2 sensorefficiency tests were conducted by placing a human at 30 cm, 60 cm and 1m distance from the sensor. The average and standard deviation of a series of 10 repeated tests were calculated.

The motion sensor tests were performed for two different scenarios to measure the success rate of the sensor as a function of distance. The tests were kept running for 10 minutes and the results were calculated on the basis of correct recognition of motion.

The infrared thermal camera was tested for the quality of thermal image over distance and exposure to human, provided line of sight was available.

(**SN2**) We used materials like wood, metal, plastic and cardboardto create a closed setup imitating a collapsed building scenario in an indoor environment.

(**SN3**) Outdoor setup was created with the same set of obstacles to create an earthquake like scenario.

In all `the scenarios it was made sure that only one human is present in the test setup.The efficiency of device with all three sensors integrated together was tested in SN2 and SN3.

Results

(a) Individual testing of sensors: A significant change of by presence of a human was only observed (50 ppm), when the CO_2 sensor was placed inside an enclosure (Fig1). During indoor measurements, a slight increase of the average CO_2 concentration was observed by moving towards the human, although the standard deviation was higher than the average change. Outdoor measurements were distorted by changing wind conditions.

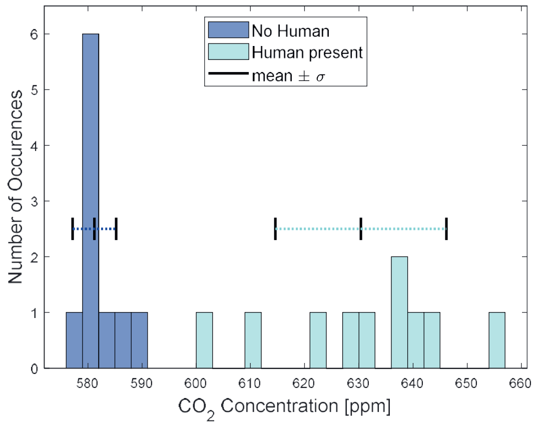

Fig.1. Measured CO_2 concentration inside enclosure

The success rate of motion detection for two commonly made human motions is shown in Fig 2. For up to a range of 4 meters the sensor was able to track both the motion efficiently, but the success rate further declined as the distance between the human and the sensor increased.

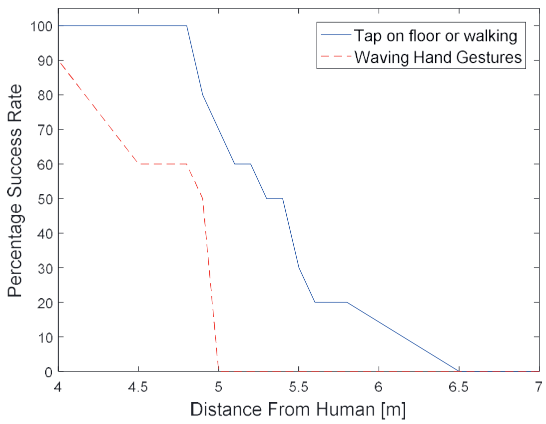

Fig.2. Measured success rate of motion sensor

For AMG8833 camera, it was found that it could detect a human at a range of about 1.5 feet.

(b) Testing of device as whole in collapsed building scenario(s): The device exhibited different behavior. The results from the two multi-sensor scenarios are given in Tab. 1.

Tab. 1: Preferred sensor for Scenario 2 and 3

SN	Preferred sensor and their behavior
2	*Thermal Camera*- Good Images up-to 1.5 feet. *Motion sensor* - Efficient in tracking all movements. *CO_2 sensor* – Able to differentiate the *CO_2*values in absence/presence of test victim.
3	*Thermal camera*– worked efficiently, in case of line of sight available.

Discussion

We have evaluated the sensor technologies which could be used for detection of humans. Sensor selection was made on the criteria that there may or may not be line of sight available between the system and the victim in a real earthquake debris. During individual testing of sensorswe found that the CO_2 sensor must be placed inside enclosures in the debris or laboratory setup. The motion sensor gave us few false results due to diverse disturbances in open environment. In any case with a line of sight, thermal camera worked efficiently in providing thermal images of trapped human. By integration of the sensors together and testing them as a device in whole, a success rate of 93% for our laboratory test scenarios was obtained.However,in a real worldsituation, system performance should be improved by using a better motion sensor giving a probability output and thus enabling better algorithms for sensors data fusion.

References

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