In-Car Suffocating Prevention Using Image Motion Detection

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Abstract: - Child left unattended in a car until they are suffocated has become a common issue today. A video-based system to automatically check whether there are any human left in the car when the engine has been turned off is proposed to solve this problem. A simple edge and motion detection technique has been used in order to detect human inside the car.

Key-Words: - security, suffocating prevention, motion detection, image processing, empty car detection

1 Introduction

Life casualty caused by suffocating inside a closed parked car has become a worldwide tragedy. Statistic has shown the occurrence of death inside a non-moving vehicle involving children is the largest, followed by handicapped and elderly person. Cases involving adults usually happens while the victims are taking a nap inside the car. This are due to dehydration, reduced amount of oxygen and heat exhaustion from the car's interior. When it became hard to breath, it is usually too late to react as the body already too weak to do anything.

Cited from an article about child's injury and death caused by suffocation inside a closed parked car, 54% of these cases are due to parent's carelessness by leaving the child intentionally while doing some chores and 42% of the cases are the opposites as the parents forgets or did not realize that their child is inside the car when they parked it. Usually the biggest factor of this fatality is caused by hyperthermia as the temperature inside the car will drastically increase when the engine has been turned off [1].

As a solution, an automatic system based on image processing has been developed where it can detect any human presences inside a parked car. If any movement is detected while in this condition, the car's alarm will be triggered automatically to alert the driver that something is wrong with the car. This system will prevent any parents from intentionally leaving their child inside the car while doing chores. Hence, this will reduce the number of life casualty especially the fatality among children inside the car.

2 Related Works

There are several known developments have been made closely related to the proposed system but their purpose are different. For an example, a similar automated system has been developed in an Airport People-Movers (also known as inter-terminal train) to detect any passenger or baggage left inside the carrier after it has reached its destination [2]. This system used a simple edge detection technique where the real video taken for detection is compared frame-by-frame with an empty carrier video as its reference. Any difference from the comparison will be categorized as object detected. The system is very suitable for detecting any object left inside the carrier. But this method is not fully suitable for this proposed system because the system must be able to differentiate between human and non-human objects as it needs to detect the human presence only, not the other non-living objects left inside a parked car.

Other development that has been spotted is the use of stereo camera in several projects such as preventing infant death due to airbags [3]-[4]. This method will require more than one camera to be used at one time which will significantly increase the system's complexity and overall cost. The system's complexity is increased by complicated algorithm of merging and processing the images from more than one video camera.

Besides development in image or video-based system, there are also other projects that use combination of various types of sensors to detect human presence inside a car. Passive Infrared sensor, temperature sensor and sound sensing device are the common combination of sensors used for detection in a close compartment [5]. Some developments also have been spotted where the use

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of microwave sensor or the breathing motion of a human being for detection [6]-[7]. These multi-sensors methods of detection will increase the manufacturing cost significantly. Thus, these approaches are not the best solution for this problem.

3 Hardware Concept

3.1 Operational Activities for the System

The in-car suffocating prevention system is design to prevent child death or injuries happened due to the adult carelessness. The system is proposed as an alternative solution that is much lower cost compare to the previously designed project.

The flowchart for the whole system activities is shown in Fig.1. The system will automatically activate after the alarm system of the car is activated by the owner. The system will then execute the detection procedure by comparing each frame of the video recorded by the camera installed in the car. If any motion is detected inside the car, the car alarm will go off until the owner of the car deactivates the alarm system. The alarm indicates that there is someone or something left inside the car.

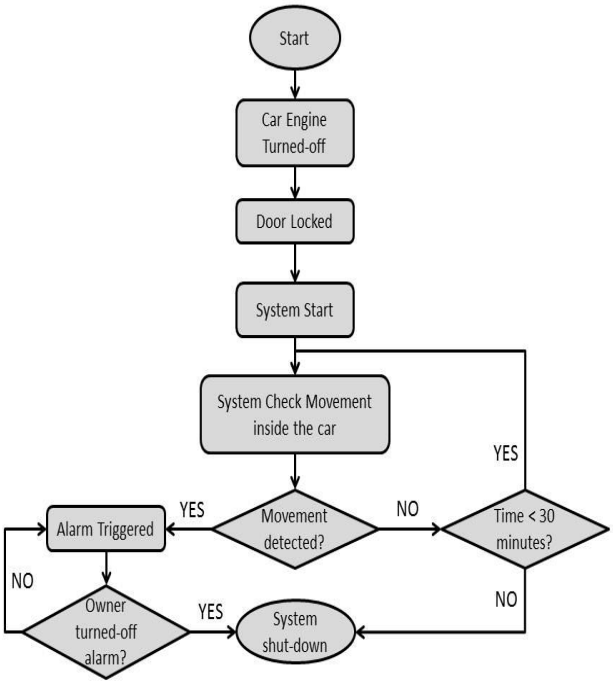

Fig.1 Full System Flowchart

To prevent battery drainage and to provide efficient power management, the system will only activated for 30 minutes only. If nothing is detected within the 30 minutes time span, the system will automatically shut down. 30 minutes time span is chosen in order to provide ample time for detection process. Since sleeping human is rarely moved, the system might not be able to detect anything in a short period of time. Sleeping human usually will show some movement that is sufficient enough for the system to detect the movement is within 15 minutes. The detection process must not exceed 30 minutes because the temperature of a vehicle could rise up to 60 degree Celsius within 30 minutes despite of any ambient temperature [8]. This amount of temperature could cause hyperthermia or heat stroke to the child left in the car. To avoid this, the system must be able to detect any living things in less than 30 minutes.

3.2 Full Hardware Architecture

The detection method for the system is based on video image processing. Two cameras has been setup in a car as shown in Fig.2 where each camera only covers a certain viewing angle. The idea is to allow maximum visibility and remove any blind spot. Both cameras are facing 30 degree downwards so that they will only focus on the car seat and the car floor where it is the highly probable location for the child being left. This will reduce the interference from the sunlight and the motion from outside of the car. Thus, it can give a more reliable result.

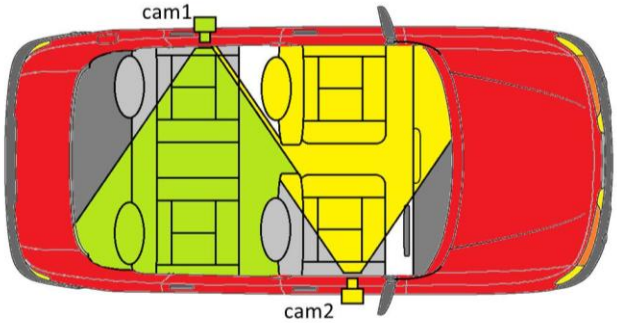

Fig.2 Camera position and their respective viewing angle

These cameras are connected to a Raspberry Pi Single Board Computer which will be the storage and controller unit for the system. This single board computer will process the video image and then control the car alarm system depending on the result. The full hardware architecture is shown in Fig.3.

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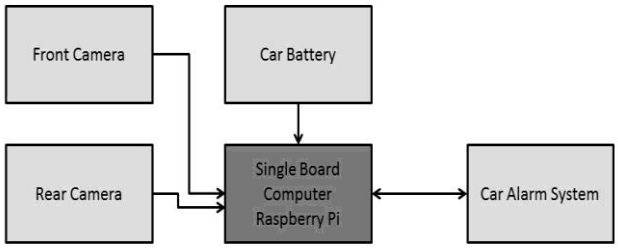

Fig.3 Full Hardware Architecture

3.3 Raspberry Pi Model B

Raspberry Pi is a Single Board Computer (SBC) with a dimension of 86mm x 56mm x 21mm. This very small size can be easily fitted in any car. The Raspberry Pi Model B is chosen because it could provide a higher RAM and CPU speed if compare to Raspberry Pi Model A and PIC microcontrollers. Its ability to add external SD card storage up to 32GB is the major factor that this type of SBC is chosen as processing and controlling unit. This is because; a real time video image processing requires a large amount of storage space to store the data. Microcontrollers like PIC would not have enough memory to store the processing data. The only drawback for this type of SBC is it only has a limited number of General Purpose Input/output (GPIO) pins. But this is not a major concern for this project because the output for this project is only the car alarm. We do not need many GPIO pins to turn on and off the alarm system of the car.

3.4 BTC PC380 Webcam

The camera use to record the video in this project is the BTC PC380 Webcam produced by Behavior Tech Computer Corporation. This webcam is chosen because of its low cost and it provides a 640x480 (VGA) resolution which is enough for the system image processing. We do not need a higher definition image because a higher definition image will only cause the processing time to be much longer. The webcam also can record a smooth video at 30 frames per second. The camera is placed on the window frame with 30 degrees facing downwards as shown in Fig.4.

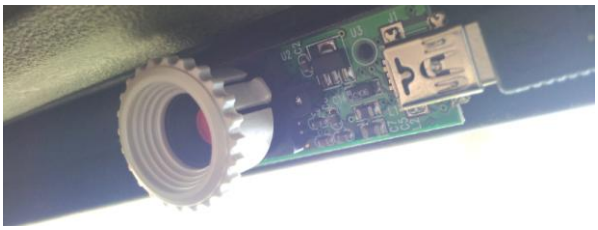

Fig.4 Webcam Installation

4 Algorithm

Since the video recorded by the webcam is in 640x480 frame size, we do not need to scale down the resolution further. This will shorten the full detection coding as well as the processing time. A simple motion detection algorithm is used in order to detect the small movement inside the car. We start with noise removal by using bilateral smoothing to preserve the edges so that movement features can be detected.

Image quality enhancement is done next by increasing the contrast and adjusting the brightness. Then, Laplacian formula is used to enhance the edges in the image. The running average of the incoming video frame is then created using the OpenCV function RunningAvg() so that only significant motion stands out in the image frame. After that, the current frame is subtracted to the running average to show the blobs that have moved. We convert the image to grayscale and set the threshold value here so that the blobs could be clearer. If there is no motion detected, the resulting image will be pure black. If there is any motion detected, a pure white color will be appeared in certain region in the resulting image where the small motion is detected as shown in Fig.5 and Fig.6.

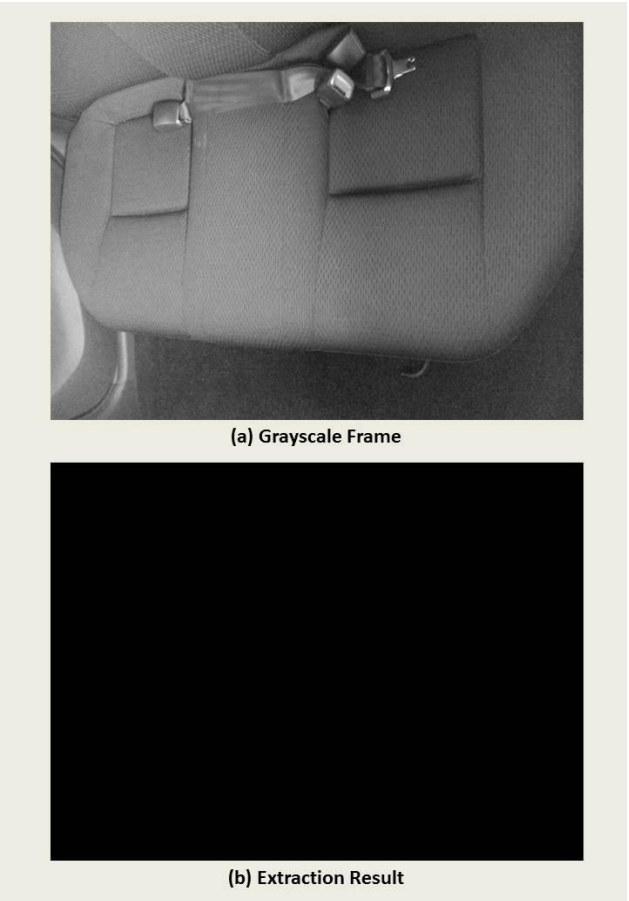

Fig.5 Image Result for Empty Car

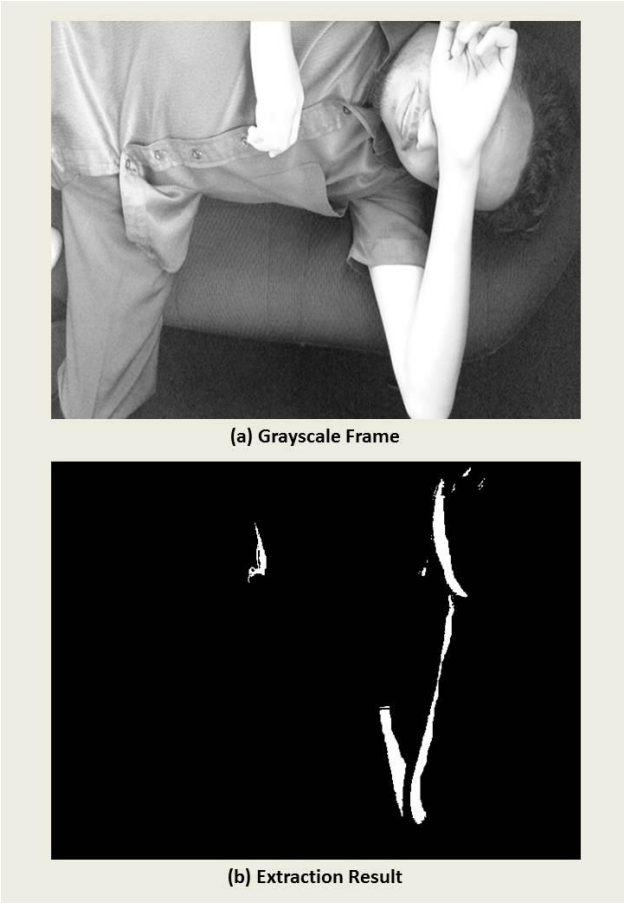

Fig.6 Image Result for Occupied Car

A certain amount of dilation and erosion is applied on the thresholded image in order to enhance the blobs and removing any unwanted noise. Finally we search the contours of the blobs to provide decision to the system whether any motion is detected or not.

The system will output one signal. When the car engine is turned off and the alarm system is turned on, the system will start to record the video of the car interior automatically. If the car is found to be empty after 30 minutes of operation, it will initiate system shutdown. Otherwise, if any motion is detected inside the car, the system will set the alarm off to warn the car owner that there is something or someone left inside the car.

5 Results

The system has been tested in various conditions using video sequences recorded from a car. These conditions are considered in order to test the reliability and performance of the system. The identified variables are as follows:

1. Controlled variable (controlled lighting condition and image sequences without any object exist in the car or empty car).
2. Different body sizes (man, women, fat, thin, and child).
3. Different body positions (sit and lie down).
4. Different objects (boxes and balls).
5. Conditions where human and object exist inside the car.

Based on these conditions, we analyze all the recorded data. The system successfully identified every image sample that have human inside it. No detection error has been recorded. Fig.7 shows an image frame that is full with objects. None of them has been detected as human since no motion exists. Fig.8 shows an image with human sitting at the far side of the camera frame. Although the person inside the image is sitting in a very static condition, a very small movement is still detected. Fig.9 shows a combination of human and object on the seating compartment. The very small movement of the person still can be detected without failure. The object is still cannot be detected unless it is being moved by the human. This is not a major concern since we only want to detect small movement, not to classify whether the movement is human or not.

Fig.7 Car Full with Objects

(a) Original Frame

(b) Motion Detected

Fig.8 Human sitting static at the far side of the camera

(a) Original Frame

(b) Motion Detected

Fig.9 Combination of Human and Object

Motion in each sample can be detected in less than 3 minutes. The longest time taken for detection is 2.53 minutes where the subject inside the image is trying to kept static for as long as possible. Even though we cannot detect any movement using our naked eye, the system can still detect the very small movement of the subject. This is a huge success since the system needs to be able to detect movement as fast as possible in order to prevent any harmful situation to the human being left inside the car.

6 Conclusion

The In-car Suffocating Prevention System has been successfully developed with the promising testing results as it can detects a small fragment of human motion inside a parked car. Within a 30 minutes time span, human lives can be saved as this prevention system will triggered the car's alarm system to alert the owner to check back any faulty reason due to his or her carelessness. The system uses a very simple video image processing technique where feature extraction of a human presence is analyzed in order to detect any slight interior movement. By doing this, the system can helped preventing child or pet fatality inside a car after being left alone for a certain amount of time for any reason.

As for testing procedures, the experiment has been done in a controlled lighting condition. For further development, investigations into different lighting conditions need to be done where it may require some changes in the algorithm and the hardware design.

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