

Child Presence Detection System and Technologies

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Child Presence Detection (CPD) is a safety system designed to assist drivers to prevent the consequences of mistakenly left children in closed parked vehicles. Recently, ASEAN NCAP has released its 2021-2025 Roadmap that outlines the implementation of CPD technology as an initiative to prevent such incidences from happening in the future. This paper aims to provide an overview of these CPD systems and their associated technologies that are readily embedded in vehicles, or commercially available in the market.

Taugh or his real name, Ruslan Ayob, is a legendary cartoon artist (Ujang humour magazine) based in Sungai Besar, Malaysia. His Facebook page is <https://www.facebook.com/taughstudio/>.

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There have been several tragic incidents in which children have been unintendedly left in closed parked vehicles after the drivers had reached their destination. When a vehicle is parked with all windows closed under direct sunlight, the vehicle interior temperature can build up into excessive heat in response to the greenhouse effect. The phenomenon is illustrated in Figure 1, where yellow arrows representing sunray entering a vehicle through its windshield. The heat is absorbed by vehicle interior parts such as seats, floor mats, and dashboard, which in turn radiates within the vehicle cabin (red arrows) resulting in temperature increase inside the vehicle.

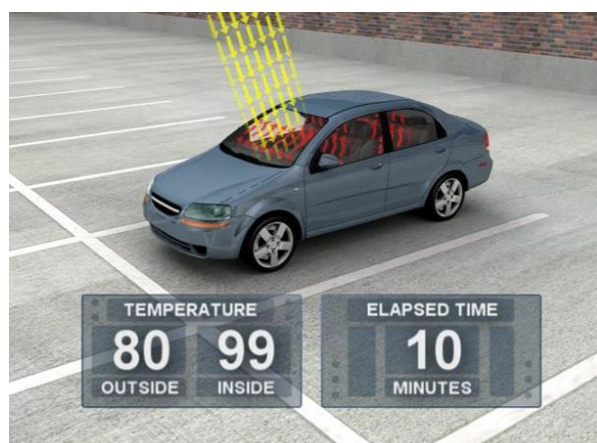


Figure 1: Temperature reading (in degree Fahrenheit) for a closed vehicle within 10 minutes (Grundstein et al., 2009)

The previous study found that, at similar or lower ambient temperatures ranging from 22 to 35°C, 4°C internal temperature is expected to increase, putting children at significant risk (McLaren et al., 2005). In addition to the greenhouse effect, the less efficient children's thermoregulatory system increases their risk for hyperthermia – a condition that happens when the body generates more heat than it can release it. Children are more inclined to have hyperthermia due to their inability to effectively lower their body temperature than adults, mainly due to children having a larger surface-to-body ratio, produce more metabolic heat and have lower sweating capacity than adults.

In Malaysia, a total of eleven cases related to the forgotten child in parked vehicles had been reported until October 2019, where more than half of these cases involved children of three years old and below (Jawi, 2018). The circumstances mostly involved a caregiver, especially a parent, forgetting the child due to a condition known as the Forgetting Baby Syndrome. This worrying trend has captured the attention of the New Car Assessment Programme for Southeast Asian Countries (ASEAN NCAP), with Child Presence Detection (CPD) technology being included in newly released ASEAN NCAP Roadmap 2021-2025 (ASEAN NCAP, 2018) to promote the use of any available technologies that could prevent

such tragedies from happening again in the future. ASEAN NCAP plans to reward car manufacturers who offer such technology as standard equipment, which will be done through ASEAN NCAP's Child Occupant Protection rating system. To kick-start the initiative, ASEAN NCAP conducted an educational seminar involving various stakeholders in July 2018 with the aim to raise awareness about the dangers of leaving unattended children in vehicles (Hwong, 2018; Ismail, 2018; Jawi, 2018; Mousel, 2018).

Child Presence Detection (CPD)

In recent years, numerous studies, researches and inventions have been performed to address the problem of unintended children left in vehicles. Karaman et al. (2017) proposed a system consisting of the Sensor Unit, Processor Unit and Response Unit, as shown in Figure 2. It was designed to detect any movements in the vehicle for human presence and determine if the environment is a dangerous situation. The system will then notify related authorities or perform interventions such as lowering the vehicle window through the response unit.



Figure 2: Block diagram of the child heat injury prevention system (Ferrara et al., 2013)

In a proposed design by Baid et al. (2017), the system will trigger the alarm system when it detects child presence when the engine is OFF. Based on Figure 3(a), a sound sensor is added to the system to recognize the crying baby voice. Moreover, Sulaiman et al. (2017) proposed a system to detect the presence of children including infants in an unmanned vehicle. Figure 3(b) describes two major components of the system consisting of detection and feedback systems. The detection system detects voice, odour, motion and temperature inside the vehicle. This information will trigger the feedback system to perform feedback functions in stages: (a) the system sends a notification to the driver's mobile phone through short messaging system once a child presence is detected; (b) the system triggers the vehicle's alarm system if no action is taken by the driver; and (c) the system lowers down the window to reduce the temperature inside the vehicle.

Another design proposed by Khamil et al. (2015) comprises a reminder system that includes a safety pad fixed into a child car seat or a child restraint system (CRS), and a keychain alarm device for the driver. An overview of the safety pad design is shown in Figure 4. There are three major components in the safety pad, which are the load sensor, Arduino UNO and 1Sheeld. Arduino UNO provides the converted and amplified load sensor signal to 1Sheeld and gives notification to the driver's smartphone. On the other hand, the keychain alarm device uses a radio frequency signal to determine the range between the keychain and the child car seat. When the weight of a child is detected in the CRS while the keychain alarm device is within a specific range, a reminder will be sent to the driver through the smartphone. As the distance of the keychain alarm device getting further from the set range, a notification is given to the driver to remind that the driver has left the vehicle without the child.

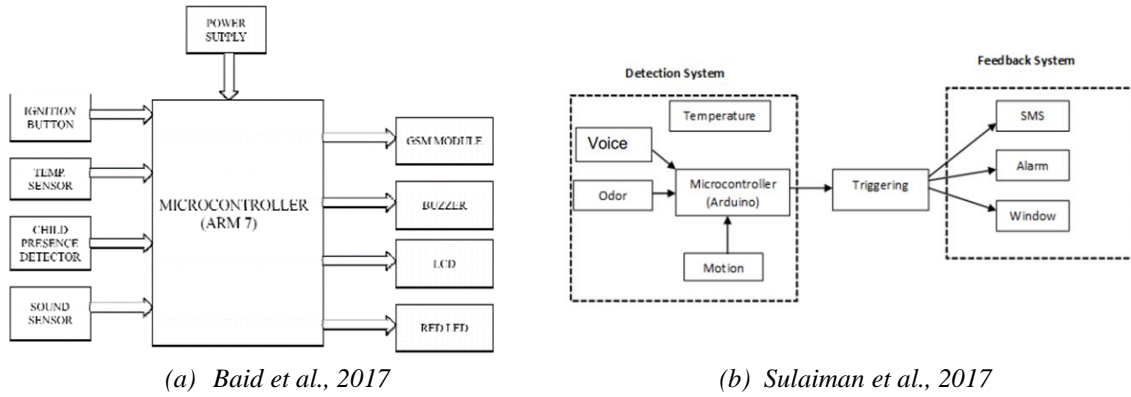


Figure 3: (a) Block diagram of CPD in unmanned vehicle; (b) block diagram of detection and feedback system

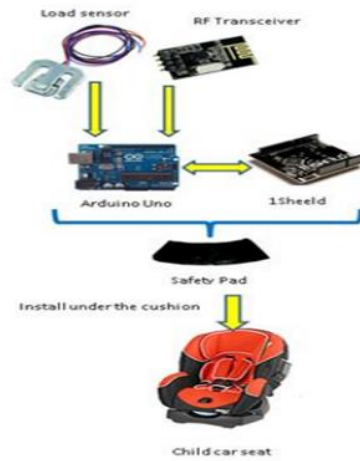


Figure 4: Safety pad design consists of load sensor, Arduino UNO and 1Sheeld (Khamil et al., 2015)

A patent by Rams (2006) consisted of a switch that is attached to the CRS strap and a sensor that is located underneath the driver’s seat (Figure 5). The system will activate the alarm system once the child seat strap is inserted into the belt buckle and no driver's presence in the driver seat. A delay timer is added to the system to give the driver time to enter and exit the vehicle to either refuel or access the vehicle trunk without setting off the alarm.

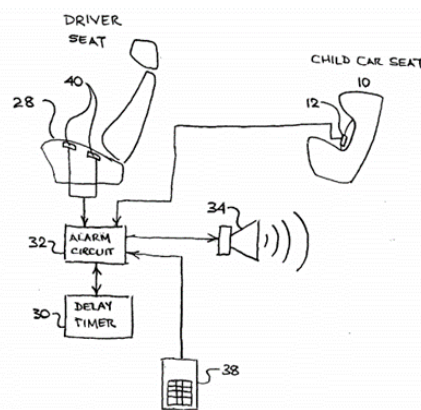
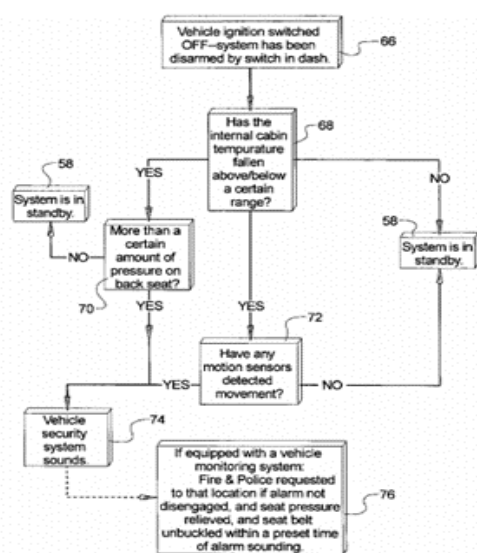


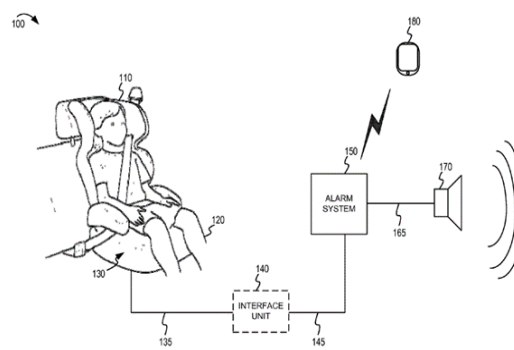
Figure 5: Layout of child occupancy detection system (Rams, 2006)

Cole (2004) developed a system to detect the presence of an unattended child in a vehicle (Figure 5(a)). When a child has been detected in the vehicle, the system deactivates the vehicle's door or prevents them from being locked. The presence of the child is also detected by pressure sensors mounted on the rear seat of the vehicle. Another method to detect child presence is by the sensors attached to the seat belts. The system has a retract switch that activates the system based on the threshold temperature of the vehicle and can be turned off by the driver. The pressure sensors can also be substituted with motion detection sensors for the detection of a child in the vehicle.

Borgne et al. (2017) invented a seat alarm for child safety as shown in Figure 5(b). It has built-in pressure sensors for the detection of a child in the vehicle. If a child is detected, the alarm system will sound an initial alarm to grab the driver's attention. Then, a louder alarm will be produced to alert the driver or surroundings of the presence of a child in the vehicle. The alarm is linked to the driver's phone.



(a) Cole, 2004



(b) Borgne et al., 2017

Figure 5: (a) Block diagram of the unattended child detection system integrated with the door system; (b) layout of child safety seat alarm system

In the research of Gonçalves (2018), the system was designed using a motion sensor for presence detection and provides alert to the driver. When any motions are detected, an alert message is sent to the driver's phone to notify the presence of humans inside the vehicle. The main components used in this design are microcontroller, motion sensor and GSM module.

Mousel et al. (2017) presented another solution to reduce the risk of children's heatstroke fatalities. The radio frequency-based system is capable of detecting respiration as well as the heartbeat of sleeping babies or children. The sensor used electromagnetic waves, which can penetrate through sunshades and clothing, and thus children in forward-facing and rear-facing CRSs can be detected by the system. Figure 6 shows the sensor position and the sensor itself.



Figure 6: Radio-frequency based system sensor location (Mousel et al., 2017)

Vehicle Reminder System

In addition to the CPD systems, there are a few vehicle reminder systems that have been added to vehicles thus far. These systems generally fall into a reminder system that does not necessarily require to detect the presence of a child. These systems also remind the drivers if they have left anything at the rear passenger seats; for example, the Nissan Rear Door Alert and the GMC Rear Seat Reminder systems. These systems employ the door system logic to detect if someone has opened the rear door before the car was started and consequently provide a reminder on the vehicle meter cluster to check the rear passenger seats when the driver exits the vehicle. Another example is the Hyundai's system called the Rear Occupant Alert equipped in Santa Fe 2019 provides a reminder to the driver that the rear door has been opened before the trip. It continuously monitors the rear seat after the vehicle is parked and all doors are locked.

There are also products in the market targeting the problem of at-risk unattended children. Some of the products are attached to the base or the straps of the CRS. The system will provide notifications or alerts to a fob or device carried by the driver such as a smartphone, key fobs, etc. Systems that can be attached to the base of a CRS use pressure weight type of sensor. If the sensor detects the presence of a child in the car seat, the alarm system will be activated. Other child seat reminder systems use a switch clip closure that is attached to the strap of CRS to indicate the seat is occupied (an example is shown in Figure 7). Notification will be provided to the driver as a reminder of the child left in the CRS when the system detects the fob is getting away from the sensors. These products are listed in Table 1 as a reference.



Figure 7: Example of reminder product available in the market

Table 1: List of reminder products available in the market

No	System name	Sensor			Warning Indicator			Price (RM)
		Type of sensor	Sensor location		Audible	Visual	Phone	
			base child seat	child seat strap				
1	Elite Pad system	weight	•		•			
2	ChildMinder Softclip	clip closure		•				631.10
3	Sense A Life	weight	•		•			
4	Sunshine Baby iRemind Car Seat Alarm	weight	•		•	•	•	420.55
5	Elpho eClip	Bluetooth					•	210.20
6	Driver's Little Helper	weight	•				•	
7	Bee-Alert	door switch			•			126.20
8	Ride N Remind	door switch			•			546.95

* Prices shown are correct at the time of publication.

Conclusion

This paper presented an overview of CPD systems and their associated technologies including embedded vehicle systems and products available in the market. Several CPD systems are described, although none of them is currently readily available in the market. In addition to CPD systems, a few examples of vehicle reminder systems are also included in the paper. In conclusion, both CPD and reminder systems could help in protecting children from being left behind in the unattended vehicle. Therefore, immediate actions should be taken by vehicle manufacturers and automotive suppliers to speed up the availability of these systems in the commercial market.

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