CHILD PRESENCE DETECTION USING 60 GHZ RADAR

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CHAPTER 1 : INTRODUCTION

1. RESEARCH BACKGROUND

Nowadays, more and more cars are on the road, more and more car brands are being developed, and more and more cars are being produced. This happens because the number of people using car is increasing. Furthermore, nowadays cars are necessity for most people to move or migrate. Of course, the car is beneficial, but it also has the potential to be dangerous. Even though cars can shorten our travel time and can carry a lot of our things, but they can also cause an accident. Among the accidents that are often neglected by a driver is forgetting and being careless about the condition of passengers, especially baby passengers and children.

In the last year, it was reported in the USA that there were as many as 29 cases of child deaths due to extremely hot car interior temperatures. This makes the annual average number of deaths of children under the age of 15 as many as 38 cases in the USA that have been recorded since 1998 [1][2]. While in Malaysia, it was also reported that the number of cases of babies under the age of 3 who died in cars due to hyperthermia due to being left unattended is also increasing. This is also because parents are less sensitive to risks and threats [3].

On November 8, 2023, there was a two-year-old girl who was found dead in a car after her parents accidentally left her in the car for seven hours at Petaling Jaya. It is understood that this happened as a result of the mother forgetting to drop her daughter off at kindergarten. Her mother had completed an online business while in the kindergarten parking lot. Because she thought she had dropped his daughter off at kindergarten, she went straight back to her house. She became aware of this accident again at about 3:40 in the afternoon [4]. In Shah Alam, a 5 year old girl was found dead because of her mother accidentally leaving her in the car for 4 hours [5].

The situation is about the accident happen in Petaling Jaya, Selangor. It describes and highlights how a child or baby has died in a car due to the carelessness of a parent or driver [6]. A baby left in a car with the engine turned off can have

serious and potentially life-threatening consequences. This is because a closed car can heat up quickly due to greenhouse effect, even on an overcast and cool day [7]. Among the things that can happen to a baby left in a closed car for a long time are Heatstroke, Dehydration, Strangulation, Unintentional Suffocation, and so on. And the most feared and worried is the Hot Car Death.

Hot Car Death is a situation happen when someone leaving kids, child, or pet alone in a car when the car is parked. The situation will lead to the serious injury or fatality due to the heat [8]. When the car is turn off, the air cond is turn off, the heat is rapidly heat up the car interior, even on mild days, and it will posing a significant risk to vulnerable individuals. Children and pets bodies can easily heat up quicker than an adult [9]. This situation can make organ failure or organ damage. To prevent hot car deaths, caregivers and pet owners must be aware by avoiding leaving individuals in vehicles, especially during hot weather. Awareness campaigns strive to highlight these dangers and offer guidelines to ensure safety and prevent these devastating situations.

So, as a solution, a safety device should be introduced to detect kids left in the car. Many solutions have been proposed such as using load/temperature sensor [7], passive infrared sensors [10], and machine learning technology [11]. But these methods usually experience a high false alarm rate and can only offer a limited amount of coverage. Actually, by using Wi-Fi [12][1], the detection process is better and more accurate, but it just relies on the connection, and 2.5 GHz and 5 GHz interference and disturbance easily affected it around the vehicle. There is also a child detection system in the car that uses Radio Frequency (RF) signals [13]. This is because this RF signal is less disruptive to privacy and is easy to install. However, this is very dependent on millimeter-wave (mmWave) signals with limited coverage, and most modern cars today do not provide millimeter-waves.

To improve the data acquisition, 60 GHz radar [14][15] has been chosen as another way to detect the presence of children or babies left in the car. In theory, the radar will emit electromagnetic energy and reflect the electromagnetic energy to the radar receiver. The time it takes for the electromagnetic energy to reach the receiver will be calculated to get the distance in a space that was emitted. In this way, the system can identify the presence of children in the car, because the processor will

analyse the data received from the receiver. If there are children present, the pattern of electromagnetic waves received at the receiver will be different from the pattern when there are no passengers. Notifications will be sent to parents and guardians through the IoT system integrated with this radar system if there are children present. The signal will be sent to the PSoC 6 MCU platform as the main IoT platform in this radar system. This XENSIV CSK BGT60TR13C kit is also capable of detecting human vitals.

To develop a more peaceful and prosperous society, and at the same time a population that is healthy and away from accidents, the United Nations has made a Goal named Sustainable Development Goal, which has 17 elements in it, so by developing Child Presence Detection to some extent can fulfils the 3rd Goal, which is to be very concerned about the health of the individual and to ensure that the individual is healthy. In addition, this project aligns with the overall policy goal of protecting children from harm, which is a key priority for the Malaysian government. The Child Act 2001 (Act 611) emphasizes safeguarding children's health, safety, and well-being. While it doesn't specifically address children left in cars, it could be argued that this project supports broader child safety objectives.

2. PROBLEM STATEMENT

i. The cases of deaths of children and babies due to being left in car is increasing.

ii. It is challenging to determine the presence of children in the car by relying on motion detection due to the noises.

iii. Lack of integration between IoT and Radar system, making it difficult for user to use efficiently for child detection in cars.

3. OBJECTIVES

i. To develop a 60 GHz radar system to detect the presence and movement of children left in car.

ii. To evaluate the performance of the proposed 60 GHz radar to detect the presence of children.

iii. To integrate the Radar system for child presence detection with IoT technology.

4. SIGNIFICANCE OF THE PROJECT

Children or babies who are left in the car must be take care immediately so that the child does not experience any danger. So, by using a 60 GHz radar sensor, it can be a first step to save children who are left behind in the car. With this project, we can follow and comply with the Sustainable Development Goals (SDG) created by the United Nations as a call to action for everyone throughout the country to resolve five critical areas by 2023: people, planet, prosperity, peace, and partnership. To make this SDG more successful, this Child Presence Detector can fulfil Goal 3 [16] of SDG which is good health and well-being, which emphasizes Ensuring healthy lives and promoting well-being for all at all ages. These goals focus on improving health outcomes, reducing mortality, and addressing a range of health issues. This project was also developed to detect the presence of children left in the car and be able to deal with cases of hot car death.

Figure 1 : Sustainable Development Goals. Goal 3 and Goal 11

In addition, this Child Presence Detector project can also meet Goal 11 [17] of SDG which is Sustainable Cities and Communities. The main goal of Goal 11 is to make cities and human settlements inclusive, safe, resilient, and sustainable. So, this creation will be able to further improve the safety of children in cars in urban areas, and at the same time, this goal seeks to make cities and human settlements inclusive, safe, resilient, and sustainable. By improving the safety of children within vehicles parked in urban areas, your project would contribute to creating a safer and more sustainable environment for all residents.

5. PROJECT SCOPE

In this project, a Child Presence Detection system has been developed using a XENSIV CSK Kit BGT60TR13C microcontroller. This microcontroller has a radar system installed on it, which can detect the movements of both children and adults. The radar has one transmitter and three receivers, and it functions as an active radar. It emits 60 GHz electromagnetic waves throughout the interior of the car and receives the waves that are bounced back. By measuring the time, it takes for the receiver to receive the electromagnetic wave, the system can detect whether or not there is a child in the vehicle.

Furthermore, the XENSIV CSK Kit BGT60TR13C is not a standalone system. It is equipped with a PSoC 6 microcontroller, Wi-Fi, and Bluetooth, which makes the system more stable and efficient. This will make the developer more flexible in developing the system.

Additionally, this microcontroller supports IoT technology, making it easier to implement IoT sensors and send notifications to parents to remind them to be careful and not leave their children in the car. Overall, the XENSIV CSK Kit BGT60TR13C microcontroller is a reliable and efficient solution for Child Presence Detection systems, and its additional features make it a flexible platform for developers to build and program.

CHAPTER 2 : LITERATURE REVIEW

1. INTRODUCTION

Due to too many cases of child and baby deaths today, a system to track was introduced and created to reduce the cases of child and infant death, and at the same time to prevent parents from leaving their children alone in cars. Furthermore, today there are also many studies and research that have been carried out on the problem of children being left in the car to ensure that these children are no longer left alone in the car. This presence detector is very important to put in the cars nowadays, especially for those who are newly married or who have small children.

The problem of leaving children in the car is very dangerous and can lead to many accident factors, among which the car that is closed and left for a long time can get hotter, at the same time the oxygen level will decrease and will result in children left in the car will drown. Among the more dangerous accidents is the abduction and theft of children who are left in the car. Or the child plays with all the levers in the car if he plays with the gear and the handbrake it can cause another accident.

In this literature review, the most important findings are about the manufacture and construction of a human movement detection system, a 60 GHz radar system that can detect the movement of people and children accurately and precisely, and a radar system that can integrate with the IoT system.

2. Detecting the Children and Human Motion in the Car

Detecting the children that left in car can be done by using the Wi-Fi technology. The commodity Wi-Fi and Wi-Fi sensing based CPD system will be used to detect the presence of children in parked cars. Based on the autocorrelation function (ACF), the system can detect three condition of the child, which is detecting the awake/motion condition, detecting sleeping/static condition, and detecting the vital signs using Naive Bayes Classifier [18].

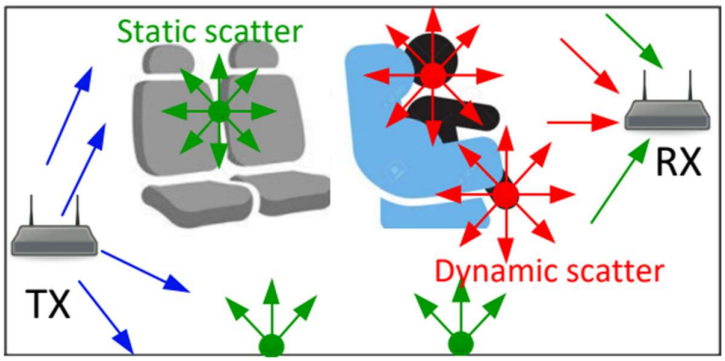


Figure 2 : CPD using Wi-Fi

Previously researcher has been using camera. Asha Banu S.M et.al. has proposed the idea of detecting the children that left in car by using Machine Learning. The system employs image classification techniques, particularly the Local Binary Pattern Histogram (LBPH) algorithm, to detect the presence of a child in a vehicle. Additionally, the system incorporates an Arduino Pro Mini microcontroller board and an IR proximity sensor to check the closed state of doors and windows. Upon detecting a child in the car, the system sends an email alert to the parent or guardian [11].

The other method has been proposed is by using ViMo technology to monitor multi person vital sign. ViMo can accurately detect stationary and nonstationary users and estimate respiration rates and heart rates without requiring any calibration. ViMo utilizes adaptive object detection to identify reflecting objects, a motion detector to differentiate static objects, stationary human subjects, and human with large body

motion, and a robust HR estimator that eliminates the respiration signal and leverages dynamic programming to resist the random measurement noise [13].

There is also a method that uses multi-agents to detect the presence of children left in the car and can send notifications to parents and guardians about the child's condition. The system consists of two main types of agencies: the Monitoring Agency and the User Agency. The Monitoring Agency includes agents such as the Temperature agent, GPS agent, Sound agent, Motion agent, and Coordinator agent, all of which work together to detect and analyse the risk of heatstroke. The User Agency comprises the Interface Agent, which mediates between users and the agents and sends heatstroke risk alerts to the driver's smartphone [19].

3. 60 GHz Radar Performance on Detecting the Presence of the Children

A multi-channel 60 GHz FMCW radar sensor has been used to detect the occupancy of passengers inside a vehicle in various seating arrangements. The received radar signal will be converted into a range angle map, performing clutter suppression to eliminate unwanted signals, and utilizing classification algorithms such as support vector machine (SVM), multi-layer perceptron (MLP), and convolutional neural network (CNN) to identify the location and number of passengers inside the vehicle. The radar performance has been evaluated based on the classification accuracy of various algorithms and network structure. The CNN algorithm have produced the highest classification accuracy of 95.36% to 97.68% by using variance-based clutter suppression. By using the high-resolution imaging radar with enhanced angular resolution can improving the performance of the system [14].

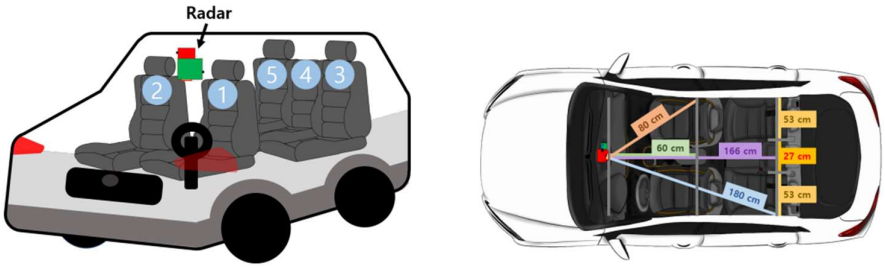


Figure 3 : CPD using 60GHz FMCW radar sensor

In others, radar identifies human movement and motion can be applied by combining two techniques that involve two parallel signal processing. The first technique uses statistical characteristics of the radar signal to determine the moment when a person's movement changes. The second technique employs a deep learning-based classification algorithm to identify the specific actions a person is taking. The radar spectrograms, which contain characteristics of distance change over time, are used as input for both signal processing techniques [20].

The study by Min-ho Jang et.al shows an idea of Radar detecting human motion is that the change point detection algorithm can be applied to the radar spectrogram to identify the movement changing in subject breathing pattern.

Furthermore, the respiration rate is calculated from the movement change in distance between the subject and the radar over time [21].

Frequency Modulated Continuous Waves (FMCW) radar also has been widely used in recognizing the hand gesture [22]. Which is applied either in the car or as a smart home appliance. We also know and are often told about the smart home that with just a wave of a hand, the house curtains can close automatically. This is because this radar system detects the hand gesture and it is translated by machine learning or deep learning algorithms that have been trained. So 60 GHz mmWave radar is capable of detecting human hand signals. Before that information and data will be collected as classes of hand signals. In the end, the hand signal obtained from the radar will be translated and understood to obtain the actual form of the hand gesture.

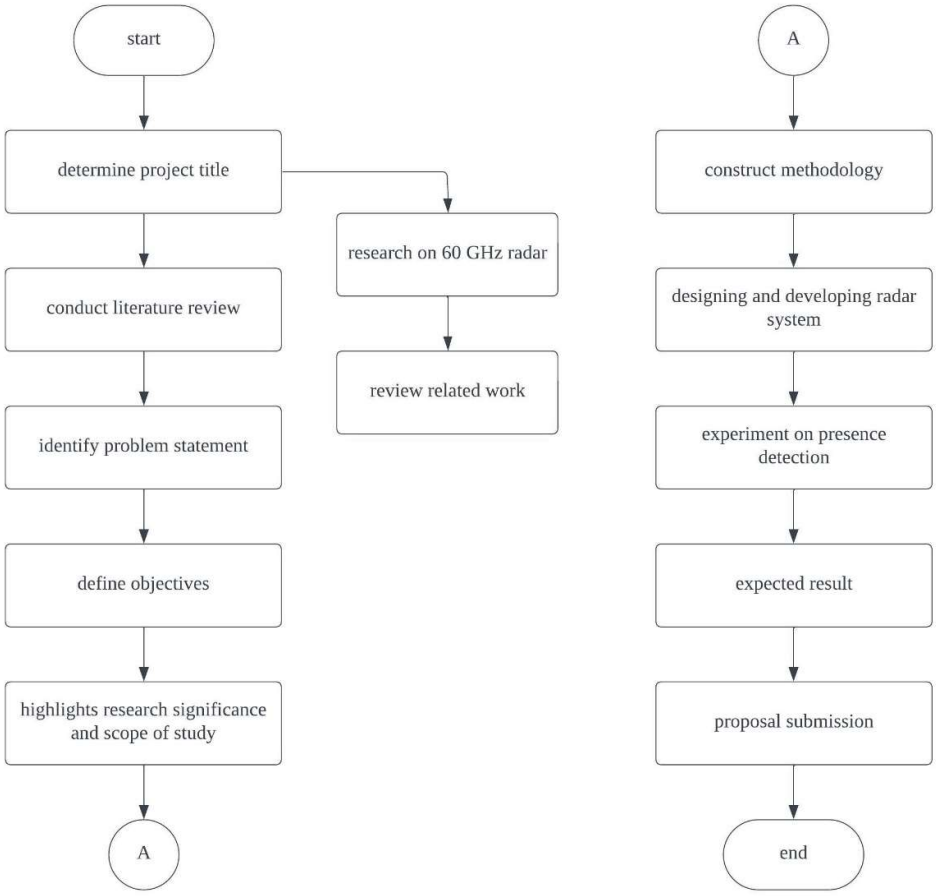
4. Integrating Radar Sensor with IoT Technology to Detect Children and Human

Radar-Based sensors can be integrated into the Internet-of-Things (IoT) for applications such as smart homes and security. Radar systems can provide information and enhance security within the IoT environment. By integrating radar system and IoT technology, it will produce something that brings benefits, such as enhanced security and management of connected devices, as well as the challenges involved in this integration. This conclude that integrating radar into the IoT system not only serves as a sensor device but also contributes to securing the entire IoT environment.

In others, it is used to improved tracking performance while considering constraints such as power, processing, and communication rates. The approach is involving data fusion to combine measurements from heterogeneous sources and prediction to identify the configuration parameters for each sensing node. Algorithm for tracking a single target using measurement from configurable image and radar nodes also has been presented. The IoT nodes are utilized for data acquisition, processing, and communication in a distributed tracking system [23].

CHAPTER 3 : RESEARCH METHODOLOGY

1. Flowchart of the Proposal



The flowchart above shows the process of writing a proposal to develop a 60 GHz radar capable of detecting the presence of children left in the car. The following is a flowchart that shows the important process throughout the writing of this proposal. This process begins with the search for a project title to explain the main goal of producing this project. Child Presence Detection using 60 GHz radar was chosen as the title to implement this project. Then, the research and reading of the technical papers for the previous projects were done to help make this project easier. The research in the Literature Review was carried out to find additional information about other methods, their advantages, and their limitations. For example, previous

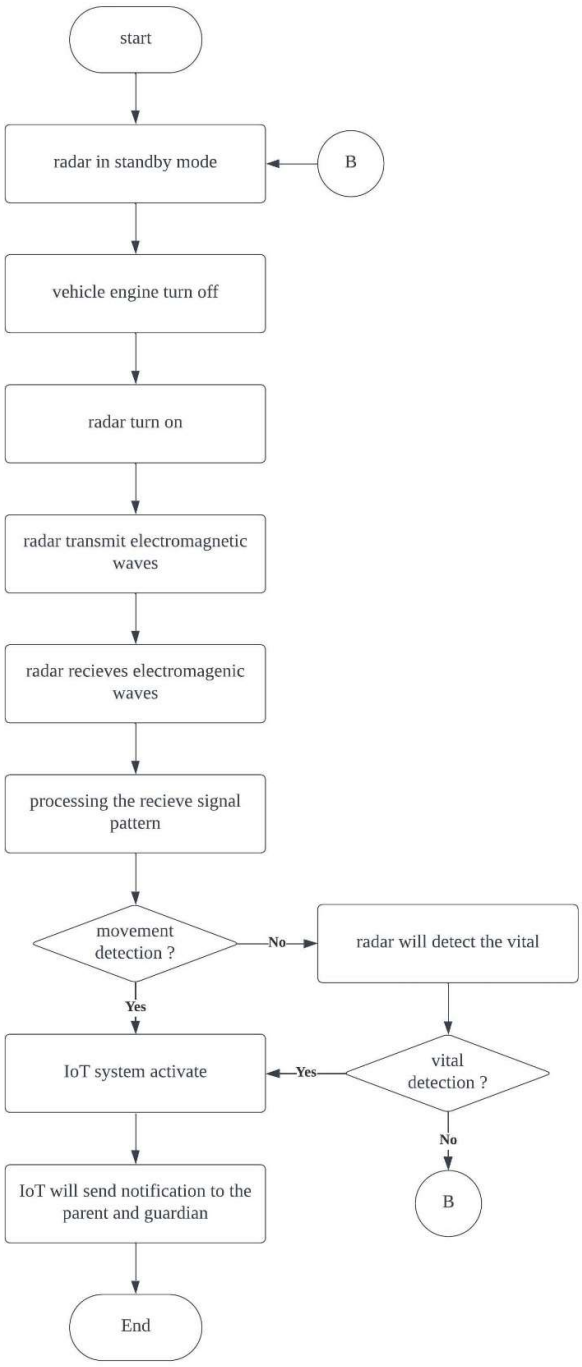
projects used a Pressure Sensor or Wi-Fi to detect the presence of children left in the car.

Next, we need to identify the problem statement to further strengthen the project we want to develop. problem statement can be identified by knowing what is needed to build a radar that detects the presence of children left in the car. After presenting the problem statement, the objective of the project will be proposed, the objective is intended to help us express the final goal of our project. Before constructing the methodology, research significance, and scope of study it is also important to tell a little about the impact of this project.

The following is to construct the methodology. This is a very important step in developing a project. The methodology is like a recipe in cooking, if the recipe is wrong then the food is also wrong. We need to specify the hardware and software used, and we also need to specify the process to create a system. The next step is to design and develop the radar system so that it can achieve the objective target.

After designing and developing the radar system, the radar system will be tested to see the radar's ability to detect the movement and presence of children. This process is very important because it will show the achievement of our project against our objective statement. Finally, the proposal will be submitted, following proper formatting guidelines and meeting submission requirements.

2. Flowchart of the System



The flowchart explains how the 60 GHz radar system detects the presence of children left in the car. This radar will be in a standby state until the car engine is turned off. When the car engine is turned off the radar will be activated, at the same

time this radar will emit a 60 GHz FMCW signal from the transmitter to the entire surface of the car. Next, the electromagnetic waves produced by the radar will be reflected. Electromagnetic waves with higher frequencies can be reflected when materials with different properties come into contact with one another due to an impedance mismatch. For example, air and metal are two different material properties. Then the receiver will receive back the reflected electromagnetic waves. At the same time, the received waveform will determine whether there is a child in the car or not. The processor will process the received data and signals to identify and compare the time-taken frequency bounce back when there are no passengers and the current time-taken. If the time taken now is different from the time taken when there are no passengers, then the system will declare that there are children left behind in the vehicle. Whereas if the current data and signal received are the same as the data when there are no passengers, then this system will also detect vitals in the vehicle. If there is a respiration rate or vital sensing, then the system will also declare that there are children left behind in the car. If there is a child in the car, then the system will activate the IoT system to send information to parents and guardians about their child left in the car.

3. Software and Hardware Implication

Figure 4 : XENSIV™ KIT CSK BGT60TR13C

The main hardware proposed to be used in developing this child presence detection system is the XENSIV Kit CSK Radar, a radar hardware offering a real-time evaluation for presence detection cases with custom configurations. This XENSIV kit has two main boards that are important microcontrollers in developing a radar system integrated with IoT systems. The two boards on this Xensiv kit are the CYSBSYSKIT-DEV-01 rapid IoT connect developer kit and XENSIV™ BGT60TR13C wing. There is another microchip in this XENSIV Kit, the XENSIV™ DPS368 barometric pressure sensor that is mounted together with the XENSIV™ BGT60TR13C wing board which is a sideboard that has its function. This XENSIV kit is often used in developing Smart Home and Building, Smart Retail, and Smart Appliances systems. The following is a basic diagram of the XENSIV Kit CSK Radar.

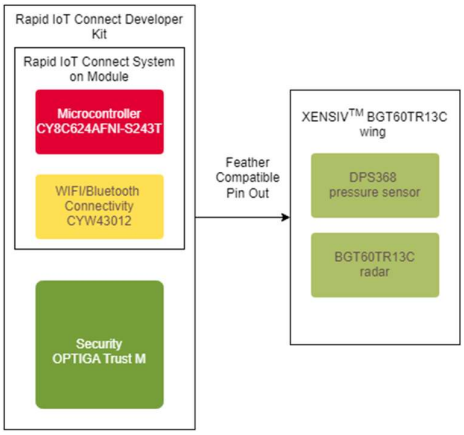


Figure 5 : XENSIV Kit CSK Radar in Block Diagram

Based on the diagram above, we acknowledge that there are two basic components on this XENSIV Kit board, the components found on it are Rapid IOT Connect System and Security OPTIGA Trust M. While on the Rapid IoT Connect System component there are also two basic blocks that support Rapid IoT Connect System components which are Microcontroller CY8C624AFNI-S243T and WiFi/Bluetooth Connectivity CYW430.

Figure 6 : CYSBSYSKIT-DEV-01 rapid IoT connect developer kit

Microcontroller CY8C624AFNI-S243T is a 32-bit Arm Cortex-M4 Microcontroller with low power, high performance, and secured MCU platform produced by Cypress Semiconductor. This CY8C624AFNI-S243T microcontroller is also one of the PSoC 6 MCU products designed suitable for IoT technology. With I2C, SPI, and USB 2.0 interfaces, the CY8C624AFNI-S243T easily connects to various sensors, actuators, and communication modules that are commonly used in IoT devices. This versatility enables integration into diverse IoT ecosystems. The microcontroller's low-power features are crucial for battery-powered IoT devices, extending their operational life and reducing maintenance needs.

Infineon’s AIROC™ CYW43012 also mounted on the Rapid IoT Connect System in the diagram. The AIROCTM CYW43012 from Infineon is an ultra-low power single-chip combo device with Bluetooth 5.0 and 1x1 dual-band Wi-Fi 4 (802.11n) at 2.4 GHz and 5 GHz. The CYW43012's low-power architecture makes it perfect for battery-powered applications where it is the best in its class. By supporting 256-QAM (for 20 MHz channels in the 5 GHz band), the CYW43012 makes 802.11ac friendly and allows data rates of up to 78 Mbps when used with 802.11ac access

points. For the 2.4 and 5GHz bands, there are low-noise amplifiers and an on-chip power amplifier included.

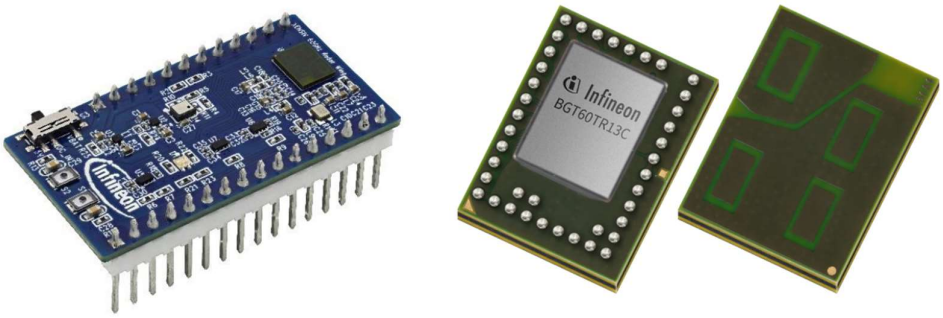


Figure 7 : XENSIV™ BGT60TR13C wing

XENSIV BGT60TR13C wing is an important microcontroller in developing this 60GHz radar. This is because the XENSIV BGT60TR13C is the main radar that has one transmitter antenna and three receiver antennas capable of emitting a frequency range of 58 GHz - 63.5 GHz with a total bandwidth of 5.5 GHz. The total output gain that can be produced by this XENSIV BGT60TR13C is +5dBi with a distance range that can be detected by the radar is around 0.2m to 15m. The selection of this radar is right because The radar sensor can be configured and obtained from the digital interface and the integrated state machine, this allows independent data acquisition with power mode optimization for the lowest power consumption.

For the software part, the Rapid IoT Connect Platform provided on the website has been used to observe the performance of the radar initially. From the Rapid IoT Connect Platform, we can see the radar's response to human presence. In addition, we can also integrate this radar with IoT technology by connecting this radar system with the Rapid IoT Connect Platform to monitor children's presence remotely. We can also change some parameters of this radar through the Rapid IoT Connect Platform so that the radar can work more efficiently and suit our radar project. For example, we can change the maximum distance for the radar to perform detection range. Figure 9 shows the result from the radar capture. The red dot is when the radar is detecting the human presence, while green dot shows there are no presence detected.

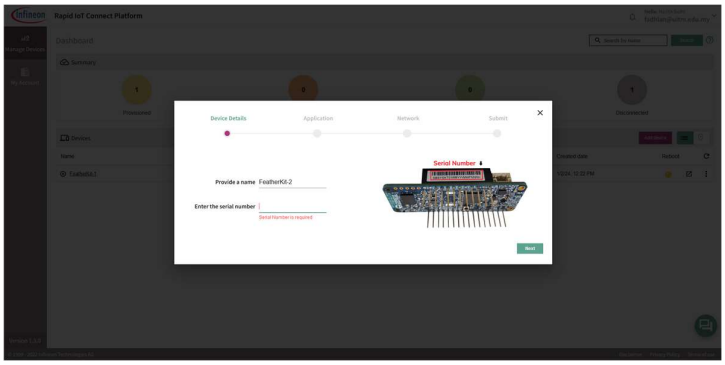


Figure 8 : Rapid IoT Connect Platform Interface

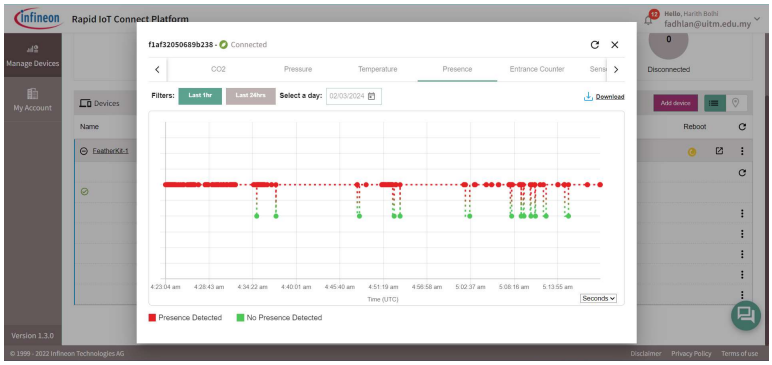


Figure 9 : Radar Presence Detection ouput

For more in-depth information about the radar parameters, the Eclipse IDE for ModusToolbox application can be downloaded for setting the radar. Eclipse IDE for ModusToolbox application is capable of creating Project creation and management, Code editing and debugging, Device configuration, Building and programming, and Integration with ModusToolbox tools and libraries.

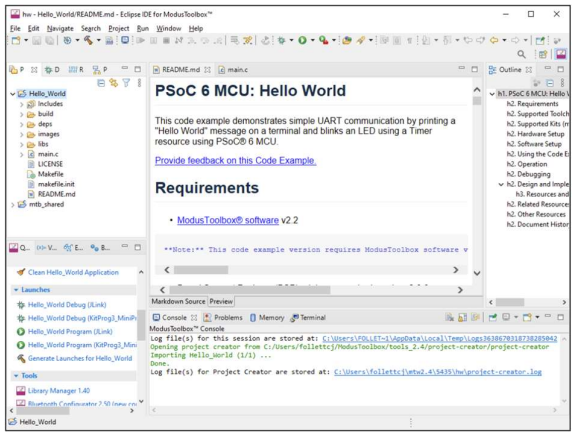


Figure 10 : Eclipse IDE for ModusToolbox interface

CHAPTER 4 : EXPECTED RESULTS

i. Development of a 60 GHz radar system capable of detecting the presence and movement of children left in a car.

ii. Integration of radar system for child presence detection with IoT technology.

iii. Sending notifications to parents and guardians through the IoT system integrated with the radar system if children are present in the car.

iv. Contribution to the Sustainable Development Goals, particularly Goal 3 which is Good health and well-being, and Goal 11 which is Sustainable cities and communities.

v. Improved safety for children in cars particularly in urban areas.

vi. Alignment with the overall policy goal of protecting children from harm is a key priority for the Malaysian government.

CHAPTER 5 : CONCLUSION

In conclusion, Child Presence Detection is very important in today's era, because this is based on the analysis of accident cases of children left in the car in the past. Child Presence Detection is also important to succeed in the Sustainable Development Goals announced by the United Nations. So with the proposal to develop a 60 GHz radar system that can detect the presence of children left in the car, it can increase safety for children, and at the same time reduce cases of child deaths. In addition, this Radar system is also able to be integrated with IoT technology which will make it easier and faster to share information with others.

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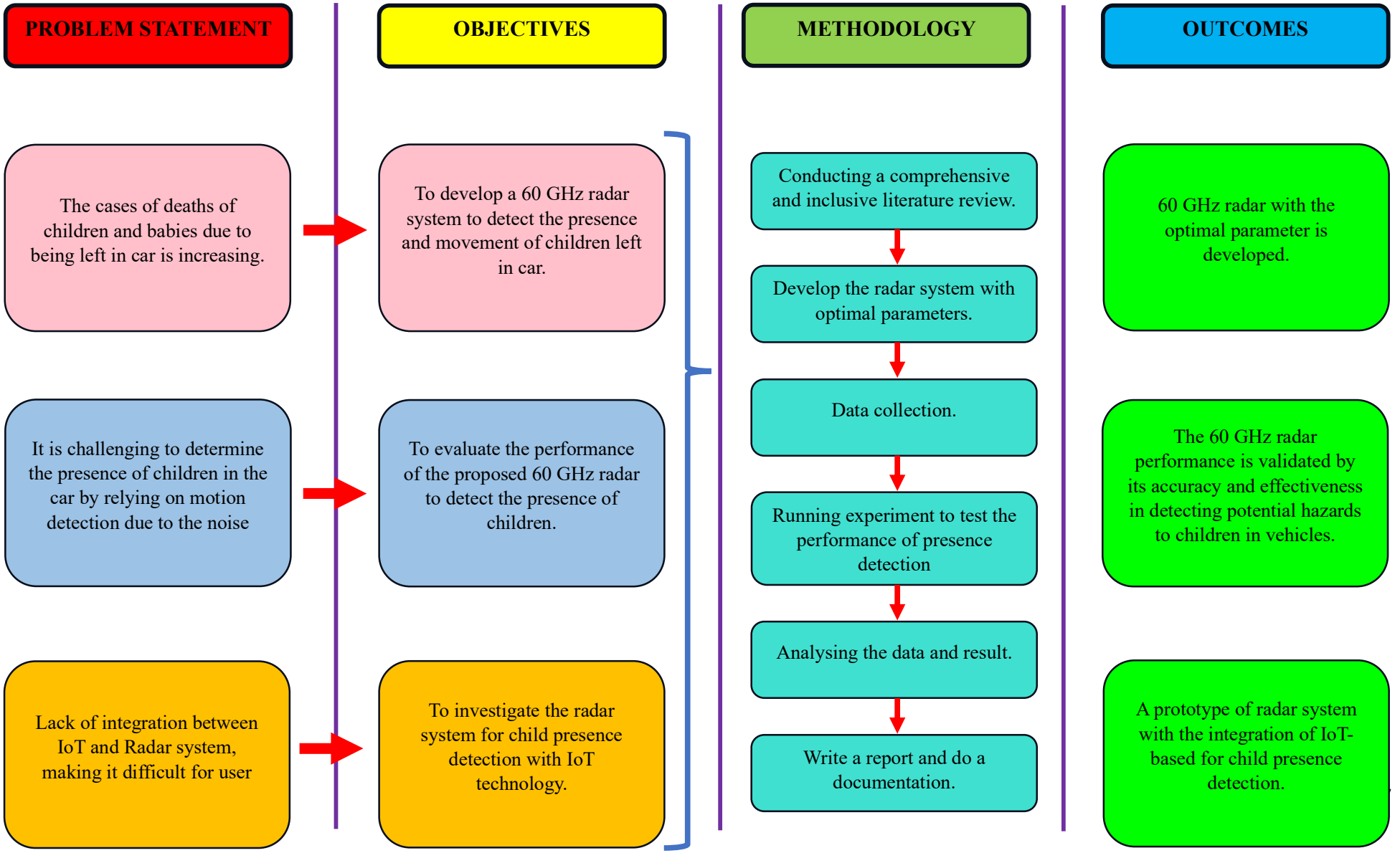
GANTT CHART

	October				November				December			January				
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16
Fyp1 registeration supervisor application																
Update personal info on system																
Title decision																
Project Research																
Progress Report Update																
Title Update																
Literature Review Research																
Methodology Research																
Expected Result Research																
Proposal Summary Preparation																
Proposal Summary Submission																
Progress Report Update																
Final Proposal Preparation																
Final Proposal Submission																

APPENDIX


PROBLEM STATEMENT
OBJECTIVES
METHODOLOGY
OUTCOMES
The cases of deaths of children and babies due to being left in car is increasing.
It is challenging to determine the presence of children in the car by relying on motion detection due to the noise
Lack of integration between IoT and Radar system, making it difficult for user
To develop a 60 GHz radar system to detect the presence and movement of children left in car.
To evaluate the performance of the proposed 60 GHz radar to detect the presence of children.
To investigate the radar system for child presence detection with IoT technology.
Conducting a comprehensive and inclusive literature review.
Develop the radar system with optimal parameters.
Data collection.
Running experiment to test the performance of presence detection
Analysing the data and result.
Write a report and do a documentation.
60 GHz radar with the optimal parameter is developed.
The 60 GHz radar performance is validated by its accuracy and effectiveness in detecting potential hazards to children in vehicles.
A prototype of radar system with the integration of IoT-based for child presence detection.