# Parameter Setting and Reliability test of a Sensor System for Person Detection in a car wearing winter wear.

**Course: Information Technology**

**Modules: Autonomous Intelligent Systems**
**and**
**Machine Learning**

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**Milestone-2**

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## INTRODUCTION

The accurate detection of individuals within a vehicle environment is of paramount importance for ensuring safety and enhancing user experience in automotive systems. Particularly in winter climates, where people often wear thick and different types of garments, the dependability and efficiency of sensor systems for detecting individuals become significantly more vital. This milestone endeavors to thoroughly investigate the configuration of parameters and the testing of reliability concerning a sensor system designed specifically for identifying individuals within vehicles during winter conditions The primary objective of this milestone is to assess the performance and reliability of a sensor system designed to detect individuals wearing winter clothes within a car front seat with different jackets with different persons.

This milestone report signifies a pivotal phase in our project, emphasizing the collection of data from an Analog-to-Digital Converter (ADC) and Fast Fourier Transform (FFT). Then the central objective is to convert the ADC data into Fast Fourier Transform (FFT) datasets, enabling a comprehensive analysis. The ADC sensors in the vehicle capture analog signals that offer crucial insights into the vehicle's surroundings. Our initial task involves pre-processing this data to eliminate any noise and extraneous details. Subsequently, we will apply FFT to transform the refined ADC data into a format conducive to studying diverse frequency elements.

## METHODOLOGY

This milestone methodological approach consists of following phases as mentioned below:

**Phase1:** Setup Hardware and Software.
**Phase2:** Dataset Acquisition.
**Phase3:** The classification result of the sensor will be stored automatically.

## OBJECTIVES

- Obtain ADC data from the vehicle when a passenger is seated nearer to the sensor.
- Acquire ADC data from the vehicle when a passenger is seated in a leaned position.
- Gather FFT data from the vehicle when a passenger is seated nearer to the sensor.
- Collect FFT data from the vehicle when a passenger is seated in a leaned position.
- Record ADC data from the vehicle when a passenger sits normally.
- Capture ADC data from the vehicle when a passenger sits in a cross position.
- Gather FFT data from the vehicle when a passenger sits normally.
- Collect FFT data from the vehicle when a passenger sits in a cross position.
- Obtain ADC data from the vehicle when a passenger is seated nearer to the sensor with the seat slightly adjusted away from the sensor.
- Acquire ADC data from the vehicle when a passenger is seated in a leaned position with the seat slightly adjusted away from the sensor.
- Gather FFT data from the vehicle when a passenger is seated nearer to the sensor with the seat slightly adjusted away from the sensor.
- Collect FFT data from the vehicle when a passenger is seated in a leaned position with the seat slightly adjusted away from the sensor.
- Get the ADC and FFT data if the passenger wears different kinds of winter jackets and passenger seated in a constant position or with the movements.

## SOFTWARE AND HARDWARE SETUP

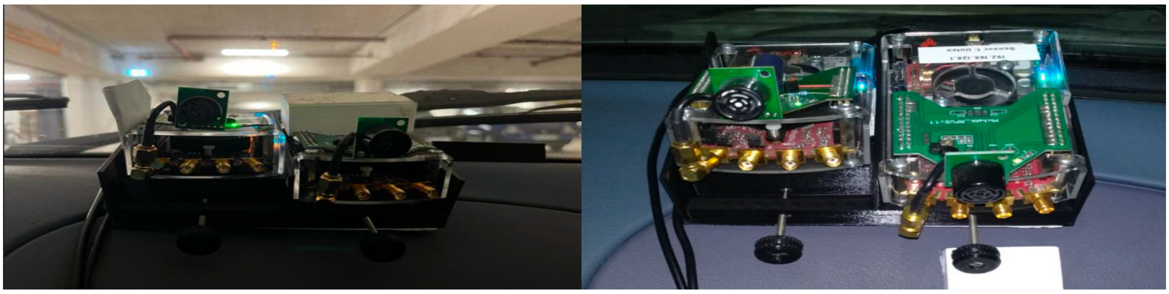

*Figure : Red pitaya placement in the car*

For the experiment, we are utilizing upward-facing Red Pitaya hardware. Two Red Pitaya sensors are installed within the vehicle where the experiment takes place. Depending on the sensor's positioning, a wireless connection is established to one of them through the GUI software. The image below illustrates the Red Pitaya device used for measurements within its natural setting, affixed to the car's dashboard to record data from the passenger side. Numerous test scenarios and configurations have been assessed.

i. Setting up the GUI software for measurements involves several steps: First, load the UDP Client software and provide the wireless network credentials for the specific sensor, such as the upward-facing Red Pitaya hardware. Once connected, a green signal at the bottom left corner confirms successful establishment of connection to 'Sensor 1'.
ii. The GUI software stores the recorded readings in a designated folder. The full path of this folder is '\GUI_V0.23_2024-02-01\GUI_SW\save'.
iii. Before initiating the recording process, ensure to select the 'FFT' checkbox. Afterward, clicking the 'Start FFT' button begins recording the readings. Once all measurements are completed, the GUI program automatically halts the measurement process and saves the file with the specified name.
iv. To get the ADC values, check the ADC checkbox and check the save checkbox and click on start logging button and click on the start ADC button to get the ADC values and stores it in the saved files.
v. Repeat the same steps for recording measurements across all use cases and thresholds considered.

## DATA COLLECTION

For collecting the ADC and FFT dataset in scenarios with different types of winter wear jackets in the seat, the following steps were undertaken:

1. On day one at the parking lot, using Red Pitaya technology, ADC and FFT data were initially captured from the vehicle with a person wearing winter wear, recording 40 samples for each instance. Subsequently, on subsequent days, the number of samples was increased to 400. These ADC sensors, strategically installed within the car, seamlessly integrated with the front passenger seat, and became a critical component of the vehicle's surveillance apparatus.

2. The Red Pitaya sensors carefully captured many different types of analog signals, giving us insight into what's happening inside the car. This data included things like how much the car shakes, if it gets hotter or colder, and how loud it is inside. All this information together gave us a good understanding of what it's like around the passenger seat.

3. When there wasn't anyone in the passenger seat, we also collected ADC and FFT data with 40 samples per session using the Red Pitaya sensors. This data, gathered without a passenger, helped us understand the normal environment inside the vehicle.

4. During the data collection process, we made several adjustments to mimic different situations. This included changing the passenger's position near and far away from the sensor, adjusting their posture, moving their hands, and with the constant position. Passenger seated in a leaned seat and the normal positioned seat with two different seat distances from the sensor and getting in and out of the car.

5. We carefully collected data using Red Pitaya technology to capture the subtle changes inside the vehicle, whether there was a passenger in the front seat or not.

## TRANSFORMING ADC DATA TO FFT FOR ANALYSIS (IN BOTH PRESENCE AND ABSENCE OF PASSENGER)

During the pre-processing stage, the gathered ADC data is carefully refined to eliminate noise and irrelevant information, ensuring that only signals relevant to the passenger's environment are preserved for further examination. This step enhances the quality and applicability of the data, paving the way for more precise and insightful analysis of the passenger's immediate surroundings.

After pre-processing, the ADC data undergoes a transformation into an FFT dataset. This change is accomplished through the Fast Fourier Transform (FFT) technique, a sophisticated mathematical method that facilitates the breakdown of data into its constituent frequency components. Analysing these frequencies allows researchers to uncover patterns and trends within the data, offering a window into the environmental factors the passenger encounters during travel. Such analysis is crucial for identifying any elements that might affect the passenger's comfort or safety.

These systematic processes are essential in the analytical workflow, refining the data to reveal significant insights that deepen our understanding of the passenger's interaction with their vehicular environment.

For converting the ADC dataset to an FFT dataset, the following pseudocode outlines the general steps:

**Pre-process ADC Data**

- Load ADC dataset.
- Apply filters to remove noise and unwanted signals.

**Apply FFT**

- For each pre-processed data segment
- Apply FFT to convert time-domain signals into frequency domain.
- Store FFT results in a new dataset.
- Analyse FFT Data

**Examine frequency components to identify significant patterns or anomalies.**

- Compare findings between datasets with and without the passenger to assess environmental impact.
- This pseudocode provides a framework for the ADC to FFT data conversion process, aiding in the comprehensive analysis of the passenger's vehicular environment.

## MEASUREMENTS SCENARIOS

**Baseline Scenario**:
Car seat adjusted to **80cm** away from the red pitaya sensor.
Readings taken in the following situations:

1. Passenger entering the car.
2. Passenger seated normally and remaining in a constant position.
3. Passenger performing movements such as adjusting seatbelt or reaching for items.
4. Passenger moved slightly forward towards the sensor and remained in a constant position.
5. Passenger seated in a cross position and remaining in a constant position.
6. Passenger seated in a cross position and performing movements such as having a conversation with the person with hand movements and other movements.
7. Passenger getting out of the car.

*Fig: Passenger normally seated*

*Fig: Passenger moved slightly forward towards the sensor*

*Fig: passenger seated in a cross position*

**Leaned Seat Scenario**:
Same as the baseline scenario, but the seat is leaned slightly.
Readings taken in the following situations same as baseline scenarios:

1. Passenger entering the car.
2. Passenger seated in a leaned seat and remaining in a constant position.
3. Passenger performing movements such as adjusting seatbelt or reaching for items.
4. Passenger seated in a cross position and remaining in a constant position.
5. Passenger seated in a cross position and performing movements such as having a conversation with the person with hand movements and other movements.
6. Passenger getting out of the car.

*fig: Passenger seated in a cross-position*

*fig: Passenger seated in a normal position.*

**Backward Seat Scenario**:
Car seat adjusted to **90cm** away from the sensor.
Readings taken in the following situations:

1. Passenger entering the car.
2. Passenger seated normally and remaining in a constant position.
3. Passenger performing movements such as adjusting seatbelt or reaching for items.
4. Passenger moved slightly forward towards the sensor and remained in a constant position.
5. Passenger seated in a cross position and remaining in a constant position.
6. Passenger seated in a cross position and performing movements such as having a conversation with the person with hand movements and other movements.
7. Passenger getting out of the car.

**Leaned Backward Seat Scenario:**
Same as the Backward Seat scenario, but the seat is leaned slightly.
Readings taken in the following situations:

1. Passenger entering the car.
2. Passenger seated normally and remaining in a constant position.
3. Passenger performing movements such as adjusting seatbelt or reaching for items.
4. Passenger seated in a cross position and remaining in a constant position.
5. Passenger seated in a cross position and performing movements such as having a conversation with the person with hand movements and other movements.
6. Passenger getting out of the car.

Each scenario repeated with passengers wearing three different types of winter jackets.

The purpose of these measurements is to understand how different seating positions, including normal seating, leaning, and cross-seating, as well as variations in distance from the sensor, impact the readings obtained from the FFT (Fast Fourier Transform) and ADC (Analog-to-Digital Converter) sensors. Additionally, the experiment seeks to observe how different types of winter jackets worn by passengers may affect these readings under various seating conditions.

## NEXT STEPS IN ANALYSIS

As we move forward in our analysis, our team plans to create a "confusion matrix." This is an important tool that helps us check how well our predictions match up with the real data. It's like comparing what we thought would happen with what actually happened. By putting this information in a clear chart, we can see how accurate our predictions are and how good our methods are at analyzing data. The confusion matrix will help us calculate things like when our predictions are right, when they're wrong, and other useful metrics like true positives, true negatives, false positives, and false negatives, thus providing a thorough appraisal of our model's ability to predict correctly.

Finding any differences between what we predicted and what actually happened will help us figure out what changes we need to make to our methods. We aim to make our results more reliable. Other things we'll do in our process include:

- Adding the detailed measurements to our data to make our training better.
- Using the data to teach advanced models like Convolutional Neural Networks (CNN) and Support Vector Machine (SVM) classifiers.
- Using these models to make our predictions even better, so we can analyze things more effectively.

## CONCLUSION

In conclusion, this milestone signifies a crucial advancement in the development and evaluation of sensor systems tailored for detecting individuals within vehicle environments, particularly in winter conditions. Through meticulous data collection and analysis, we have gained valuable insights into the performance and reliability of the sensor system under various scenarios. Our findings underscore the importance of accurately identifying passengers, especially in climates where thick winter garments may obscure detection. By examining different seating positions, adjustments, and jacket types, we have deepened our understanding of how environmental factors and passenger presence influence sensor readings, laying the groundwork for further refinement and optimization of the system to enhance automotive safety and user experience.

Looking forward, we aim to leverage advanced analytical techniques, such as the creation of a confusion matrix, to improve the accuracy and reliability of our predictive models. Incorporating detailed measurements into our dataset and utilizing advanced machine learning algorithms will enable us to further refine our understanding of passenger dynamics within vehicles and optimize safety and comfort during car travel. Ultimately, this milestone represents a significant step towards developing sensor systems capable of effectively detecting individuals within vehicle environments, with implications for enhancing automotive safety and user experience in diverse conditions.