Week 3 Report

This week I looked at several papers regarding mmWave radar.

The first paper I looked at was “High Precision Human Detection and Tracking Using

Millimeter-Wave Radars by Han Cui, Naim Dahnoun, University of Bristol”.

This is the first paper I believe to be published by the University of Bristol that covers the topic of millimetre wave radar. The paper focuses on human activity recognition harc Ant explores how millimetre wave radar can be used as a privacy send it alternative two other better established more intrusive methods such as the use of cameras and computer vision.

The paper starts by exploring related work and the previously used senses and methods in the field of HAR such as camera based, depth camera based, Doppler radar, ultrasonic detection, Wi-Fi sensors and wearable devices using accelerometer and GPS data.

The paper then goes on to explain the theory behind millimetre wave radar how it works and in what forms data coming from the radar can take which in regards to the IWR1443 the mmWave module used in the paper is raw adc data or processed data from the user programmable on chip data processor chain with a popular form of processed data being x-y-z object data.

A soft work framework for interfacing with the radar and performing post processing was created in Python and comprised of three main parts a

radar handler; responsible for connecting to the serial ports And extracting the data from the radar module and also sending configuration and command data to the module.

A frame processor; that's takes the data from the radar handler and make sure all frames for task are in the same format

and a visualizer The process is the data to create the final 2D or 3D output of the system.

the software is written in a way to take advantage Of parallelism of the processing computer with each radar being assigned its own thread and the system working best

on multi core systems where each thread house its own dedicated CPU core.

Diagram

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Figure 1

The system uses two radars positions in a manner that produces two separate perspectives And the camera is used bye one of the radars in order to provide a ground truth this setup can be seen to the left in Figure 1.

The data from these two radars comes in the form of a point cloud with xy and Z coordinates these point clouds processed by the software framework to locate objects within each radar’s field of view. these objects in the field of view are then compared and any overlapping objects Chart

Description automatically generatedare assumed to be a detected subject this process is visually demonstrated in figure 2.

Figure 2

Once subject is detected the system then proceeds 2 track firm at the time And the movement within the space observed by the radars can be plotted on a graph as seen in figure 3.

Chart

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Figure 3

the paper then goes on to explore the effect of noise in system as more radars are added UN concludes the probability of interference is low less than 1% with 4 radars and less than 5% with 10 radars with this interference being able to be reduced if the radars are synchronised or an interference detection algorithm is used.

Table

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Table 1

Sensitivity and precision metrics I used to compare the use of 1 radar 2 2 radars. With sensitivity being the ability to detect humans when they are in the area of detection and precision being the ability to distinguish humans from false detectionS. Table one presents the results found in the paper with a single radar having high sensitivity of 96.4% with a low precision of 46.9% meaning roughly one of two detection's of a human was not actually a human. the use of two radars drastically improves this precision 2 98.6% this increase however comes at a cost of sensitivity which means but now everyone in 10 times a human is present in the area of detection they are not detected by the system.

The paper then explains that a limitation of the system is the ability to distinguish multiple people at short distances such as people in a queue It also states that for two radars the effective area was a 2.4 by 2.4 metre region and explains that this region could be expanded by adding more radars into the system.

The second paper I looked at “A REAL-TIME AND HIGH PERFORMANCE POSTURE ESTIMATION SYSTEM BASED ON MILLIMETER-WAVE RADAR by Daniel Nickalls, Jiacheng Wu and Naim Dahnoun” uses a single millimetre wave radar fixed above a sinlge person in order to determine whether they are standing sitting or lying down.

Diagram

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The way the system works is by first taking the data and filtering out filtering out the background focusing on the set region of interests of 1.4 by 0.7 by 2.35 metres. it then takes this pre processed data and uses the DBSCAN (density-based spatial clustering of ap- plications with noise) algorithm in order to identify clusters in the three dimensional data set. An example of this process data can be seen in figure 5. After the data has been clustered the head cluster can be identified and the height can be calculated.

A picture containing chart

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A decision tree model is then trained on this data 2 classify the posture. The architecture of this decision tree can be seen in figure 6.

In parallel to the decision tree model a computational neural network based on other research was also designed. this computational neural network was then fed the same information in order to Compare the decision tree approach with.

Table

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Diagram

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Table 2

Figure 6

the results of both systems can be seen in Table 2 the system proposed in this paper has an almost identical accuracy to the computational neural network system however both the processing and training time are greatly reduced This is advantageous as it means this system can more easily deployed on a low cost an embedded system.

The 3rd paper titled “A Novel High Performance Human detection, Tracking and Alarm System Based on millimeter-wave Radar by Jiacheng Wu, Han Cui and Naim Dahnoun” builds up on the work presented in the past two papers it seeks to combine the positives of both previous works and create a single unified system capabale of both human detection and tracking as well as posture estimation.

Diagram

Description automatically generatedThis new system uses a single IWR1443 millimetre wave radar placed on the ceiling of a room the detection area of which Is suitable for a small room and this area is shown in figure 7. This detection area was determined by moving a 20cm cube around under the radar And recording the points at which the radar no longer discovered the cube.

Figure 7

Software wise the system combines the approaches found in both previous papers to create a system capable of both human detection and tracking as well as posture estimation. the system can implemented as an alarm to detect unauthorised people entering it's field of view however when used in such a way more strict clustering parameters need to be used in order to reduce the number of false alarms these changes do result in losing some details of the person however in such an application this information is not so relevant.