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AUSTRALIA

Low Cost Embedded Passive Bistatic Radar Detection Testbed

by

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Submitted for the degree of Bachelor of Science (Honours)
in the division of Electrical Engineering

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Professor Michael Bruenig
Head of School
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Dear Professor Bruenig,

In accordance with the requirements of the degree of Bachelor of Science (Honours) in the School of Electrical Engineering and Computer Science, I present the following thesis entitled

'Low Cost Embedded Passive Bistatic Radar Detection Testbed'

This thesis was performed under the supervision of Professor Bialkowski(EECS). I declare that the work submitted in the thesis is my own, except as acknowledged in the text and footnotes, and that it has not previously been submitted for a degree at the University of Queensland or any other institution.

Yours sincerely,

Flynn Kelly

Acknowledgements

Acknowledgements: recognise those who have been instrumental in the completion of the project. Acknowledgements should include any professional editorial advice received including the name of the editor and a brief description of the service rendered.

SUPERVISOR, FRIENDS, ETC....

Abstract

Abstract: Minimal

NEED TO DRAFT THE ABSTRACT [3] //
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Contents

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Chapter 1

Introduction

Introduction: introduce the problem space and (at a high level) any relevant problem-space background. Summarise the contents of the remaining sections in the document (excluding appendices).
UPDATE FOR FINAL

This proposal introduces the theory, motivations and planned process for the creation of a low cost embedded bistatic passive radar detection system utilising a to be confirmed digital broadcast signal as the illuminator of opportunity.

1.1 Topic and Relevance

Passive radar detection technology is a class of radar detection whereby the radar system does not emit any radiation. Instead, it uses existing electromagnetic signals in the environment, such as television or radio broadcasts, to detect and track objects. Passive radar can be bistatic, whereby the transmitter and receiver are separate, or multistatic, where there are multiple receivers. The technology has been around since the early 20th century, but has only recently become feasible due to advances in digital signal processing and computing [2].

The technology has a number of advantages over traditional radar systems. It is covert, as it does not emit any radiation, and is therefore difficult to detect and directly jam, leading to a concentrated interest from defence cirlces (NEED CITATION). It is also relatively cheap, as it does not require a dedicated transmitter and hence has less energy consumption. Conversely, it has a number of disadvantages, such as a lower signal-to-noise ratio, and a requirement for a relatively large amount of computational power to process the received signals [2].

Bistatic passive radar detection has a wide range of applications centered around situational awareness, including air traffic control, border security, and environmental monitoring. Embedding the passive radar technology is a relatively new field buoyed by recent and increasing developments in computational power on Internet of Things (IoT) devices [3]. This project aims to reinforce and build on existing technology by creating a low-cost, modular, small-scale embedded passive radar detection system. Moreover, this project will also explore the possibility of scaling up this bistatic setup to a multistatic system, and the potential advantages and disadvantages of such.

More specifically, the project will focus on streamlining the signal processing and computational requirements of both the line of sight signal and the reflected target signal onto a singular embedded setup, without PC hardware. This will be achieved by using a combination of existing embedded IoT hardware, and through using existing DSP (digital signal processing) and radar filtering algorithms. Initially, the illuminator of opportunitys explored are digital broadcast signals, and the target signal will be aerial vehicles. Noting that a range of other terrestrial illuminator signals can be utilised, often depending on the required use case, such as the tracking target and environment [1].

1.2 Goals

The primary goals of the project include the following, provided in order of logical progression;

- Implement and investigate passive radar detection algorithms on high end computer architecture (PC) connected to SDR hardware and antenna for line of sight and target signal processing.
- Scaling down the passive radar detection system and associated algorithms to run on embedded IoT hardware, and investigate the computational and signal processing requirements, including the possible design of custom hardware such as peripheral functionality and printed circuit boards. A central feature of this specific goal is its ideally low cost nature.
- Verify functionality of low cost embedded passive radar detection system in a controlled environment against higher power computing results, and investigate the potential for scaling up to a multistatic system.
- Design and develop suitable housing for embdedded project implementation with ideal features such as modularity, portability and potential scaleability.

1.3 Scope

1.4 Relevance

Chapter 2

Background

Background: this should include all (appropriately cited) information (concepts and prior literature) for a layperson to understand your project/experiment.

The below sections reflect the neccessary research considerations for the project, and will be used to inform the project plan and optimize the implementation.

2.1 Passive Radar Fundamentals

2.2 Illuminators of Opportunity

2.3 Range Doppler Mapping

2.4 Radio Hardware

Figure 2.1: An Example Image

2.5 Digital Signal Processing

2.6 IoT Architecture

2.7 Networking with Embedded Hardware

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Chapter 3

Literature Review

There is a plethora of existing research and pilot projects which utilise a range of hardware and illuminator of opportunity signals, including existing commercial products.

3.1 Low Cost IoT Hardware

3.2 Illuminators of Opportunity

3.3 Signal Processing Architecture

3.4 Existing Commercial Technology

Chapter 4

Methodology and Design

Implementation: how was your experiment/project accomplished? Include enough details of your method and tooling that someone can easily replicate your results.

4.1 Hardware

4.1.1 Software Defined Radio

4.1.2 Embedded Computing Platform

4.1.3 NVME Based Storage

4.1.4 Antenna Configuration

4.2 Software

4.2.1 SDR Software

4.2.2 Networking Requirements

4.3 Digital Signal Processing Testing & Simulation

4.4 Pi Based Raw IQ Sample Testing

4.5 Testbed Design

Chapter 5

Results and Discussion

Results: latency comparison, design cost, sucessful detection

5.1 Detection Performance

5.2 Latency Comparison

5.3 Overall Design Cost

5.4 Comparison to Existing Work

Chapter 6

Conclusion

Conclusion: what conclusions can be drawn from the results of your research?

6.1 Summary & Conclusions

6.2 Limitations

6.3 Possible Future Work

Chapter 7

Bibliography

[1] Cristopher Coleman and Heath Yardley. Dab based passive radar: Performance calculations and trials. In *2008 International Conference on Radar*, pages 691–694, 2008.

[2] H. Griffiths, Christopher J. Baker, and Ieee Xplore. *An introduction to passive radar*. Artech House radar series. Artech House IEEE Xplore, Boston Piscataqay, New Jersey, first edition edition, 2017.

[3] Daniel Moser, Giorgio Tresoldi, Christof Schüpbach, and Vincent Lenders. Design and evaluation of a low-cost passive radar receiver based on iot hardware. In *2019 IEEE Radar Conference (RadarConf)*, pages 1–6, April 2019.

Appendices

Appendix A

Example Appendix Item

Appendix: Appendices are useful for supplying necessary details or explanations which do not seem to fit into the main text, perhaps because they are too long and would distract the reader from the central argument. Appendices are also used for program listings.

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