APPENDIX B

DESIGN PLAN

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INTRODUCTION

My name is Niall Lyons and I am the San Jose Dublin sister cities Pat Mc Mahon Scholar for 2020, undertaking my thesis in San Jose, California with Cypress Semiconductor through DCU. For the duration of this project I am working alongside my industrial supervisor Kiran Uln and my Thesis supervisors at DCU Dr. Kevin McGuinness and Dr. Dushyantha Basnayaka.

After exploring potential projects with Cypress it was agreed to pursue this project titled Detection Algorithms for Packet Based Wireless Networks using Deep Learning.

The goal of this project is to focus on an important element of communication systems, the detection algorithms to show that deep learning algorithms are significantly more robust than traditional simple detectors. With the application of deep learning methods with memory, applying an RNN, Long Short-Term Memory (LSTM) and Bidirectional Long Short-Term Memory (BLSTM) network to detect wireless packets, and show it is possible to train detectors that perform well, without any knowledge of underlying channel models. The accuracy of the LSTM and BLSTM models will be evaluated against a Recurrent Neural Network (RNN) model and traditional digital signal processing methods, for comparison to determine the best possible method. These models will be evaluated using IEEE standard compliant data where the model and channels are unknown. The aim is to find the trade-off between LSTM, BLSTM and RNN architectures and evaluate how they outperform traditional simple detectors.

RESEARCH QUESTION

“Detection Algorithms for Packet Based Wireless Networks Using Deep Learning”

PROBLEMS TO BE SOLVED

- Robust and low complexity detection
- Hardware can be reconfigured without need for re-design, thus reducing costs
- Packets can be addressed for anomalies

PROJECT SCOPE

The scope of this project is to evaluate the trade off between deep learning architectures and technologies in relation to wireless packet detection in comparison to traditional simple detection methods.

DEEP LEARNING ARCHITECTURES

In this project I will be specifically looking at three separate deep learning architectures,

- Recurrent Neural Network (RNN)
- Long Short-Term Memory (LSTM)
- Bidirectional LSTM (BLSTM)

TECHNOLOGIES TO BE USED

- Python
- Keras
- Multiple deep learning python libraries
- Matlab

DESIGN APPROACH

DATA GENERATION

- In order to train the NN models I will be using Cypress IEEE standard test data. This data is developed using maximum length sequences based on the galois field theory to represent wireless packet preambles.

MODEL GENERATION

- I will first utilize the power of deep learning by developing an RNN model to determine the tradeoff between it, and the traditional approaches.
- LSTM models will then be developed to further enhance the power of deep learning by resolving the vanishing gradient problem within RNN architectures to produce a more robust, low complexity model.
- As a stretch goal of the project, I will also try to enhance the robustness of my final model by using a BLSTM to understand the context of the wireless packet preamble and preserve information from both the past and future by running input two ways. Using this model, input is presented in forward and backward

states to two separate LSTM networks, that are both connected to the same output layer. By preserving information from the future and using two hidden states we can successfully preserve preamble information from both the past and future and compute the output sequence.

- The trade off between each model in relation to traditional methods, will be examined to determine the most robust NN model and by how much it outperforms traditional methods of wireless packet detection.

TESTING

- Neyman-Pearson testing criterion will be used to represent the fundamental trade off in hypothesis testing and detection theory
- A receiver operating characteristic (ROC) curve will be used to display the relationship between detection probability and false-alarm probability respectively
- An array of deep learning model evaluation metrics will be used to ensure the most robust, low complexity model is developed. Some metrics that will be used include:
  - Logarithmic Loss
  - Confusion Matrix
  - ROC Curve
  - Area under Curve
  - F1 Score
  - Mean Absolute Error
  - Mean Squared Error

REMOTE WORK CONFIRMATION

DCU

- It has been agreed that all meetings will be done over zoom calls. Both Kevin and Dushyantha have made it clear that they are happy to answer any questions I have and are open to zoom meetings to discuss any technical topics.

CYPRESS SEMICONDUCTOR, SAN JOSE, CALIFORNIA

- Arrangements have been made to conduct regular meetings with my supervisor at Cypress to ensure the project is going smoothly.

TIMELINE

To ensure this project runs smoothly I generated the following tables for time management, separated into two sections, spring semester and summer internship respectively.

The project plan began on my first day at Cypress Semiconductor, San Jose. As the Spring semester in San Jose State University is over, I have successfully completed the first element of my time management framework. As each deliverable was reached, the project plan was and will continue to be updated.

Here we can see the spring semester consists of the core understanding of the project and the generation of data.

Task	Allocated Time	Target Completion	Status
SPRING SEMESTER 2020 – Beginning January 21st			
Begin Cypress Placement SJ	1 day	Week 1	Complete
Meet Supervisor and Team	1 day	Week 1	Complete
Explore potential projects	1 week	Week 2	Complete
Agree project with both academic and industrial advisor	1 day	Week 2	Complete
Research project field and latest related technologies	1 week	Week 3	Complete
Read related research papers	3 weeks	Week 6	Complete
Write Literature Review	2 weeks	April 9th	Complete
Test chosen NN architectures	2 weeks	Week 9	Complete
Oral Presentation	1 Week	May 9th	Complete
Generate test dataset using LFSR	1 week	Week 10	Complete
Apply noise and test on traditional methods	1 week	Week 11	Complete
Observe traditional method results	1 week	Week 12	Complete
END OF SEMESTER – EXAM PERIOD			

While the summer internship aspect of the project focuses on implementation and testing of the NNs.

Task	Allocated Time	Target Completion	Status
SUMMER INTERNSHIP – Beginning June 1st			
RNN Implementation	4 weeks	Early June	TBD
LSTM Implementation	3 weeks	Mid-June	TBD
BLSTM Implementation	3 weeks	Mid July	TBD
Model Enhancements	1 week	Early August	TBD
Testing, Assessment and Writing of Thesis	3 weeks	Late August	TBD
Thesis Submission	1 day	September	TBD
Interview and Assessment	1 day	Mid-September	TBD

SUCCESS CRITERIA

The success criteria of this project is to show the trade off between traditional wireless packet detection algorithms with cutting edge deep learning approaches, to enhance wireless networks. By doing so I will:

- Identify what deep learning architecture best suits this type of problem, by producing a low complexity and robust model
- Show how new technologies outperform existing methodologies
- Produce a model that will be integrated into the firmware of Cypress Semiconductor chips and be used on millions of devices across the world