Analog Devices Inc. Phillpines

Machine Learning on the Edge: Hand Gesture Detection and Recognition using MAX78000

Mercano, Ivan Gil G.

A Practicum Report Submitted to the School of Information Technology

In Partial Fulfillment of the Requirements for the Degree Program

Bachelor of Science in Computer Science

Mapua University

September 2022

APPROVAL SHEET

Mapua Institute of Technology School
of Information Technology

This is to certify that I/we have supervised the preparation and read the practicum report prepared by Mercano, Ivan Gil G. and that the said practicum has been submitted for final examination by the Oral Examination Committee.

_____Mariel Tinaco_____

Adviser/OJT Supervisor

As members of the Oral Examination committee, we certify that we have examined this practicum report, presented before the committee on _____, and hereby recommended that it be accepted as fulfillment of the practicum requirement for the degree in Program Bachelor of Science in Computer Science.

_____   _____

Panel Member   Panel Member

This practicum report is hereby approved and accepted by the School of Information Technology as fulfillment of the practicum requirement for the degree in Program Bachelor of Science in Information Technology.

_____

Ariel Kelly Balan

Dean, School of IT

ACKNOWLEDGEMENTS

The intern would like to thank everyone who contributed to the success of the internship program.

First, I would like to thank God for giving me this opportunity to learn and continue to grow and experience real life application of what I have learned in my course.

To my OJT adviser, John Paul Tomas, for guiding me in the proper procedures and requirements needed for the internship.

To my parents who continuously support whatever track or field I am currently interested in and for the continuous love and support they gave me.

To my co-interns and batch mates in the department who helped me grow in many ways.

My supervisors, Mariel Tinaco and Louijie Compo, in teaching and guiding me throughout my internship. They provided the best learning environment and training plan for me to grow and explore the current market and corporate settings of my future career.

And lastly, the managers of the department, Mr. Glen Amparo, and Johann Ignacio for letting me stay in the department and giving me valuable teachings from life experiences.

ABSTRACT

This document indicates the training experiences and learnings the intern acquires during the on-the-job training program in Analog Devices Inc. (Gen Trias). The document includes the history and profile of the company and its mission and vision. Furthermore, the document also includes the documentation of the project of the intern which serves as his main activity and contribution to the said company. The project documentation consists of overview of the project, statement of the problem and objective, significance, and the brief methodology of the project.

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CERTIFICATE OF OJT COMPLETION

ANALOG DEVICES
Philippine Operations

August 12, 2022

CERTIFICATE OF ON-THE-JOB TRAINING

To Whom It May Concern:

This is to certify that **Mr. Ivan Gil Guavez Mercano** has completed 244 hours student internship in ANALOG DEVICES GEN. TRIAS, INC. from June 28, 2022 to August 12, 2022.

This certification is being issued upon the request of Mr. **Mercano** for completion of his school requirements.

Please do not hesitate to call us should you need additional information.

Thank you.

Sincerely yours,

ANALOG DEVICES GEN. TRIAS, INC.

ANABELLE P. BALLA
Regional HR Operations Manager

CHAPTER 1

Company History

The company was founded by Ray Stata and Matthew Lorber in 1965 upon graduating from engineering program at Massachusetts Institute of Technology. The two founder meets when Stata was hired by Hewlett-Packard (founder of HP) in Cambridge, Massachusetts, where he shared the apartment with his batchmate Matthew Lorber.

Since then, the company grows larger, designing and manufacturing analog, mixed signal, and DSP integrated circuits. Today, Analog Devices intend to become the leading company in the Artificial Intelligence and Machine Learning field, providing innovative solutions to improve quality of life and today's engineering problems.

Company Mission and Vision

ADI's Mission

Analog Devices mission is to be the world's best signal processing company

ADI's Vision

Analog Devices is dedicated to enriching people s lives through signal processing technologies. We transform people s experience with technology by bridging the analog and digital worlds.

CHAPTER 2

Specific Department Where the Trainee Assigned

After the orientation week, the intern was assigned to the NTI System Integration Engineering (Applications) of Analog Devices Gen Trias. The department is generally responsible for developing and researching applications for the company's product. One example of this is the project of the intern where he implemented a CNN model to a microcontroller to detect and recognize hand gestures.

Duties and Responsibilities

The intern's responsibility was the same to the employees' normal duties. The only difference is that the intern has a buddy or superior that is helping him to work. In ADI, the intern were challenged to participate in the real project of the company. The superior will require the interns to come up with a unique way to apply the current project to solve a real-world problem. One example of this the time-of-flight camera product of ADI, as an application for this product, the interns come up with an application where the user will be able to 3d print any object that is scanned using the camera.

Training with Your Company

       In the orientation, the supervisor pointed out that aside from learning how a semiconductor company operates, the intern should be able to apply what he/she have learned in the university to create an invention or an application base on his/her interest. In my case who have a specialization in Data Science, my interest falls onto apply machine learning on edge devices. But first, the intern should be familiarized first on how a team operates in creating a project. One of the basic requirements in working as a team is having a version control system, to address this, the company use private Github repository where the employees can view, save, and edit their current work. This tool also allows developers to merge their work efficiently without having code conflicts.

Commonly Used Github Commands in the Workplace

Initialization	Commits	Branch
Git init <directory>	Git add <path>	Git checkout <branch>
Git clone <url>	Git restore –staged <path>	Git checkout -b <name>
Git config user.name "username"	Git commit -m "message"	Git branch
Git config user.email "email"	Git status	
	Git push <remote> <branch>	
	Git pull -r	

       For the third and fourth week of the internship, the interns focused on familiarization in python language. This is important since 90% of work in the department use this language. Another tool the interns used is Pytest, this tool allows the developer to test the code if there are any hidden errors or bugs that can be problematic when project is deployed to the consumers.

Lastly, the interns were familiarized how to build, install, and use SDK. For me, I personally got challenged in this training since this topic is new to me. The SDK I built is for the edge device that I will going to use for my machine learning project for the company, which requires a lot of image processing imports and environment path calibration.

Learnings Acquired from the Training

The intern learned a lot, from applying the knowledge he learned from the university to gaining real life experience on how a company operates. One of the most notable learnings the I personally acquired that I think I would use in my future career is by not being to reliant on others. In the company I learn how to learn by myself, I learned how to explore things and know what I don't currently know. Here, I realized that learning never stops, that the people around and the environment itself promotes the growth of an individual.

Corporate Learning

The intern learned how employees operates on a regular basis. In the company the intern learned how important a team is and how a team should be at the same page all the time. This on-the-job training gave me an insight on what to expect when I really stepped out and find a job myself. I am certain that these learnings I have acquired from my internship would be helpful for my future career.

Technical Learning

For the technical learning, the intern learned advance use and application of python. The intern also learned how to use different tools in developing software and application such as GitHub, PyTest, SDK building, etc. Lastly, the intern gained more insight on Machine Learning specially on how it can be implemented or applied to solve an existing problem.

Assessment and Evaluation on the Company

The assessment and evaluation of the company to the intern consist of three notable insights. The first on how the intern able to adapt quickly and adjust the learning he currently has. The second is on how willing the intern to learn what ever topic he didn't currently know. And lastly how the intern handle project under pressure, during the internship, the intern usually have a daily deadline or report where he need to accomplish, this report pushed the intern to be composed and time efficient.

Career Path Assessment

The career path of the intern in the company focused on software development side. Since the company that the intern get into focuses more on hardware, the department head gets an idea on the current needs in software development team side of the company. The supervisor also recommended for the intern to pursue machine learning since this market new and have a potential to grow more in the future years.

CHAPTER 3

Project Overview/Description

The project utilizes one of the current products of the company. This product is a microcontroller called MAX78000. This microcontroller has a CNN accelerator, allowing it to collect and process data in real time.

MAX78000fthr   MAX78000evkit

The intern deployed a CNN model in the microcontroller to detect and recognize hand gestures when the user captures an image using the camera integrated in the microcontroller. The supervisor came up with this project to have a proper documentation on how to explore and implement own personalized model to the unit. According to the department, they still haven't tested the full capability of the microcontroller, that's why it would be a great help and a challenge to make this project.

Problem/Opportunities Statement

The problem/opportunity of the project include:

- What are the necessary steps in implementing own model to the microcontroller?

- What are the bottlenecks in implementing the model?

- What are the current threshold and capability of the microcontroller?

- What is the most efficient model design to detect and recognize hand gestures?

Objective Statement

- To know if a personalized created model can be implemented to the microcontroller.

- To know the full capability of the microcontroller

- To know if there are any bottlenecks in implementing own model

- To detect and recognize hand gestures

Significance

The project will be beneficial to the follow:

Company - as it will serve as a foot hold as a documentation in creating and deploying own model to the microcontroller.

Future Intern – as this project will serve as a starting line for those who want to venture machine learning in edge devices using max78000

Current Intern – as this project widen the knowledge of the intern in the field of edge devices and machine learning implementation.

Scope and Limitations

This project is limited in developing and deploying CNN model to the MAX78000 microcontroller. This project will only recognize and detect simple and common hand gestures such as fist, open palm, peace, palm, three, one, thumb, pinky, okay, four, and satan. The project will be developed using python language and the CNN model will be implemented to the microcontroller using C language.

Brief Methodology

To the start with, the intern should familiarize with the pipeline of the max78000, so for the first week of the project, the intern focuses on getting used to in using the pipeline by trying the prebuilt model in the SDK. For the second week, the intern focuses on acquiring the right dataset for the project. The dataset that is used for the project is acquired from Kaggle, this dataset pass both qualification for the project where the gesture should have solid background and consist of multiple hand gestures with variations. After acquiring the dataset, the intern then created a data loader for the dataset to be loaded to the model for the training. The intern also created his own personalized stratified sampling algorithm since the SDK doesn't support libraries used in stratified sampling. After creating the data loader, the intern then proceeds in creating the right model for the data. The model consists of six 2-dimensional convolutional network, one dense layer, and one linear layer. After preparing model, the intern then created its own shell scripts files to train the data. During the training, the intern then changed some optimizer to have a better training and validation results. After the training, the model will then be flashed to the microcontroller where the intern will need to modify the generated C code for the microcontroller

to capture images that will be loaded to data in order to predict the classes. After flashing the model to the microcontroller, the user will then validate what the model yields using data that will be captured by the microcontroller's camera. After verifying the results and validity of the model, the intern then proceeds with the documentation of the process and results of the project.
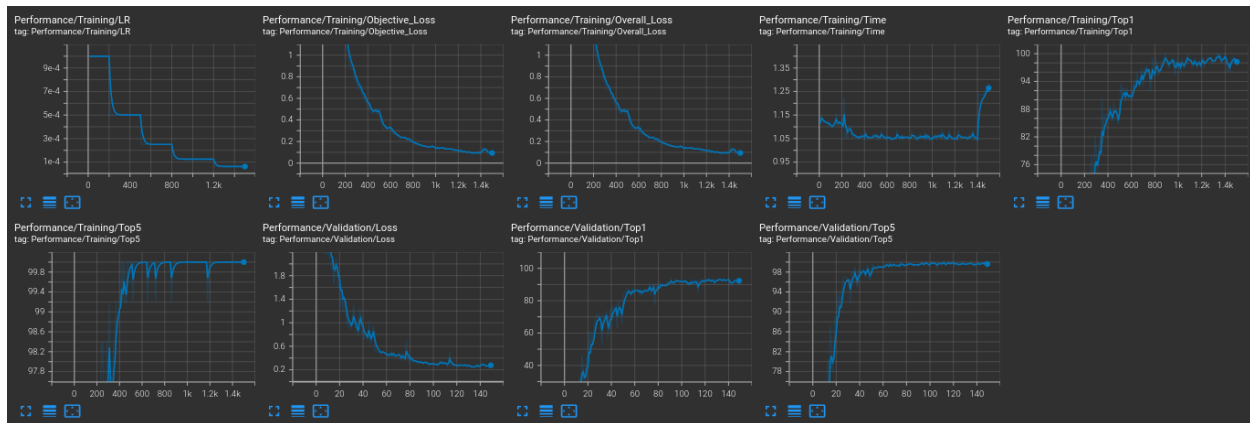
PROOF OF OUTPUT

Screenshots

Figure 3.1 Dataset Used

Figure 3.2 Model Training Graph (Tensorboard)

Figure 3.3 Training and Validation Accuracy

Figure 3.4 Successfully Detected and Recognized Hand Gestures

Figure 3.5 Unsuccessful Detection and Recognition of Hand Gesture

Diagram/Flowcharts
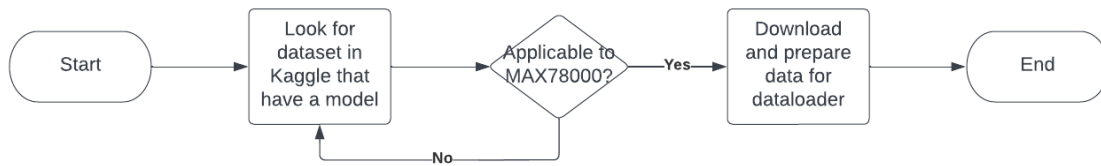
Figure 3.6 Data Acquisition
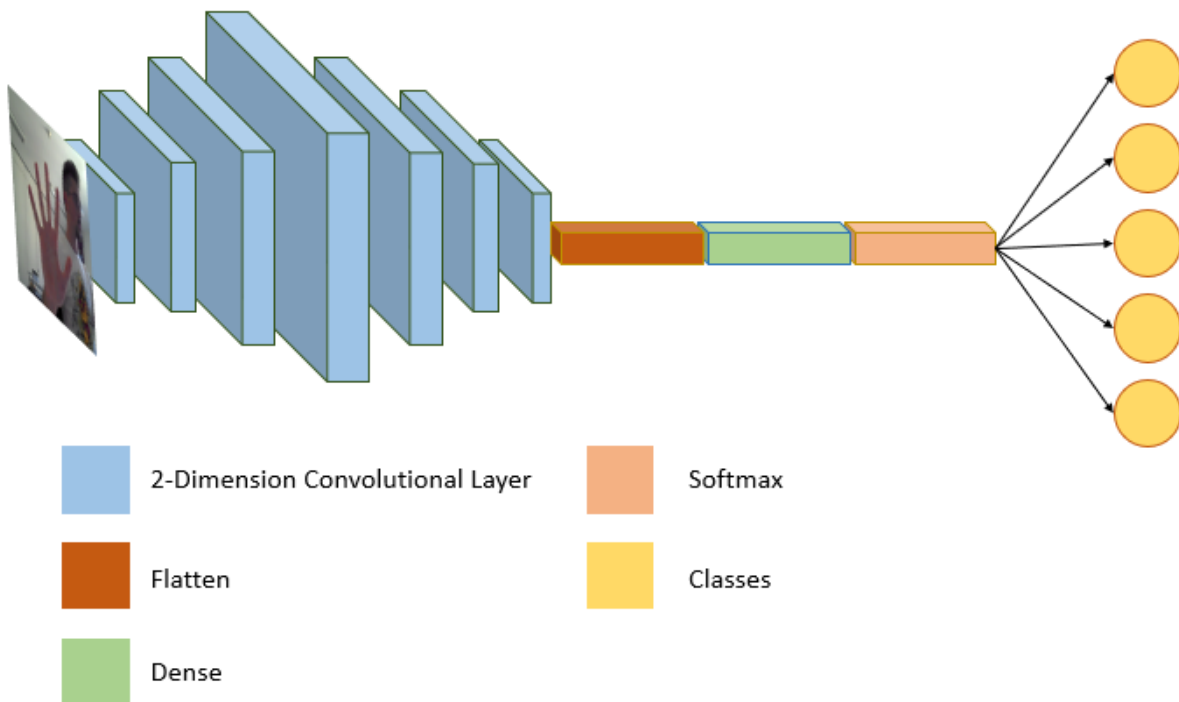
Figure 3.7 CNN Model for Hand Gesture Detection and Recognition

Resume

Ivan Gil G. Mercano

CONTACT NO.
+63 961 768 0863
EMAIL ADDRESS
iggmercano@gmail.com
HOME ADDRESS
Muntinlupa City, Metro Manila

Educational Background

Tertiary Level

Mapúa University Makati, Metro Manila
Undergraduate, Bachelor of Science in Computer Science
2019 – current
Relevant Coursework: Data Science, Web Systems and Technology, Event Driven and GUI Programming, Artificial Intelligence, Data Warehouse and Data Mining
Certificates: TOEIC ® Certificate of Achievement

Secondary Level

Muntinlupa Science High School Muntinlupa, Metro Manila
Science, Technology, Engineering and Mathematics (STEM)
2017-2019
Relevant Coursework: Web Developing, Web Designing, Statistics, Calculus, Media and Information Literacy, and Oral Communication.
Certificates: SHS Graduate with Honors

Muntinlupa Science High School Muntinlupa, Metro Manila
Science, Technology, Engineering and Mathematics (STEM)
2013-2017
Relevant Coursework: Introduction to HTML, CSS, PHP, and SQL.
Certificates: Academics and Deportment Merit Cards

Technical Skills

- Python
- SQL
- MySQL
- Rapid Miner
- Hadoop
- HTML5
- CSS3
- PHP
- SAS
- Kafka
- Tableau
- Power BI
- Microsoft Excel
- RStudio
- Spark

Research Papers and Projects Handled

- **Bacterial Colony Counter Using Different Image Processing Algorithm (Thesis)/Ongoing**
  - The researchers built a model that detects a bacterial colony from a photo that have a vague characteristic (opaque or transparent) by using different preprocessing image algorithm to enhance and define the colony before counting
  - Written in Python with the help of different libraries such as Pandas and NumPy to handle and process the data extracted from the image.
- **Machine Learning Application on the Edge (Hand Gesture Recognition using CNN)/Ongoing**
  - This project applied a CNN model capable of detecting and recognizing hand gestures. The model is applied in MAX78000. This microcontroller is developed by maxim and capable of handling CNN models at low power, making this project an application of machine learning in edge devices.
  - This is my project in my OJT, it is built inside the SDK of MAX78000 and use python as its language.

- **MMDA Traffic Accident Count Dashboard / August 1, 2022**
  - The group designed a dashboard from a dataset which tells the historical accident counts in Metro Manila. The dashboard can display data in a more understandable manner. The dashboard enables a drill down function that enables better data analyzation for the user.
  - The project is done using PowerBI.

- **Anongasaeyyo Korean Convenience Store Website / May 12, 2022**
  - The group planned and developed an e-commerce website to resolve the problems that the client is currently facing. One example of the problem that the group resolved is the problem in promotion by developing an easy access website exclusively for the store.
  - Written in HTML5, CSS3, Bootstrap, and PHP for the website's database.
- **CCTV Counts Dashboard / Oct 26, 2021**
  - The group designed a dashboard for data visualization of CCTV vehicle count.
  - For the first part of the project, the instructor made the group use Power BI and for the second part the instructor made the group redo the dashboard using a different data visualization tool which is Tableau.
- **Emotion Recognition of Images using Linear Regression Model and Random Forest / Aug 8, 2021**
  - The group studied and analyzed a dataset consisting of pictures of different faces showing different emotions. The group then extracted actions from the pictures and fitted it into the Linear Regression Model and Random Forest to recognize the emotions being showed in the picture.
  - The project is written in python with the help of different libraries to handle the data and process it for the desired result.

- **Anohi Japanese Goods Business Website / May 17, 2020**
  - The grouped developed a simple e-commerce website for promoting the starting business of the client
  - Written in HTML5, CSS3, and Bootstrap.

Work Experience

Member	Mapua University Center for Student Advising (CSA)
	2019 – Present
On the job trainee	Special Program of the Employment of Students (SPES)
	2019
Work Immersion	Crimson Hotel & Resorts
	2018

Seminar / Training Attended

- TOEIC ® Certificate of Achievement — Feb 9, 2022
- Adjusting to the New Normal: Best Practices in Peer Advising/Mentoring (CSA Webinar) — Aug 9, 2021
- PESO Special Program of Employment of Student (SPES) Training Program — June 2019
- Muntinlupa Science High School Intern Preparation Seminar — 2018
- Mental Health Awareness Seminar — 2018
- YASDO Muntinlupa Summer Camp — 2017

Relevant Skills and Abilities

Technical:	Google Suite
	Microsoft Office (Excel, Word, Power Point, Publisher)
	SQL, MySQL
	Python
	C++
Skills:	Web Developing
	Database Management
	Graphic Design (Adobe Photoshop)
	Data Analysis
	Client Relationship Building
	Social Media
Interest:	Computer and Technology
	Robotics
	Data Science
Languages:	English (Proficient), Tagalog (Native)

Awards

Dean's Lister

Academic Honors	A.Y. 2017 - 2018 and A.Y. 2018 - 2019
Best Research Award – Team Leader	A.Y 2018 – 2019
Regional Research Competition 2nd Award	A.Y 2018 - 2019

Project Approval Form

School Of Information Technology
MAPÚA INSTITUTE OF TECHNOLOGY
333 Sen. Gil Puyat Ave., Makati City 1202 Philippines

APPROVAL OF PROJECT FOR OJT

NAME OF TRAINEE	Mercano, Ivan Gil G.
COMPANY	Analog Devices Inc.
DEPARTMENT	New Technology Integration - System Integration Engineering (Apps)
REGISTERED ADDRESS	Gateway Business Park, Javalera, Gen. Trias, Cavite
NAME OF SUPERVISOR	Louijie Compo
JOB POSITION	Staff Engineer, System Integration Engineer
TITLE OF PROJECT	Hand Gesture Recognition using MAX78000

BRIEF DESCRIPTION OF PROJECT

Here in ADI, the company strive to continue in developing applications for microcontrollers. As an intern in this company, I personally want to contribute in researching what are the capabilities of the companies products. One application that me and my superior decided to pursue is the use of MAX78000. This microcontroller is a new innovative microcontrollers capable of handling neural network at low power, making it a good example of machine learning application at the edge.

For the topic and application of the device, me and my superior decided to develop a model that can be fitted with the microcontroller's capabilities and detect and recognize gestures that will be captured by the MAX78000.

I, hereby, certify that the above project and description shall be the major work to be undertaken during the OJT program. The trainee's supervisor has requested this project which will be useful in the organization and have a direct impact in the company.

Mercano, Ivan Gil G. Aug 1, 2022
SIGNATURE OVER PRINTED NAME OF TRAINEE/ DATE

LOUIJIE COMPO
SIGNATURE OVER PRINTED NAME OF SUPERVISOR/ DATE

ACTION TAKEN BY THE OJT ADVISER

☑ APPROVED
☐ DISAPPROVED
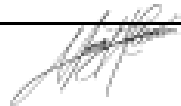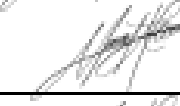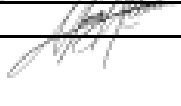
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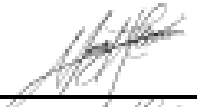
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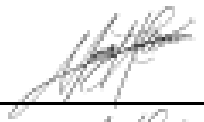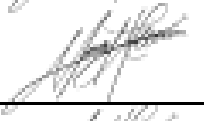
ACCOMPLISHMENT REPORTS

School Of Information Technology
MAPÚA INSTITUTE OF TECHNOLOGY

DAILY ACCOMPLISHMENT REPORT

NAME : MERCANO, Ivan Gil G. **SPECIALIZATION:** Data Science

COMPANY NAME : Analog Devices Inc. (Gen Trias)
DEPARTMENT ASSIGNED : NTI System Integration Engineering (Apps)
SCHEDULE OF TRAINEE: Monday – Friday (7:30am – 4:45pm)

EXPECTED DATE OF COMPLETION OF 244 HOURS: August 12, 2022

ACTIVITY (PLS SPECIFY THE TASKS PERFORMED)	DURATION (DATES AND NO. OF HRS RENDERED)	REMARKS (eg., ACCOMPLISHED, ON PROCESS etc)	IMMEDIATE SUPERIOR SIGNATURE
New Employee Orientation (NEO)	June 28 7:30am to 4:45pm 8.75 hours		
NEO – Company Benefits, Compensation, and Services	June 29 7:30am to 4:45pm 8.75 hours		
NEO – Company Security & Policies	June 30 7:30am to 4:45pm 8.75 hours		
NEO – Department Orientation	July 1 7:30am to 4:45pm 8.75 hours		
Python Familiarization	July 4 7:30am to 4:45pm 8.75 hours		
Activity Discussion (P2life)	July 5 7:30am to 4:45pm 8.75 hours		
P2life Activity Continuation	July 6 7:30am to 4:45pm 8.75 hours		
P2life first version release	July 7 7:30am to 4:45pm 8.75 hours		
P2life pytesting	July 8 7:30am to 4:45pm 8.75 hours		
Introduction to Pytesting	July 11		

	7:30am to 4:45pm 8.75 hours		
P2life pytesting	July 12 7:30am to 4:45pm 8.75 hours		
Unit testing of controller modules	July 13 7:30am to 4:45pm 8.75 hours		
Unit testing of controller modules continuation	July 14 7:30am to 4:45pm 8.75 hours		
Unit testing of controller modules continuation	July 15 7:30am to 4:45pm 8.75 hours		
Tkniter Familiarization	July 18 7:30am to 4:45pm 8.75 hours		
Tkniter Application to Hash Name Searcher	July 19 7:30am to 4:45pm 8.75 hours		
Hash Name Searcher Presentation	July 20 7:30am to 4:45pm 8.75 hours		
Familiarization of Machine Learning on Edge Device (MAX78000)	July 21 7:30am to 4:45pm 8.75 hours		
Familiarization of Machine Learning on Edge Device (MAX78000) Continuation	July 22 7:30am to 4:45pm 8.75 hours		
Familiarization of Machine Learning on Edge Device (MAX78000) trying other model and dataset (cifar)	July 25 7:30am to 4:45pm 8.75 hours		
Familiarization of Machine Learning on Edge Device (MAX78000) trying other model and dataset (kws20)	July 26 7:30am to 4:45pm 8.75 hours		
Familiarization of Machine Learning on Edge Device (MAX78000) Final model Creation	July 27 7:30am to 4:45pm 8.75 hours		
Project Idea – Researching possible papers for the project	July 28 7:30am to 4:45pm 8.75 hours		
Project Idea – researching possible dataset	July 29 7:30am to 4:45pm		

	8.75 hours		
Project Idea – creating a prototype model for the project	Aug 1 7:30am to 4:45pm 8.75 hours		
Project Creation – creation of data loaders, yaml files, etc.	Aug 2 7:30am to 4:45pm 8.75 hours		
Project Creation - training	Aug 3 7:30am to 4:45pm 8.75 hours		
Project Creation – training optimization	Aug 4 7:30am to 4:45pm 8.75 hours		
Project Creation - deployment	Aug 5 7:30am to 4:45pm 8.75 hours		
Project Presentation	Aug 8 7:30am to 4:45pm 8.75 hours		
Completion	Aug 8 – Aug 12		

Prepared by:

Mercado, Ivan Gil G.
Student's Signature