

GLASGOW CALEDONIAN UNIVERSITY

MEng Group Research Project

MMH723842-24-AB-GLAS

**Design and implementation of a PSD-Based
Analogue 2D Sun Sensor**

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Contents

Abstract	5
1 Acknowledgements	6
2 Introduction	7
2.1 Problem Statement	7
2.2 Aim of the Project	7
2.3 Objectives of the Project	7
3 LiteratureReview	8
3.1 CubeSat Design	8
3.2 PSD Enabled Sun Sensor	9
3.3 Mechanical Design and Analysis	9
3.4 Photodiode Simulation and Signal Analysis	9
3.5 IoT Communication Enhancement with LEO Satellites	9
4 Background	10
5 Methodology	11
5.1 System Design Overview	11
5.1.1 Functional Requirements	12
5.1.2 Design Approach	12
5.1.3 System Architecture	12
5.2 Sensor Array Development	12
5.2.1 Functional Requirements	13
5.2.2 Design Approach	13
5.2.3 System Architecture	13
5.3 Signal Conditioning Circuitry	13
5.3.1 Functional Requirements	15
5.3.2 Design Approach	15
5.3.3 System Architecture	15
5.4 Enclosure Design And Fabrication	15

5.4.1	Functional Requirements	16
5.4.2	Design Approach	16
5.4.3	System Architecture	16
5.5	Data Acquisition System	16
5.5.1	Functional Requirements	18
5.5.2	Design Approach	18
5.5.3	System Architecture	18
5.6	Testing Apparatus	18
5.6.1	Functional Requirements	19
5.6.2	Design Approach	19
5.6.3	System Architecture	19
5.7	Prototype Development Lifecycle	19
5.7.1	Functional Requirements	21
5.7.2	Design Approach	21
5.7.3	System Architecture	21
6	Results	22
6.1	Sensor Characterization	22
6.1.1	Functional Requirements	23
6.1.2	Design Approach	23
6.1.3	System Architecture	23
6.2	Amplification Performance	23
6.2.1	Functional Requirements	25
6.2.2	Design Approach	25
6.2.3	System Architecture	25
6.3	Photodiode Angular Response	25
6.3.1	Functional Requirements	26
6.3.2	Design Approach	26
6.3.3	System Architecture	26
6.4	Enclosure Effectiveness	26
6.4.1	Functional Requirements	28
6.4.2	Design Approach	28
6.4.3	System Architecture	28
6.5	Data Acquisition System Evaluation	28
6.5.1	Functional Requirements	29
6.5.2	Design Approach	29
6.5.3	System Architecture	29
6.6	System Performance Analysis	30
6.6.1	Operational Constraints Identified	30

6.6.2	Environmental Factors Impact	30
6.6.3	System Stability and Repeatability	30
6.6.4	Recommendations for Improvement	30
6.7	Comparative Analysis	30
6.7.1	Breadboard vs. Stepboard Results	31
6.7.2	Iteration Improvements Analysis	31
6.7.3	Performance Against Design Requirements	31
6.7.4	Design Evolution Assessment	31
6.8	System Limitations And Considerations	31
6.8.1	Functional Requirements	32
6.8.2	Design Approach	32
6.8.3	System Architecture	32
7	Conclusions	35
8	FutureWork	36
	Bibliography	36

List of Figures

5.1	System Design Overview Flowchart	11
5.2	System Architecture Diagram	12
5.3	System Design Overview Flowchart	13
5.4	System Architecture Diagram	14
5.5	System Design Overview Flowchart	14
5.6	System Architecture Diagram	15
5.7	System Design Overview Flowchart	16
5.8	System Architecture Diagram	17
5.9	System Design Overview Flowchart	17
5.10	System Architecture Diagram	18
5.11	System Design Overview Flowchart	19
5.12	System Architecture Diagram	20
5.13	System Design Overview Flowchart	20
5.14	System Architecture Diagram	21
6.1	System Design Overview Flowchart	23
6.2	System Architecture Diagram	24
6.3	System Design Overview Flowchart	24
6.4	System Architecture Diagram	25
6.5	System Design Overview Flowchart	26
6.6	System Architecture Diagram	27
6.7	System Design Overview Flowchart	27
6.8	System Architecture Diagram	28
6.9	System Design Overview Flowchart	29
6.10	System Architecture Diagram	30
6.11	Environmental Testing Results	30
6.14	System Design Overview Flowchart	31
6.12	Overall System Performance Analysis	33
6.13	Prototype Iteration Comparison	34
6.15	System Architecture Diagram	34

Abstract

add abstract here

1. Acknowledgements

2. Introduction

2.1 Problem Statement

2.2 Aim of the Project

2.3 Objectives of the Project

3. LiteratureReview

3.1 CubeSat Design

Puig-Suari, Turner and Ahlgren published an IEEE paper in 2001 with the help of their students at California Polytechnic State University exploring a need for micro satellites for use by universities in an ever-expanding space programme. They provide as a solution a standard satellite form-factor that will bring down the cost of both manufacture and deployment of satellites by smaller entities: the CubeSat. The paper identifies a key component for the success of this form factor a need for a standard CubeSat deployer mechanism which can deploy several satellites safely and develop such a platform, called Poly Picosatellite Orbital Deployer or P-POD. They point out the need and provide microsatellite size and shape of the CubeSat form factor [?]. Sai balaji et al. performed a study using MATLAB simulation of several attitude control algorithms to look at the ability to control a CubeSat of size 1U. They also simulated sensors such as sun sensors, magnetometer, and gyroscope. They concluded that it is possible to operate the satellite using a magnetorquer type actuator and an array of mathematical models and algorithms: it would take 2000 seconds for a 1U satellite to stabilize at 505km, 98° degree attitude in orbit with the methods utilized by them [?]. Incentivised by the rapidly increasing use of LEO, Lopez-Calle and Franco perform a quantitative comparative study on the catastrophic failure of CubeSats and Nanosats from radiation exposure due to the harsh environment of space versus failure due to collisions in the increasingly busy Low Earth Orbit (LEO). The authors concluded that while sustained damage and damage protection from radiation exposure used to be and currently still is the most crucial factor in protecting LEO microsatellites, increasingly the risk of debris collisions is becoming more important and will become the most important in the following 50 to 70 years. The authors conclude that microsatellite designers need to move their focus more towards defence from debris impacts as these, even if not resulting in catastrophic failure of the satellite, they will impact the attitude of the satellite [?].

- 3.2 PSD Enabled Sun Sensor
- 3.3 Mechanical Design and Analysis
- 3.4 Photodiode Simulation and Signal Analysis
- 3.5 IoT Communication Enhancement with LEO Satellites

4. Background

5. Methodology

5.1 System Design Overview

This section provides an overview of the System Design Overview.

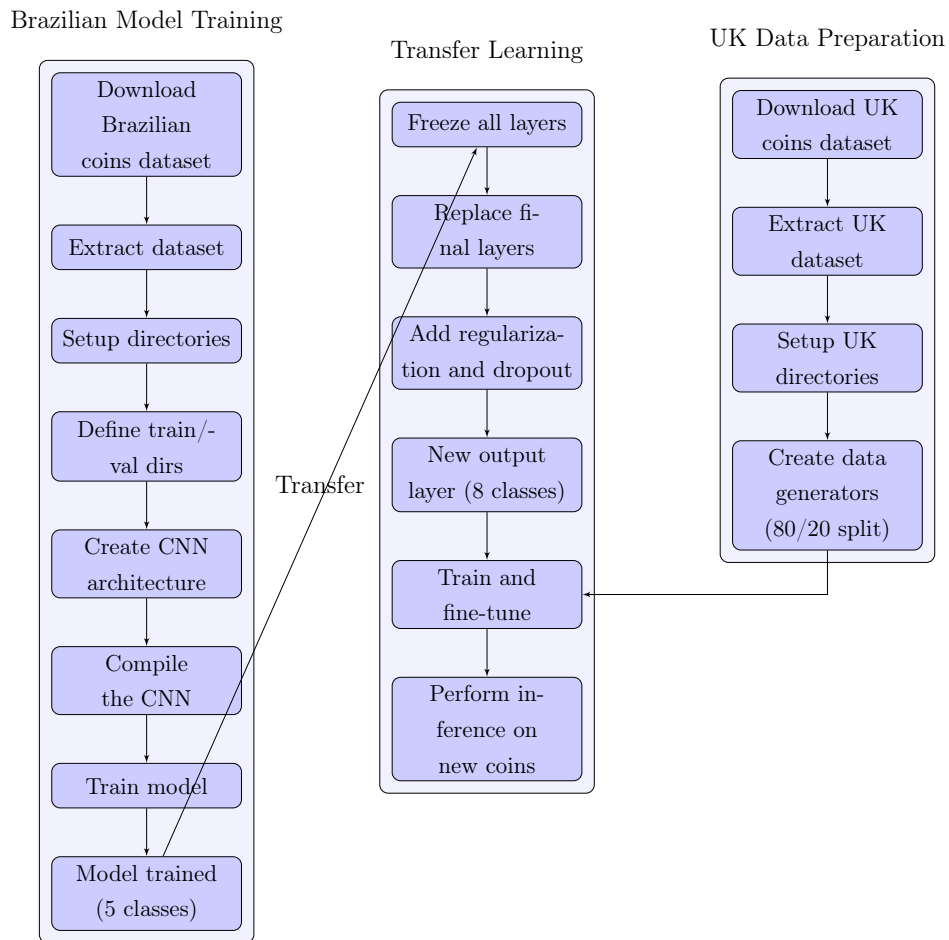


Figure 5.1: System Design Overview Flowchart

5.1.1 Functional Requirements

5.1.2 Design Approach

5.1.3 System Architecture

As shown in Figure 5.1 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.1: System Architecture Code Example

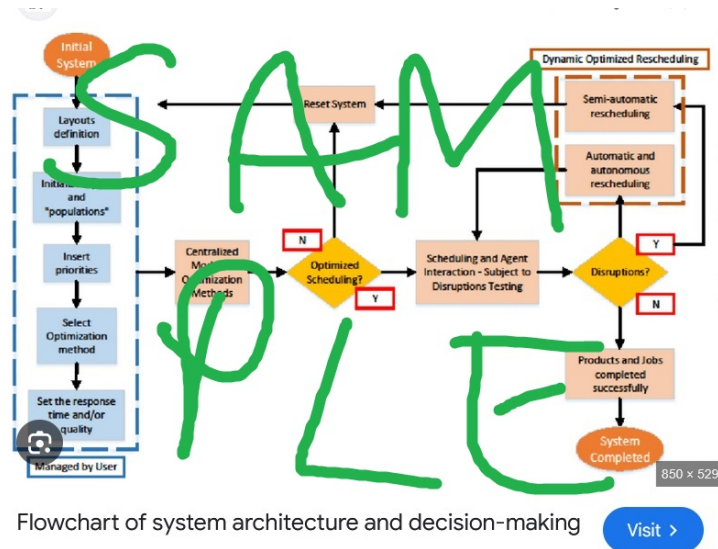


Figure 5.2: System Architecture Diagram

5.2 Sensor Array Development

This section provides an overview of the Sensor Array Development.

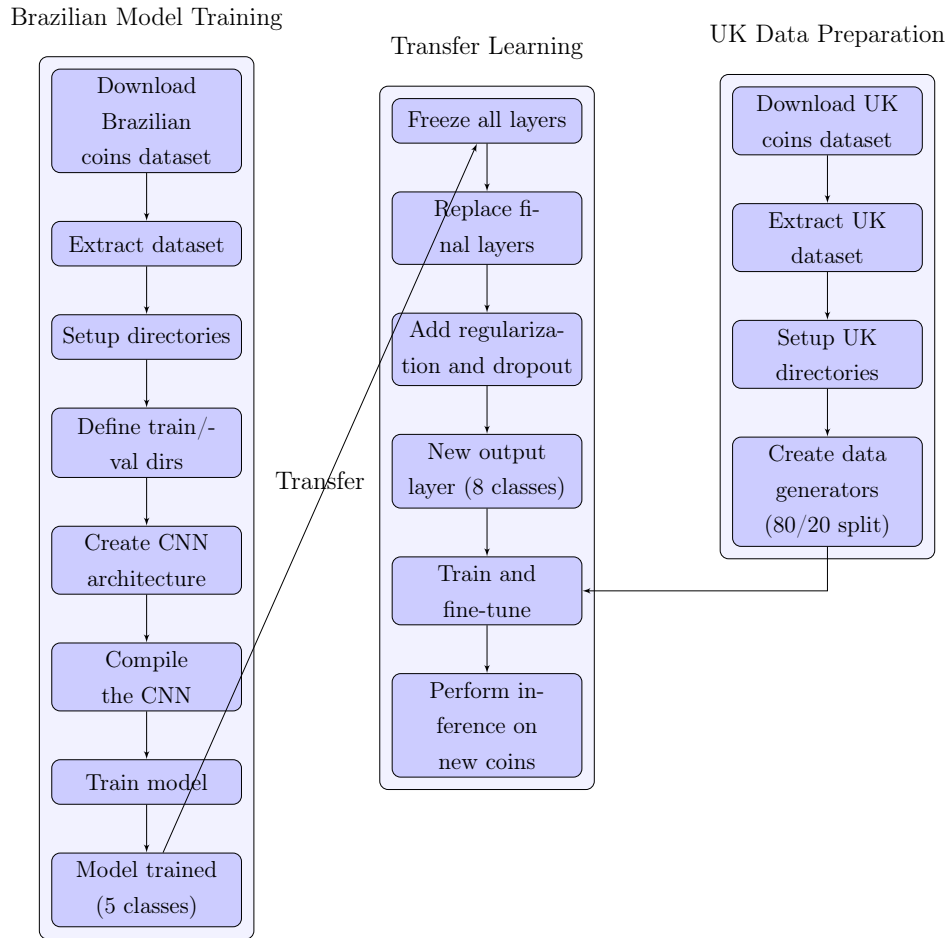


Figure 5.3: System Design Overview Flowchart

5.2.1 Functional Requirements

5.2.2 Design Approach

5.2.3 System Architecture

As shown in Figure 5.3 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.2: System Architecture Code Example

5.3 Signal Conditioning Circuitry

This section provides an overview of the Signal Conditioning Circuitry.

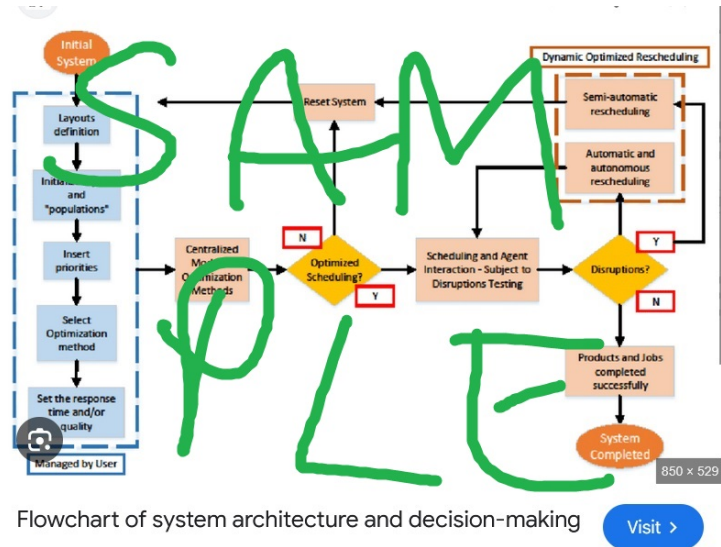
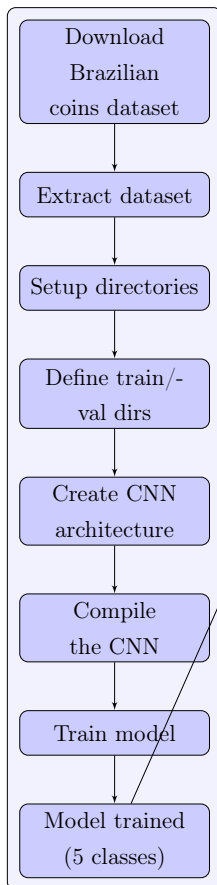
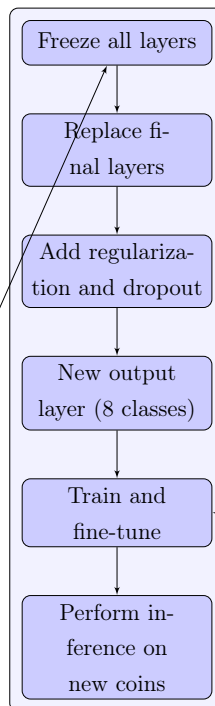


Figure 5.4: System Architecture Diagram

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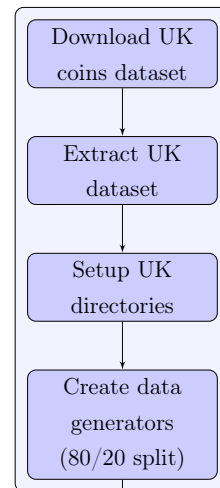


Figure 5.5: System Design Overview Flowchart

5.3.1 Functional Requirements

5.3.2 Design Approach

5.3.3 System Architecture

As shown in Figure 5.5 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.3: System Architecture Code Example

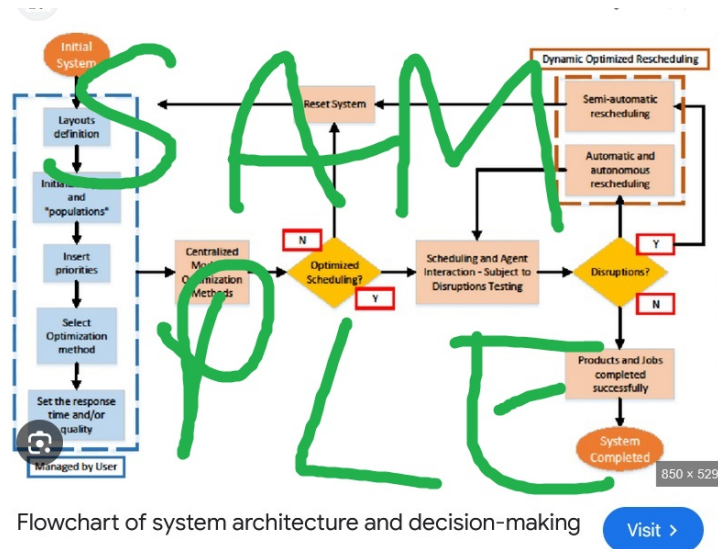


Figure 5.6: System Architecture Diagram

5.4 Enclosure Design And Fabrication

This section provides an overview of the Enclosure Design And Fabrication.

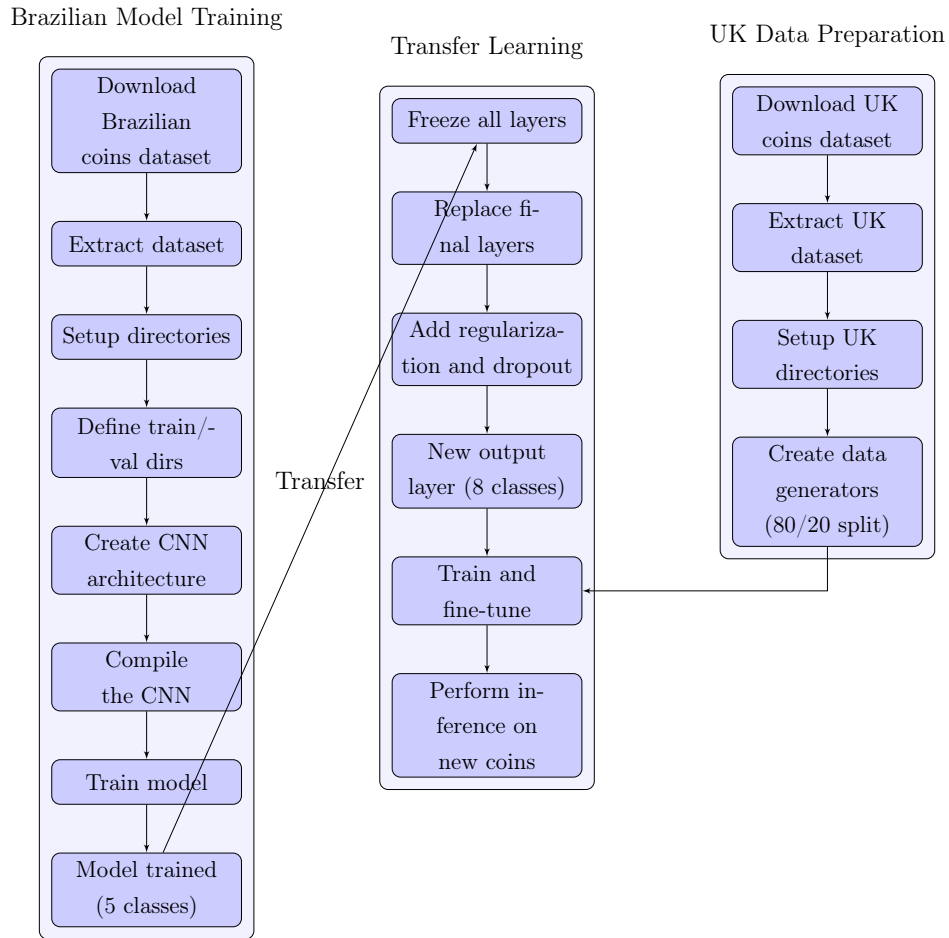


Figure 5.7: System Design Overview Flowchart

5.4.1 Functional Requirements

5.4.2 Design Approach

5.4.3 System Architecture

As shown in Figure 5.7 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.4: System Architecture Code Example

5.5 Data Acquisition System

This section provides an overview of the Data Acquisition System.

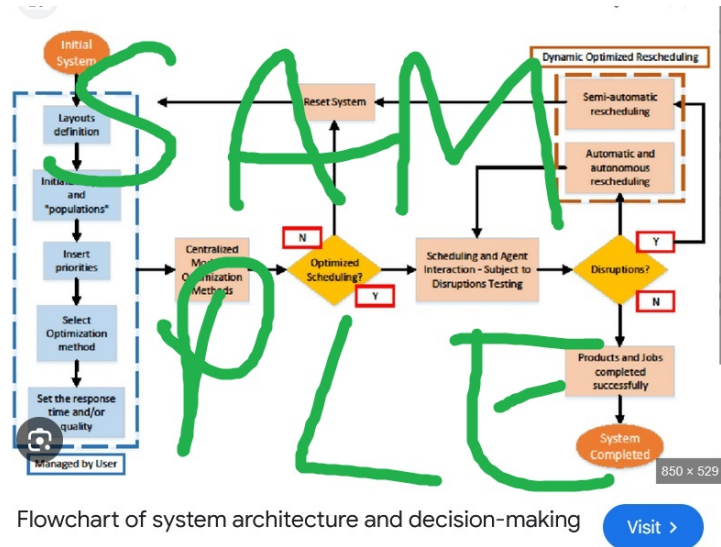
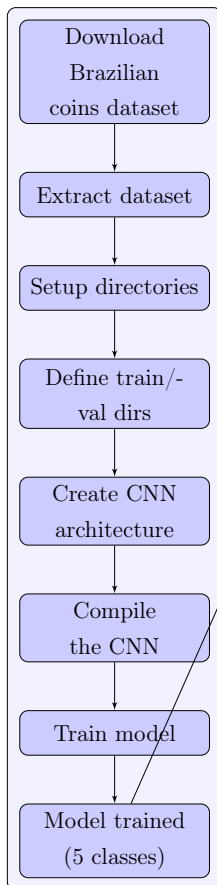
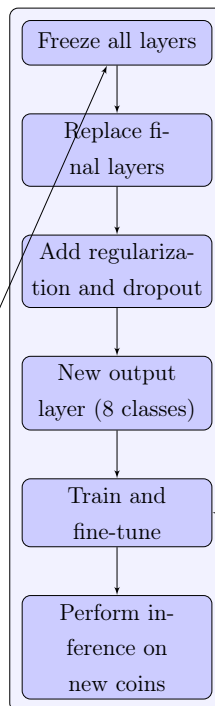


Figure 5.8: System Architecture Diagram

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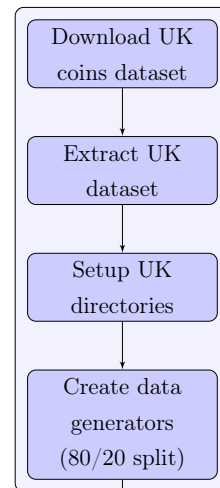


Figure 5.9: System Design Overview Flowchart

5.5.1 Functional Requirements

5.5.2 Design Approach

5.5.3 System Architecture

As shown in Figure 5.9 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.5: System Architecture Code Example

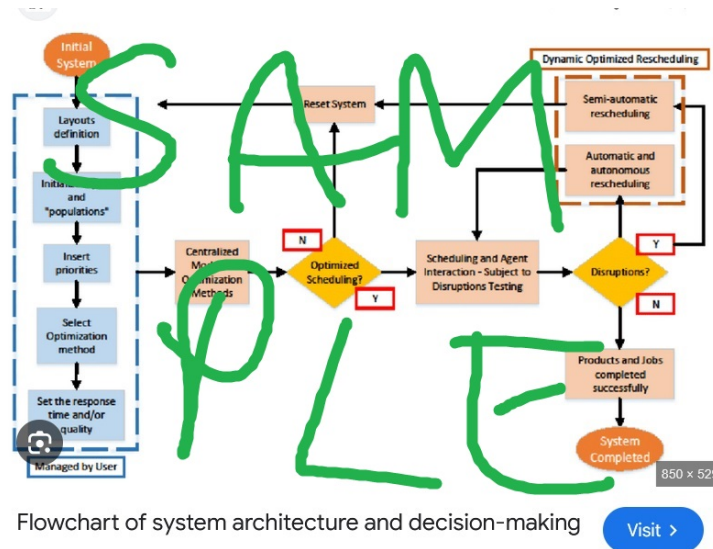


Figure 5.10: System Architecture Diagram

5.6 Testing Apparatus

This section provides an overview of the Testing Apparatus.

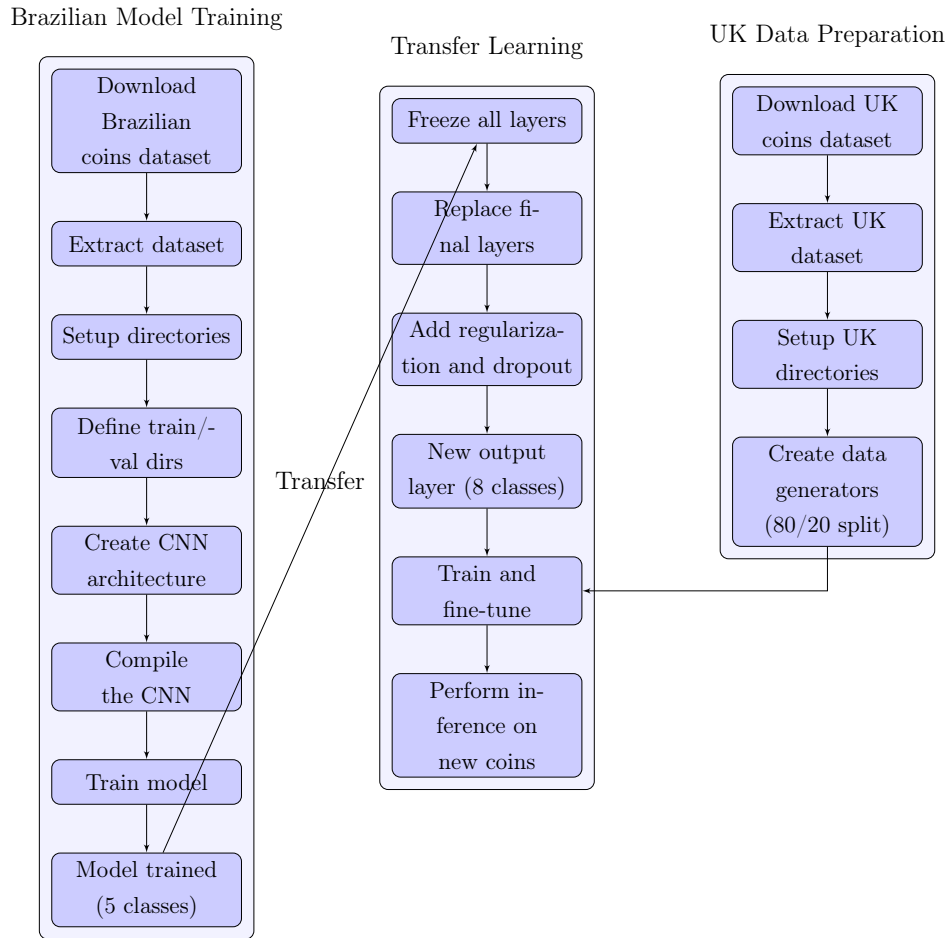


Figure 5.11: System Design Overview Flowchart

5.6.1 Functional Requirements

5.6.2 Design Approach

5.6.3 System Architecture

As shown in Figure 5.11 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.6: System Architecture Code Example

5.7 Prototype Development Lifecycle

This section provides an overview of the Prototype Development Lifecycle.

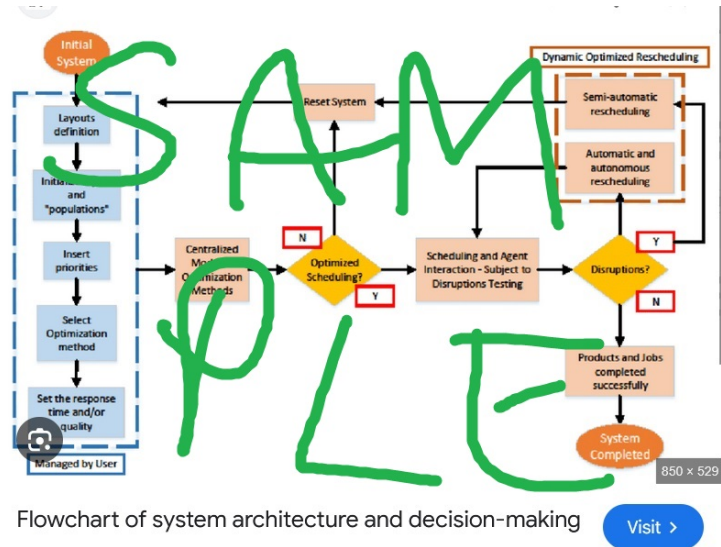
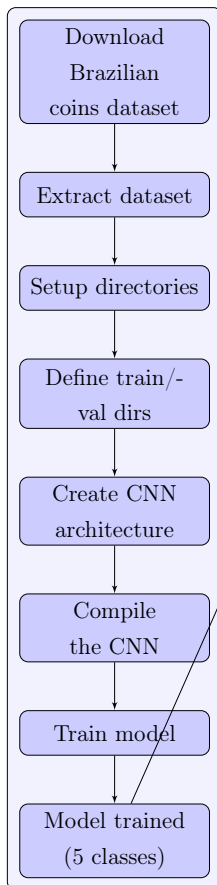
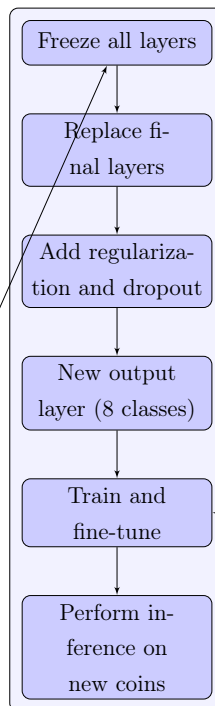


Figure 5.12: System Architecture Diagram

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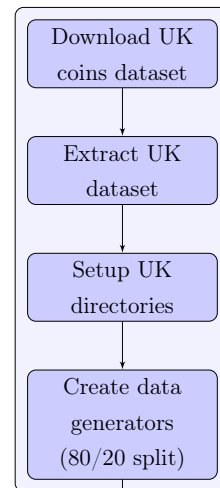


Figure 5.13: System Design Overview Flowchart

5.7.1 Functional Requirements

5.7.2 Design Approach

5.7.3 System Architecture

As shown in Figure 5.13 the system architecture consists of various components.

```
1 # Your code here
```

Listing 5.7: System Architecture Code Example

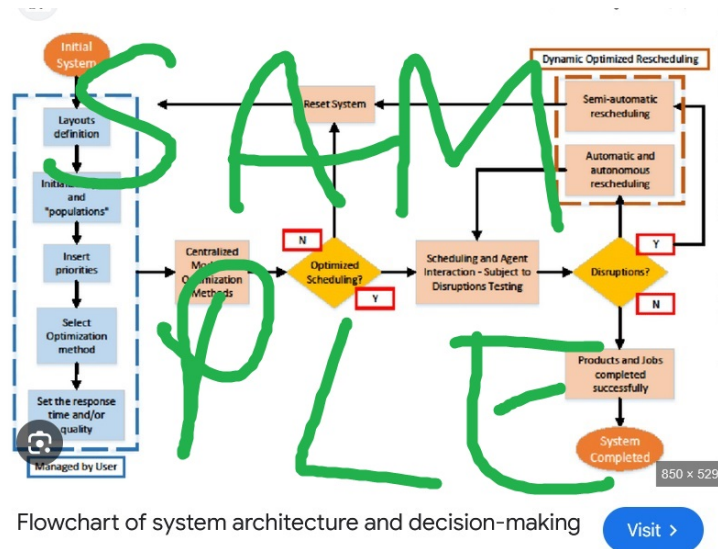


Figure 5.14: System Architecture Diagram

6. Results

6.1 Sensor Characterization

For the SensorCharacterization.tex file, you'd want to focus on the fundamental properties and performance of your photodiodes themselves, distinct from the other subsections. Here are some key elements that would belong specifically under SensorCharacterization:

- Basic Photodiode Electrical Characteristics:

- Dark current measurements
 - Junction capacitance
 - I-V characteristics in different lighting conditions
 - Spectral response profiles (sensitivity vs. wavelength)

- Individual Sensor Benchmarking:

- Performance comparison between the 4 photodiodes (matching/differences)
 - Responsivity measurements (A/W)
 - Quantum efficiency calculations
 - Detection threshold levels

- Response Linearity:

- Measurements showing linear range of the photodiodes
 - Saturation point characterization
 - Recovery time from saturation

- Temperature Dependency:

- Performance drift with temperature
 - Baseline shift measurements
 - Temperature compensation data

- Aging/Stability Tests:

- Long-term drift measurements
 - Repeatability of measurements over time

This section should focus on the inherent properties of the photodiodes themselves - essentially providing the baseline characterization data that underpins all the other analysis. The other sections then build on this foundation by examining how these sensors perform when integrated into the complete system with amplification, angular positioning, enclosure effects, etc.

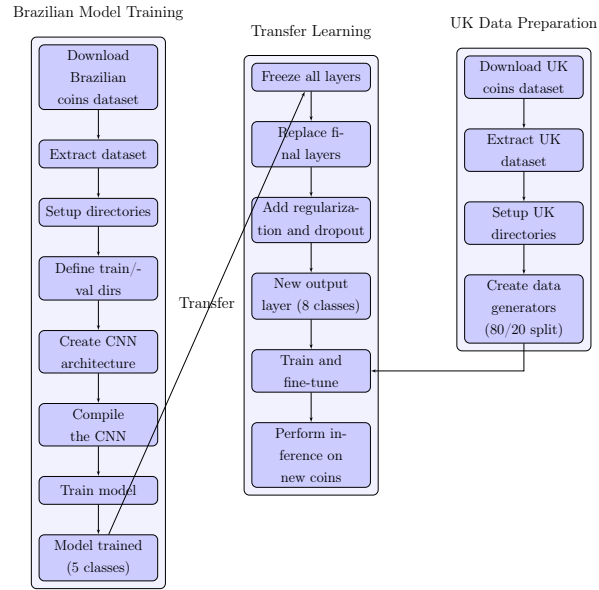


Figure 6.1: System Design Overview Flowchart

6.1.1 Functional Requirements

6.1.2 Design Approach

6.1.3 System Architecture

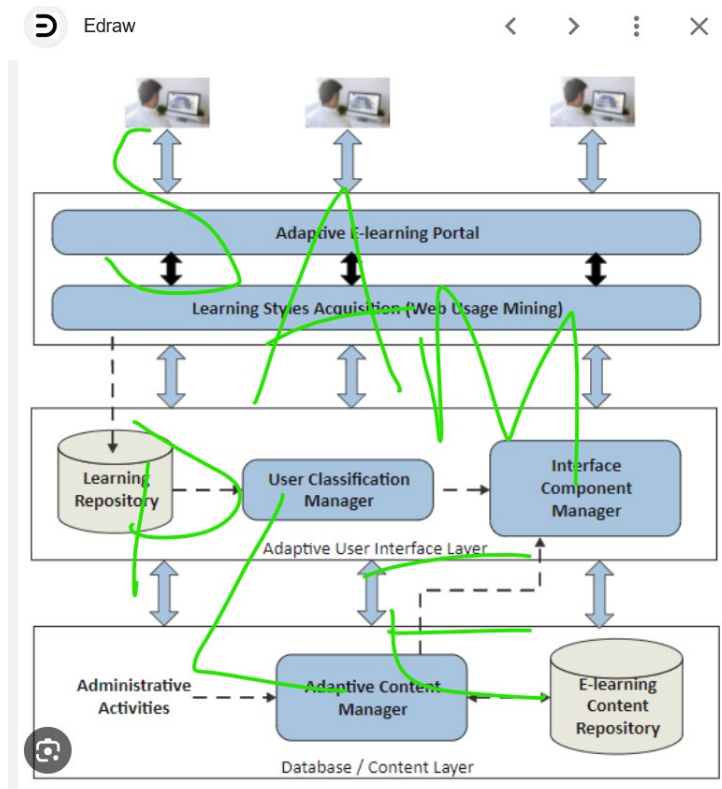
As shown in Figure 6.1 the system architecture consists of various components.

```
1 # Your code here
```

Listing 6.1: System Architecture Code Example

6.2 Amplification Performance

This section provides results of the amplifier performance.



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Figure 6.2: System Architecture Diagram

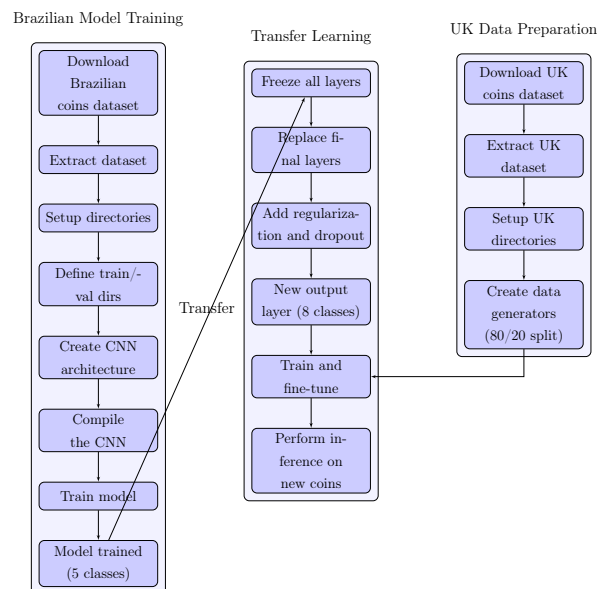


Figure 6.3: System Design Overview Flowchart

6.2.1 Functional Requirements

6.2.2 Design Approach

6.2.3 System Architecture

As shown in Figure 6.3 the system architecture consists of various components.

```
1 # Your code here
```

Listing 6.2: System Architecture Code Example

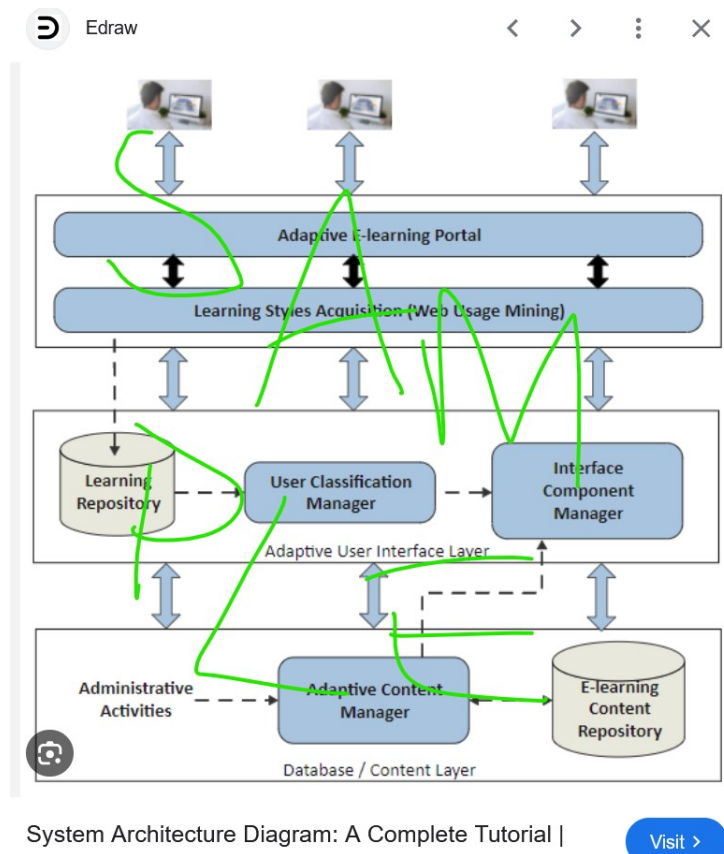


Figure 6.4: System Architecture Diagram

6.3 Photodiode Angular Response

This section discusses the results of the response of the solar sensor to angular changes of the light source.

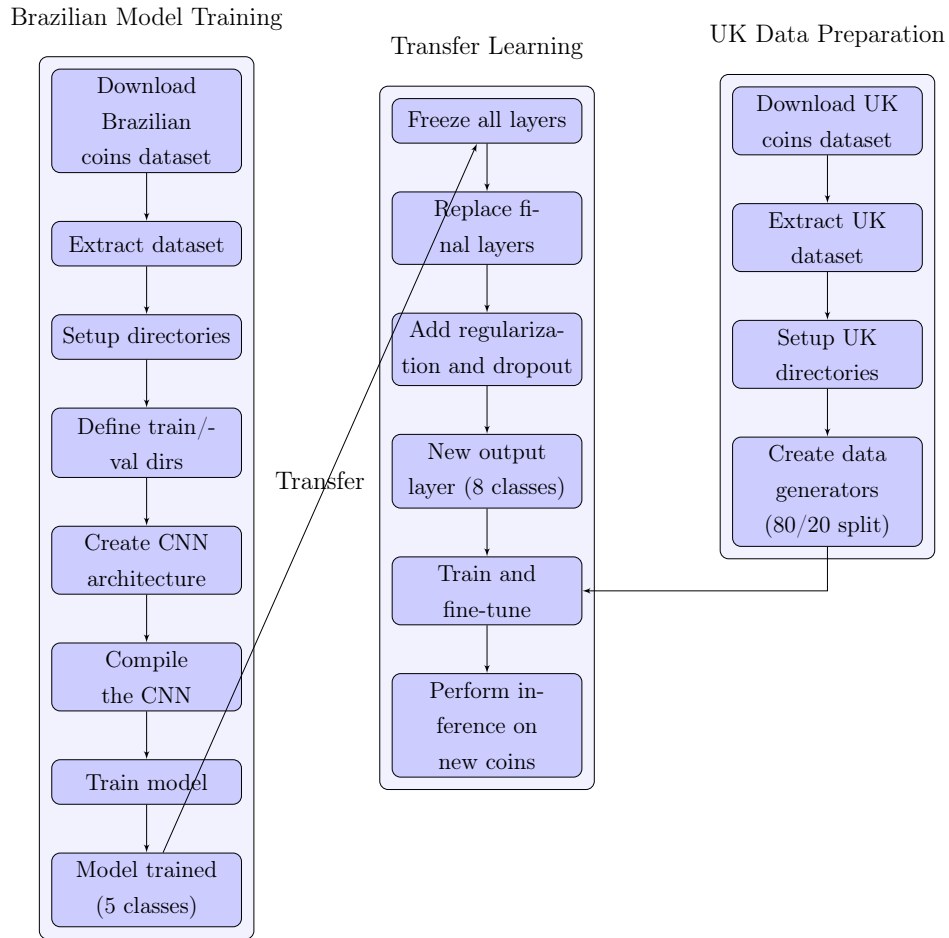


Figure 6.5: System Design Overview Flowchart

6.3.1 Functional Requirements

6.3.2 Design Approach

6.3.3 System Architecture

As shown in Figure 6.5 the system architecture consists of various components.

```
1 # Your code here
```

Listing 6.3: System Architecture Code Example

6.4 Enclosure Effectiveness

This section discusses the effectiveness of the Photodiode enclosure.

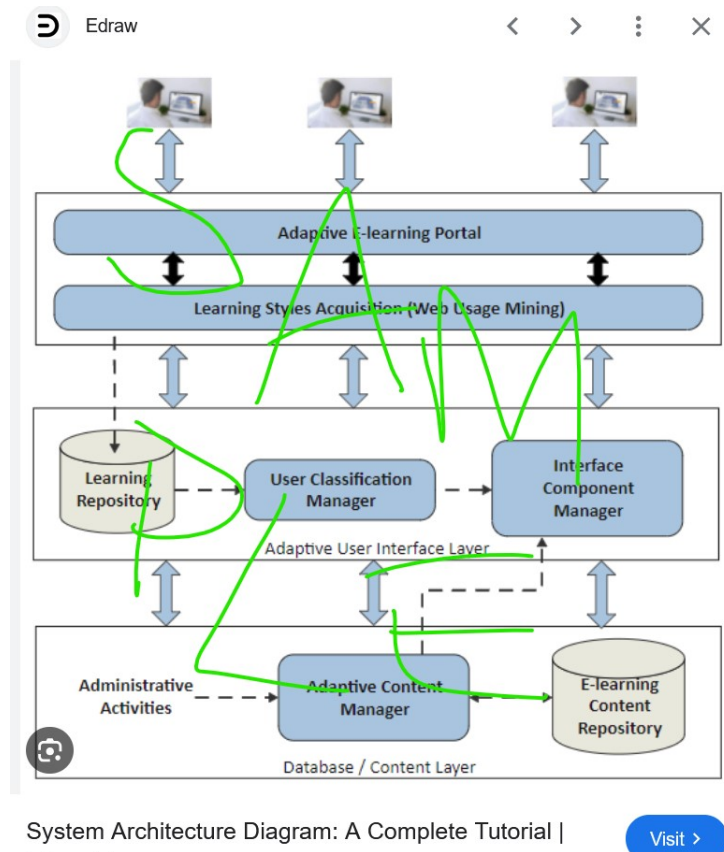
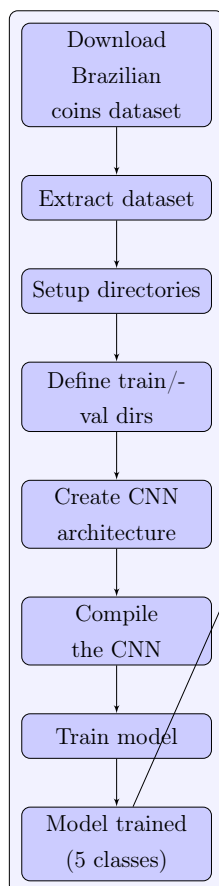
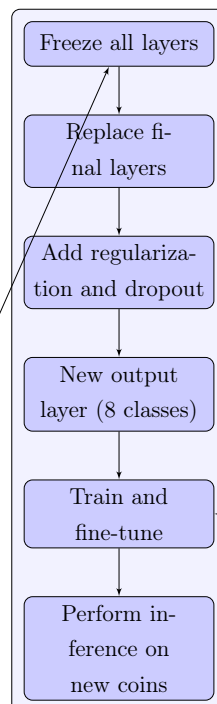


Figure 6.6: System Architecture Diagram

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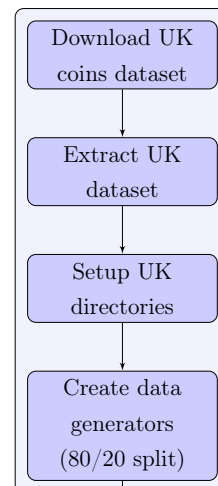


Figure 6.7: System Design Overview Flowchart

6.4.1 Functional Requirements

6.4.2 Design Approach

6.4.3 System Architecture

As shown in Figure 6.7 the system architecture consists of various components.

```
1 # Your code here
```

Listing 6.4: System Architecture Code Example

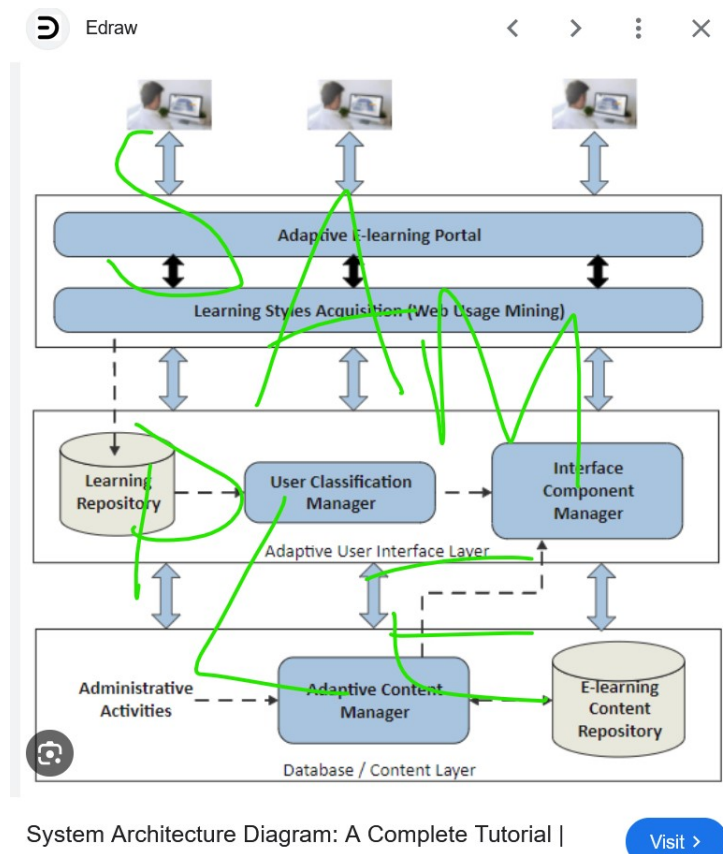


Figure 6.8: System Architecture Diagram

6.5 Data Acquisition System Evaluation

This section provides results related to the Arduino DAQ.

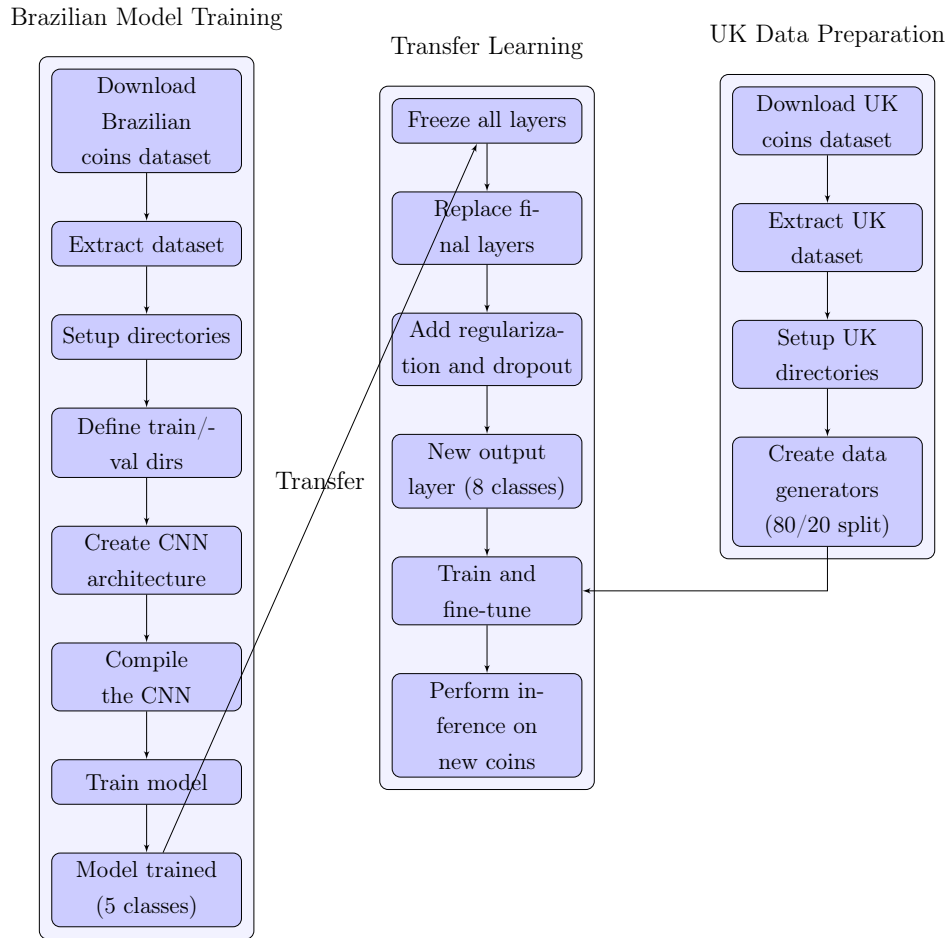


Figure 6.9: System Design Overview Flowchart

6.5.1 Functional Requirements

6.5.2 Design Approach

6.5.3 System Architecture

As shown in Figure 6.9 the system architecture consists of various components.

```
1 # Your code here
```

Listing 6.5: System Architecture Code Example

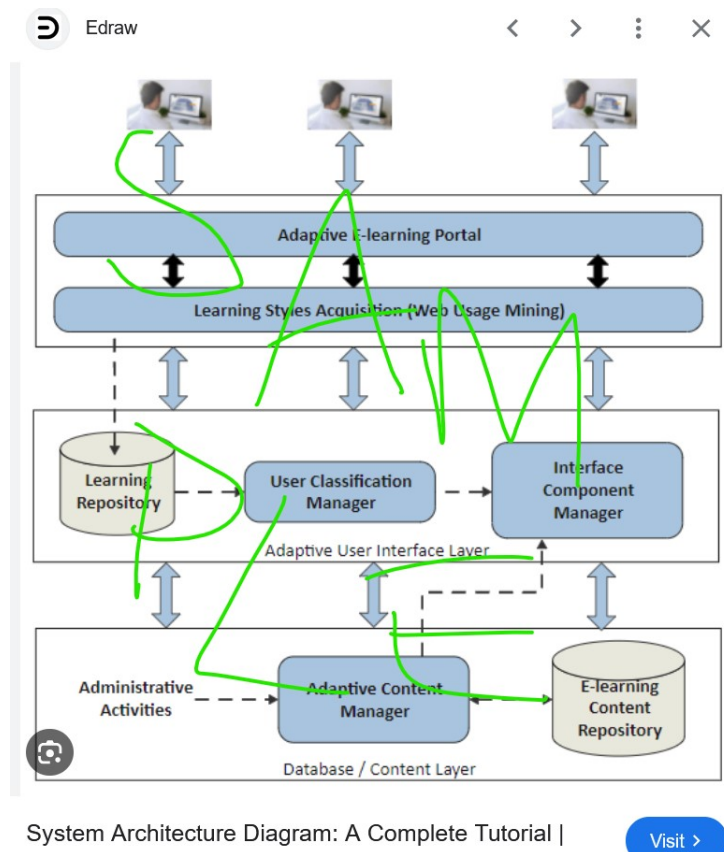


Figure 6.10: System Architecture Diagram

6.6 System Performance Analysis

6.6.1 Operational Constraints Identified

6.6.2 Environmental Factors Impact

```
1 // Environmental test results
2 // Temperature, ambient light, and vibration effects
```

Figure 6.11: Environmental Testing Results

6.6.3 System Stability and Repeatability

6.6.4 Recommendations for Improvement

6.7 Comparative Analysis

This section compares the simulation with the prototype results.

6.7.1 Breadboard vs. Stepboard Results

6.7.2 Iteration Improvements Analysis

6.7.3 Performance Against Design Requirements

The performance ...

6.7.4 Design Evolution Assessment

The what now?

6.8 System Limitations And Considerations

This section discusses the limitations and future work.

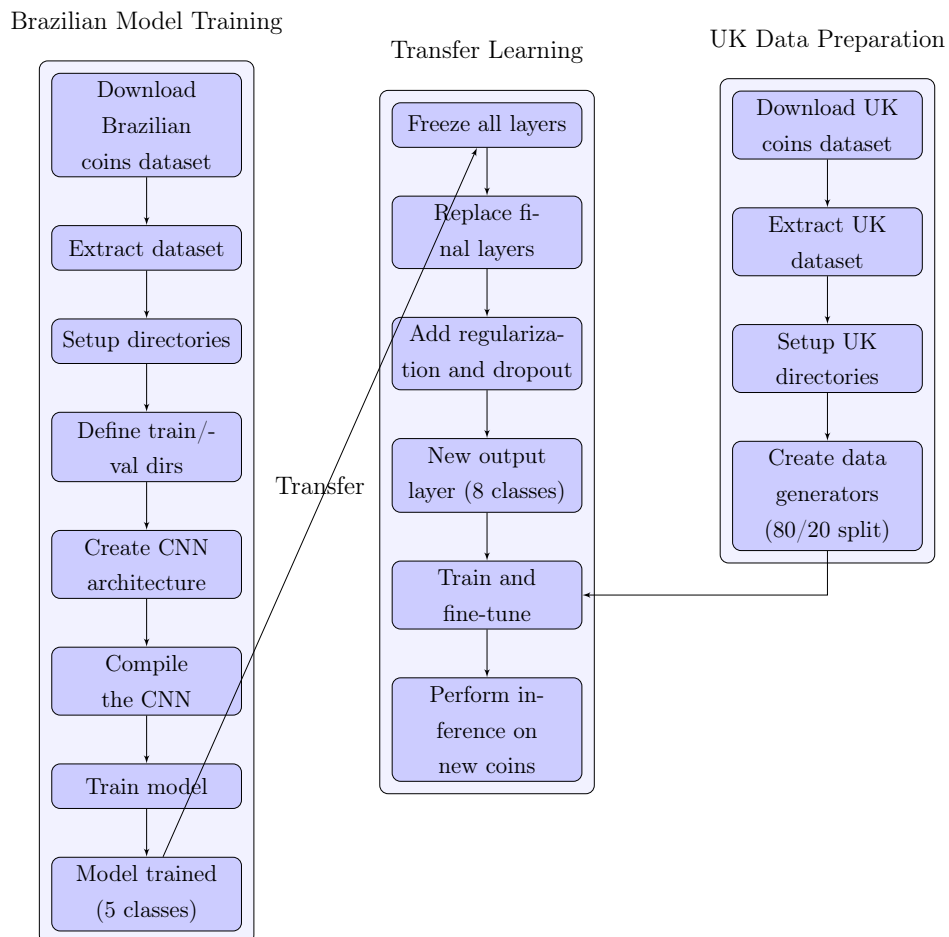


Figure 6.14: System Design Overview Flowchart

6.8.1 Functional Requirements

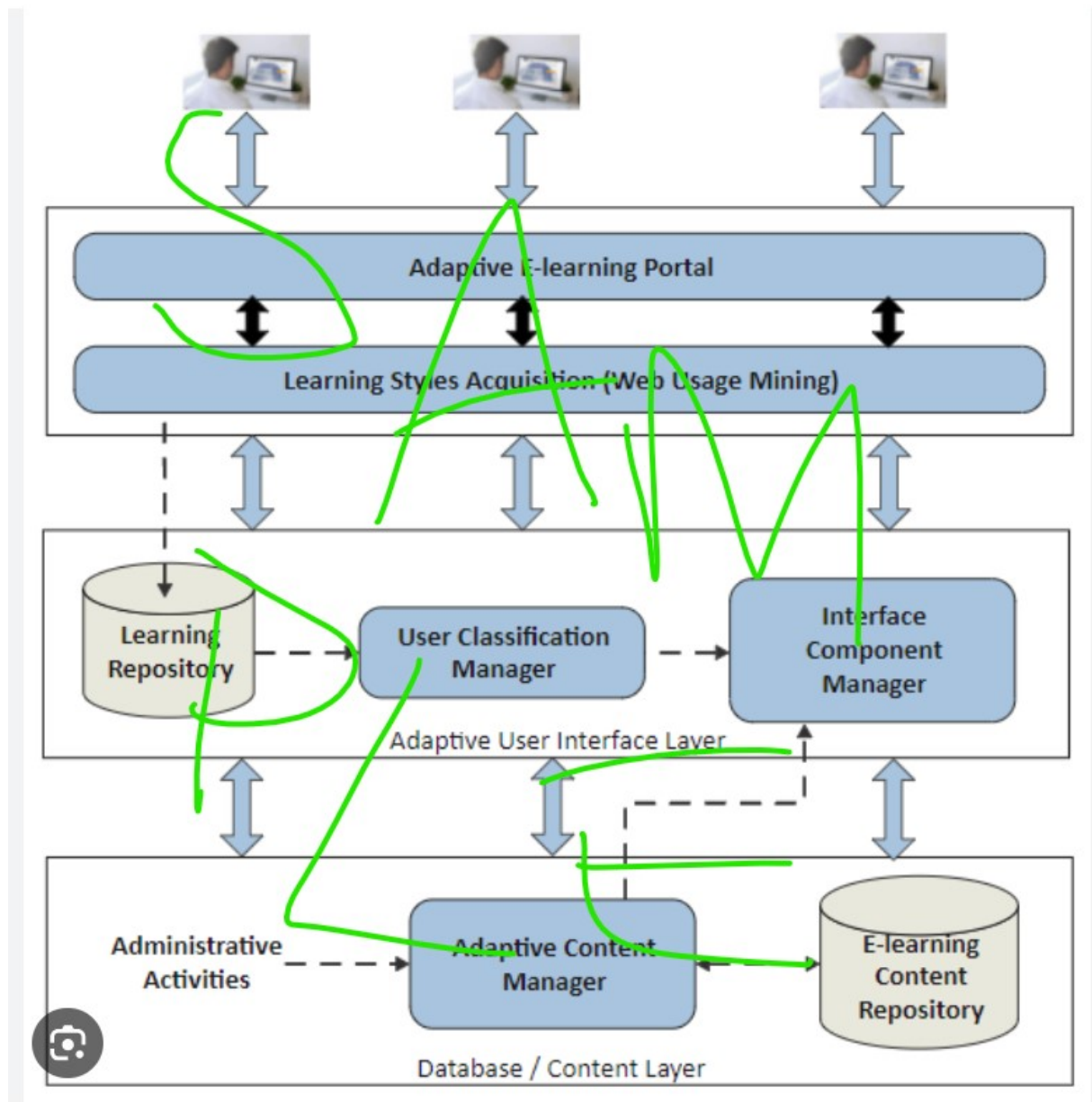
6.8.2 Design Approach

6.8.3 System Architecture

As shown in Figure 6.14 the system architecture consists of various components.

```
1 # Your code here
```

Listing 6.6: System Architecture Code Example



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Figure 6.12: Overall System Performance Analysis

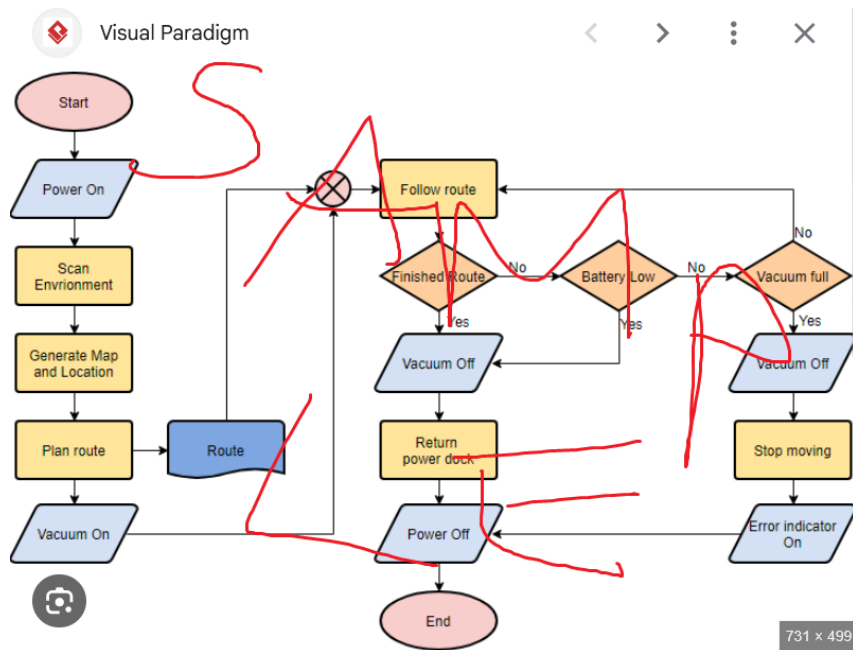
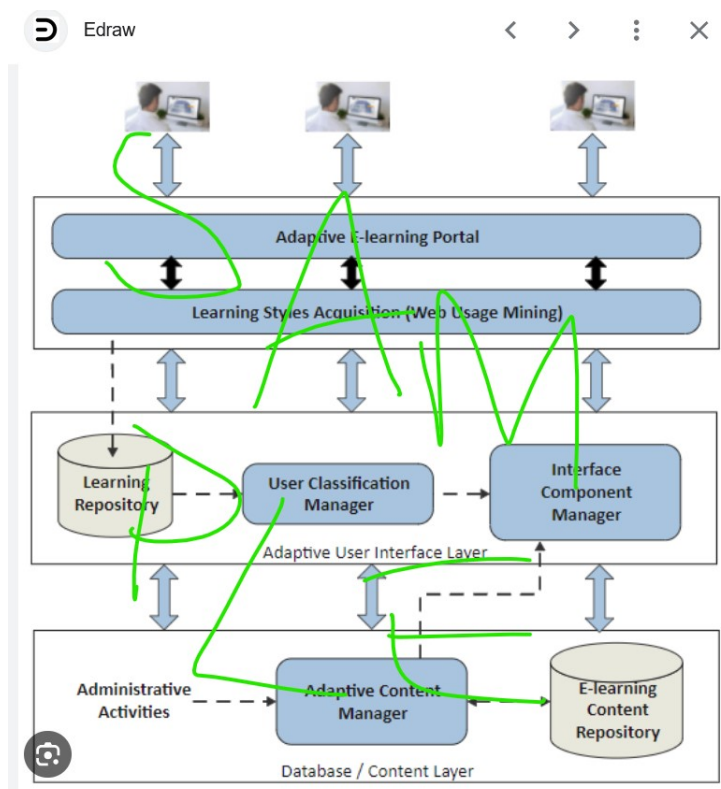


Figure 6.13: Prototype Iteration Comparison



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Figure 6.15: System Architecture Diagram

7. Conclusions

8. FutureWork

Bibliography