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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Abstract

add abstract here

1. Acknowledgements

2. Introduction

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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.

4. Background

5. Methodology

5.1 System Design Overview

This section provides an overview of the System Design Overview.

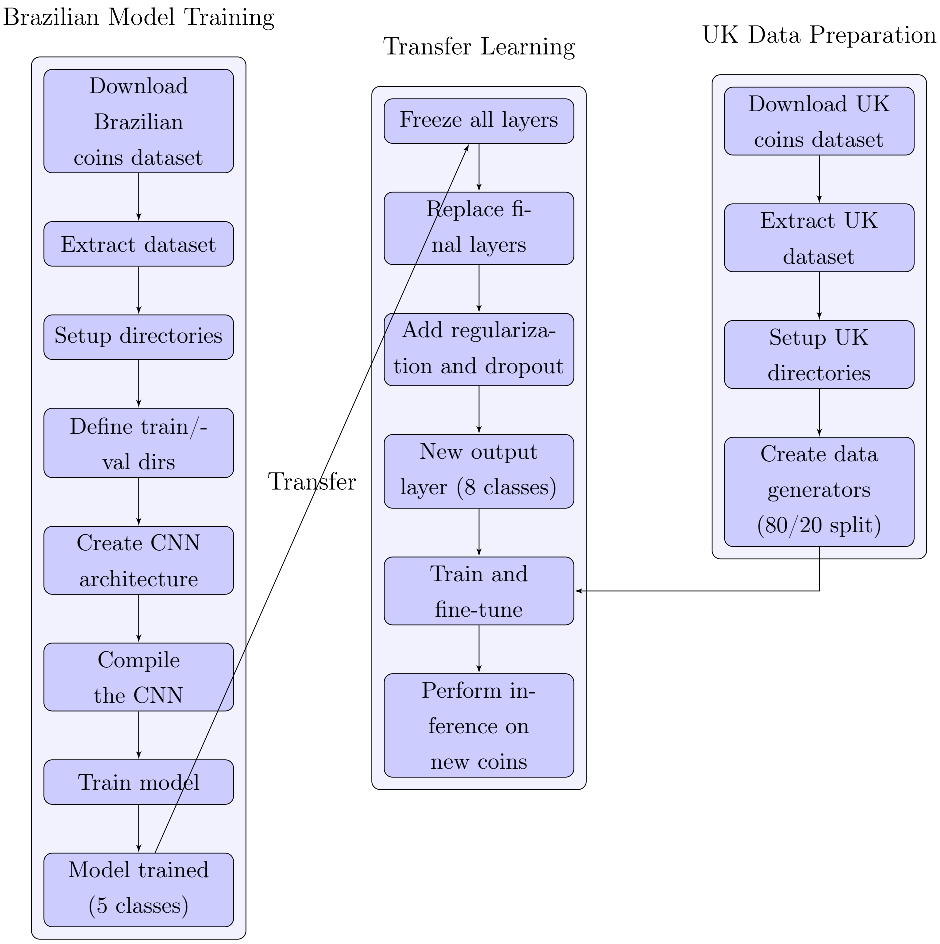

Figure 5.1: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 5.1: System Architecture Code Example

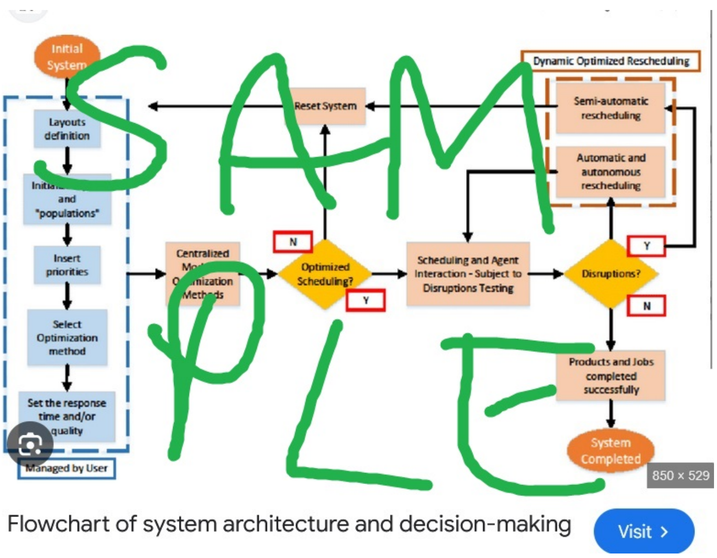

Figure 5.2: System Architecture Diagram

5.2 Sensor Array Development

This section provides an overview of the Sensor Array Development.

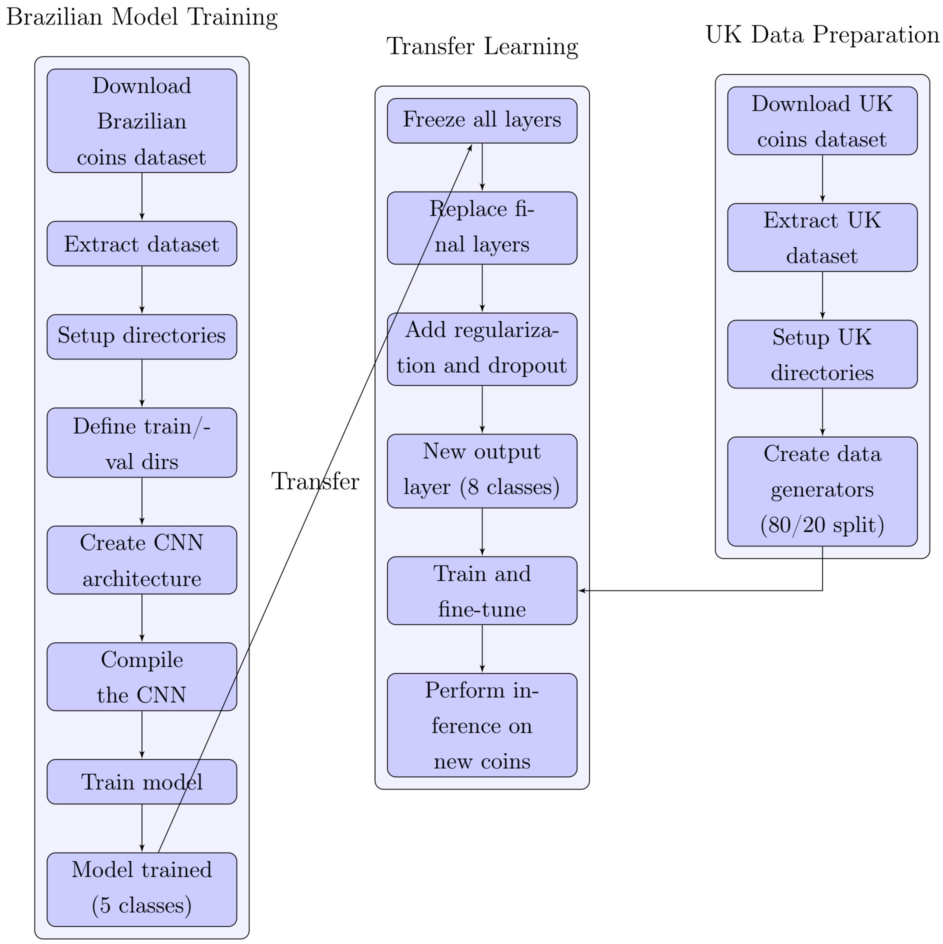

Figure 5.3: System Design Overview Flowchart

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.

```
# 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.

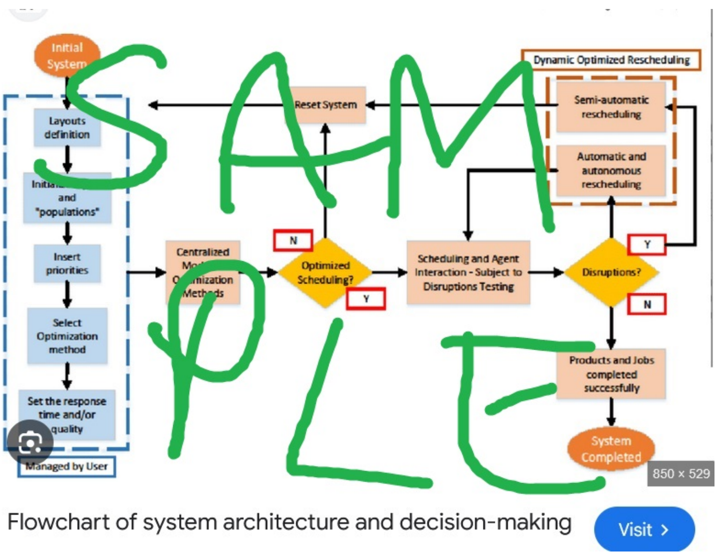

Figure 5.4: System Architecture Diagram

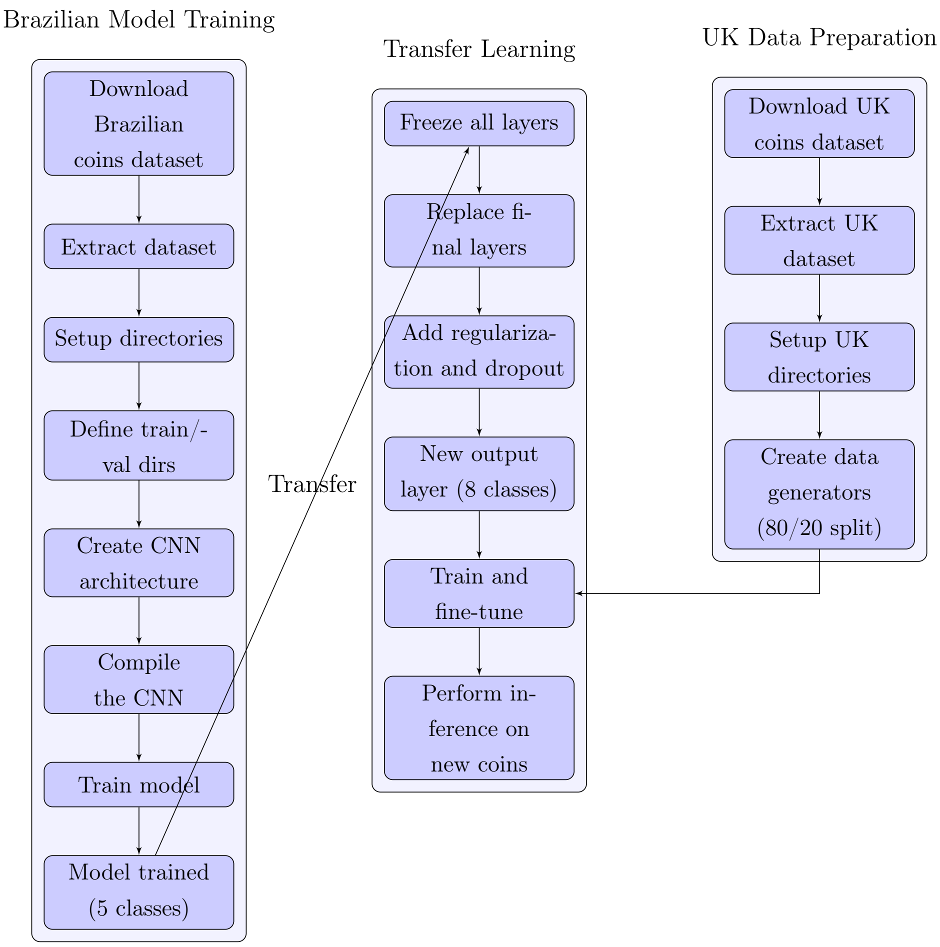

Figure 5.5: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 5.3: System Architecture Code Example

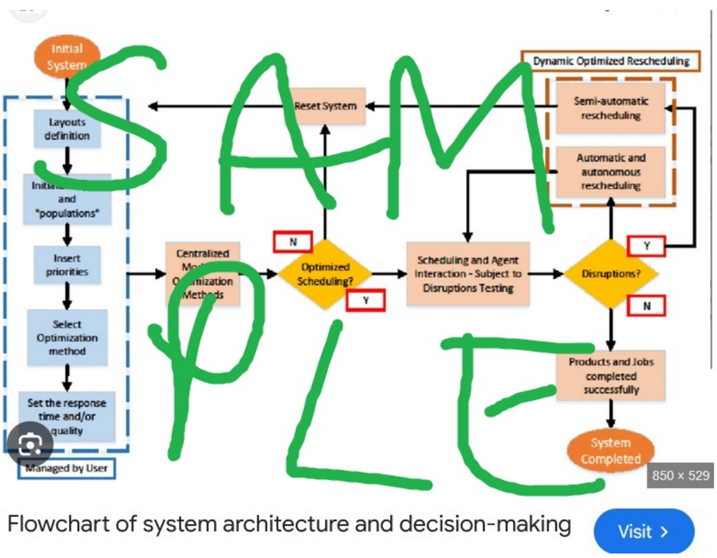

Figure 5.6: System Architecture Diagram

5.4 Enclosure Design And Fabrication

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

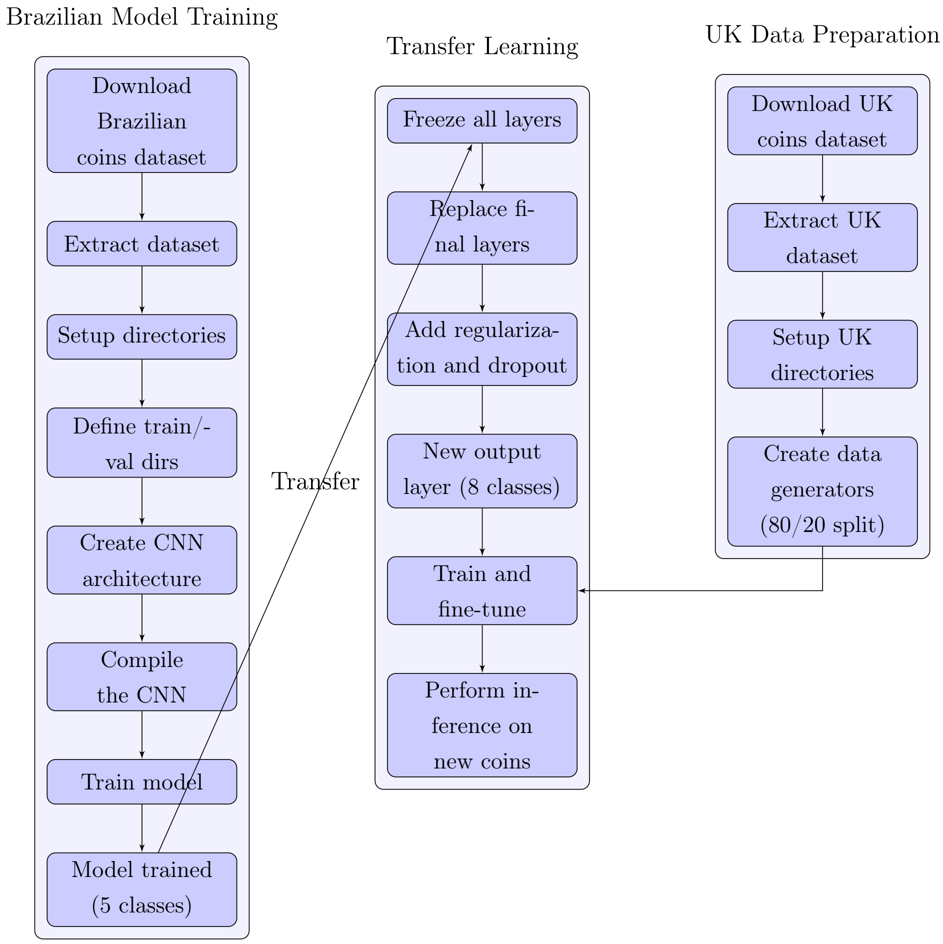

Figure 5.7: System Design Overview Flowchart

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.

```
# 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.

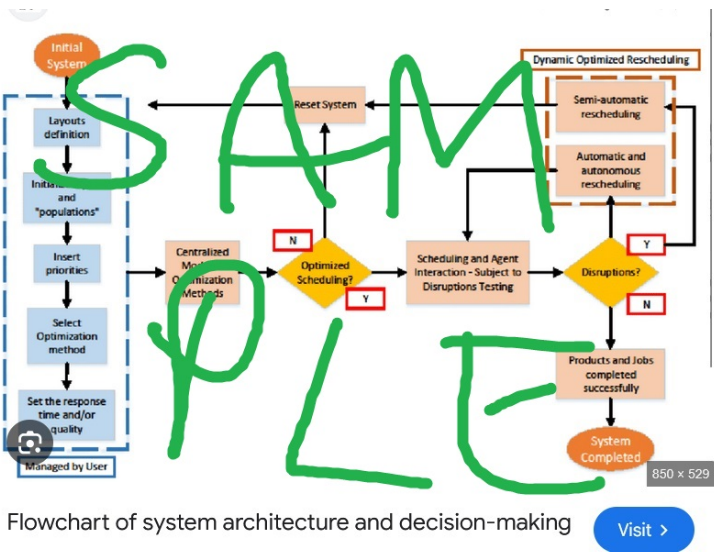

Figure 5.8: System Architecture Diagram

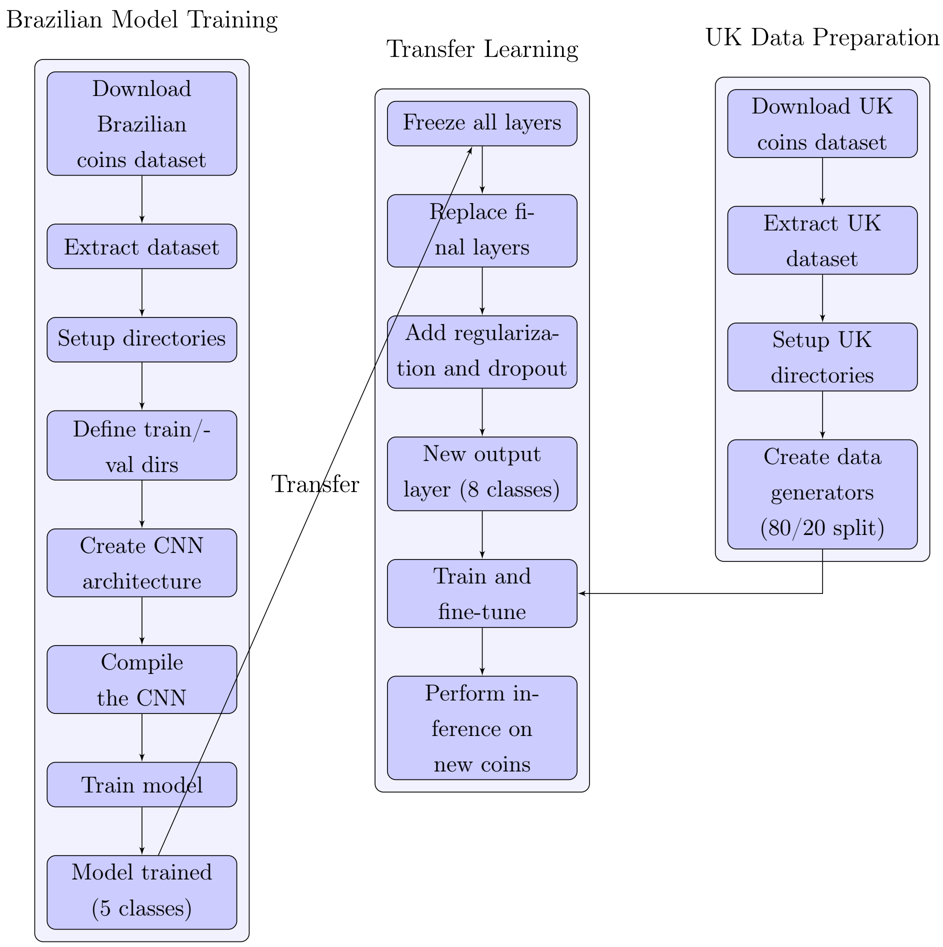

Figure 5.9: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 5.5: System Architecture Code Example

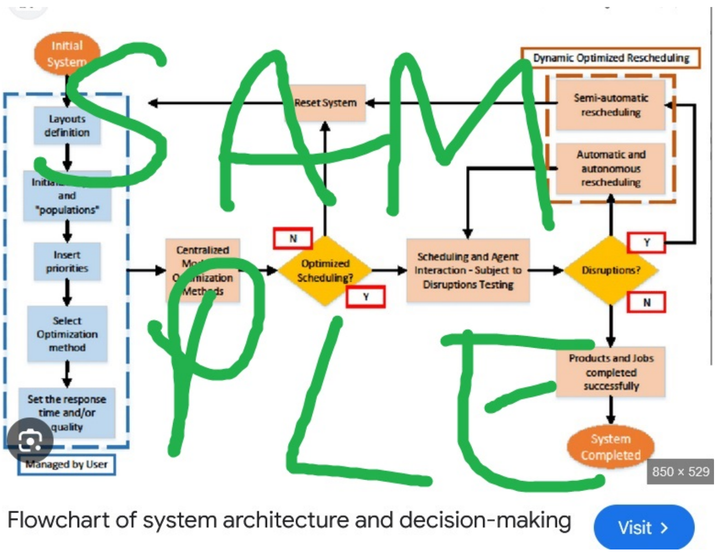

Figure 5.10: System Architecture Diagram

5.6 Testing Apparatus

This section provides an overview of the Testing Apparatus.

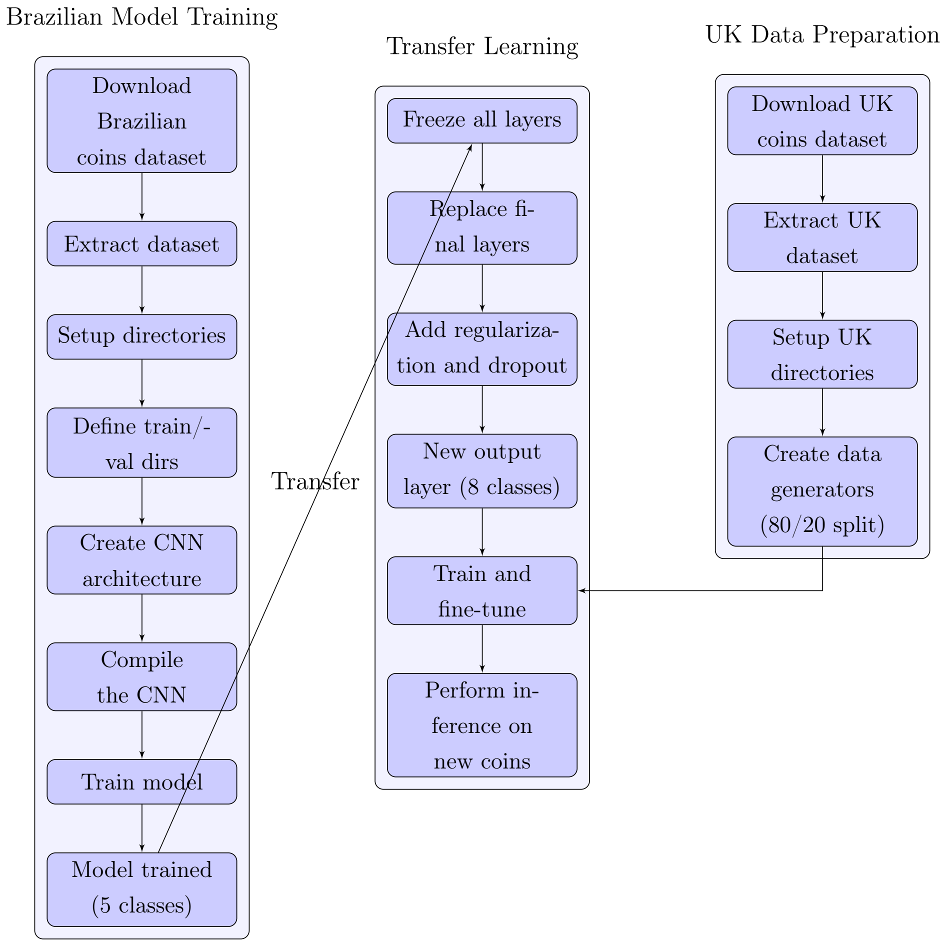

Figure 5.11: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 5.6: System Architecture Code Example

5.7 Prototype Develop ment Lifecycle

This section provides an overview of the Prototype Develop ment Lifecycle.

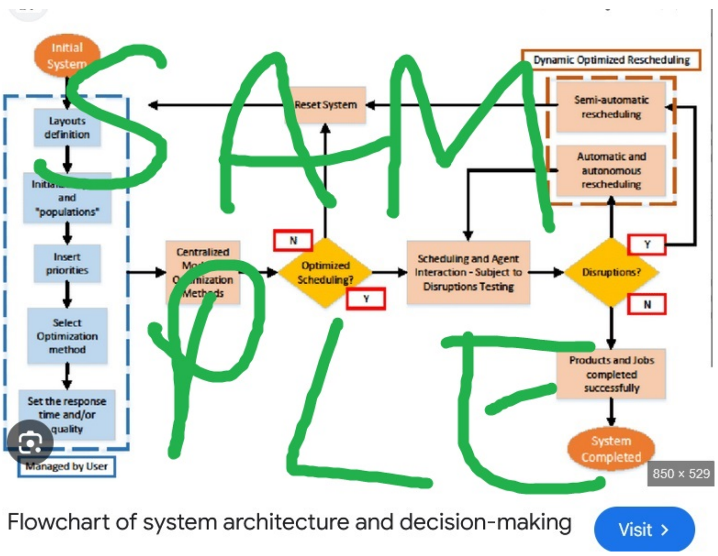

Figure 5.12: System Architecture Diagram

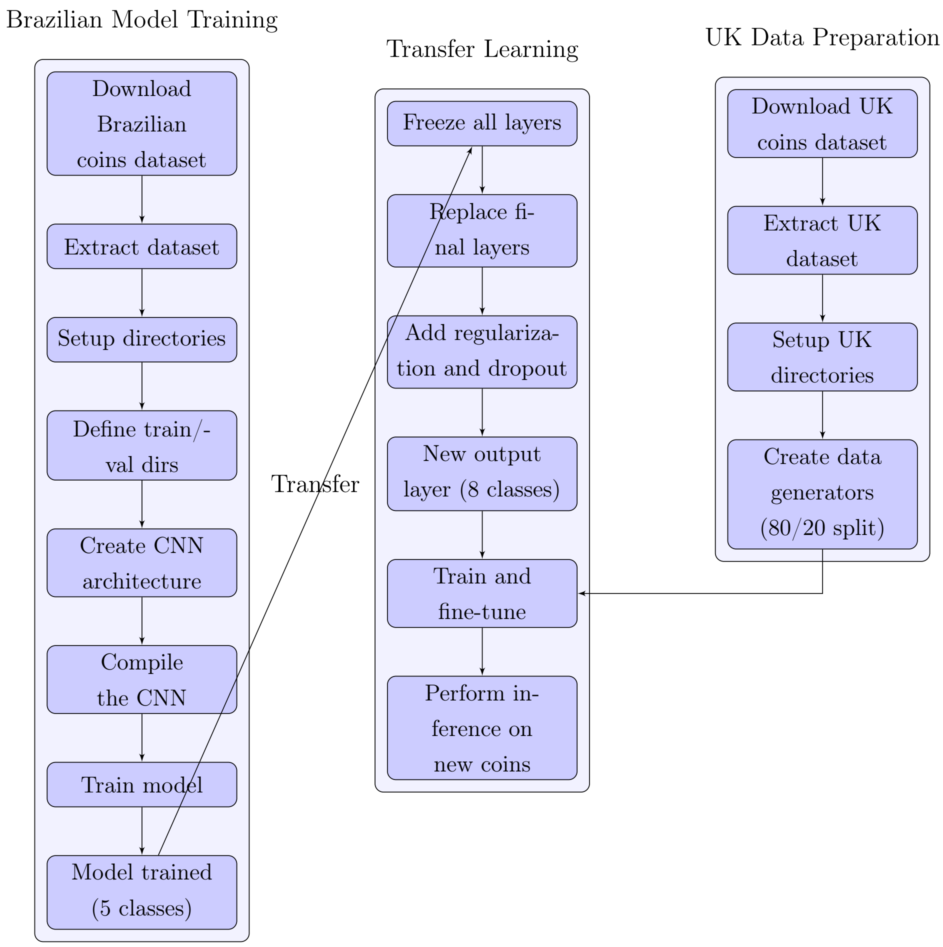

Figure 5.13: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 5.7: System Architecture Code Example

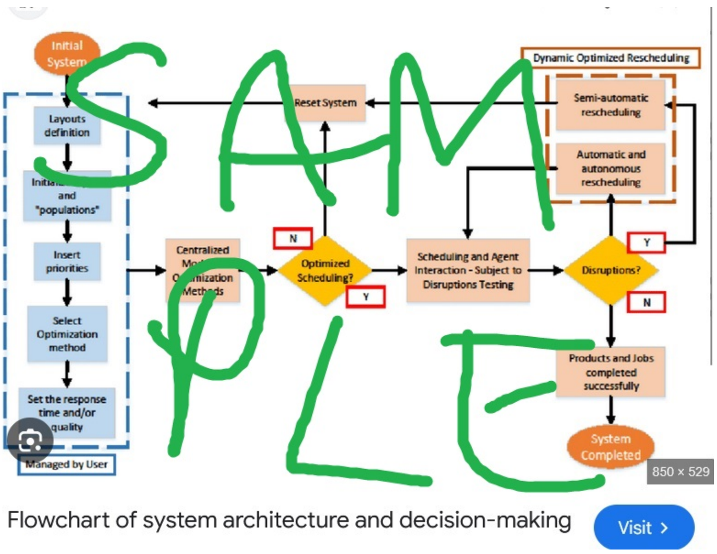

Figure 5.14: System Architecture Diagram

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.

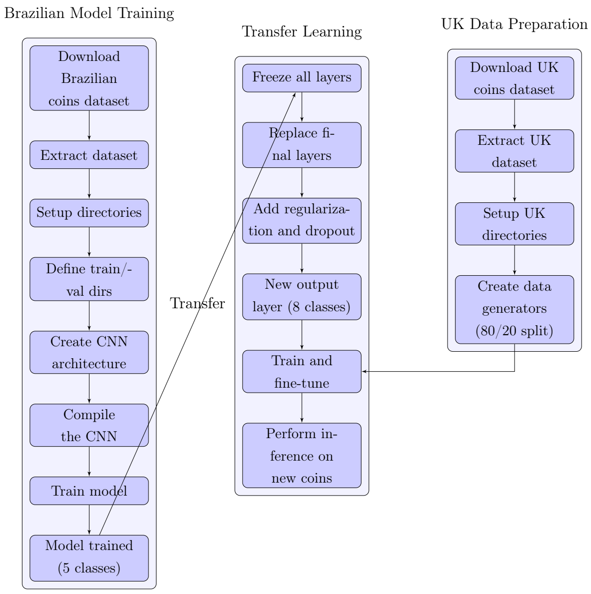

Figure 6.1: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 6.1: System Architecture Code Example

6.2 Amplification Performance

This section provides results of the amplifier performance.

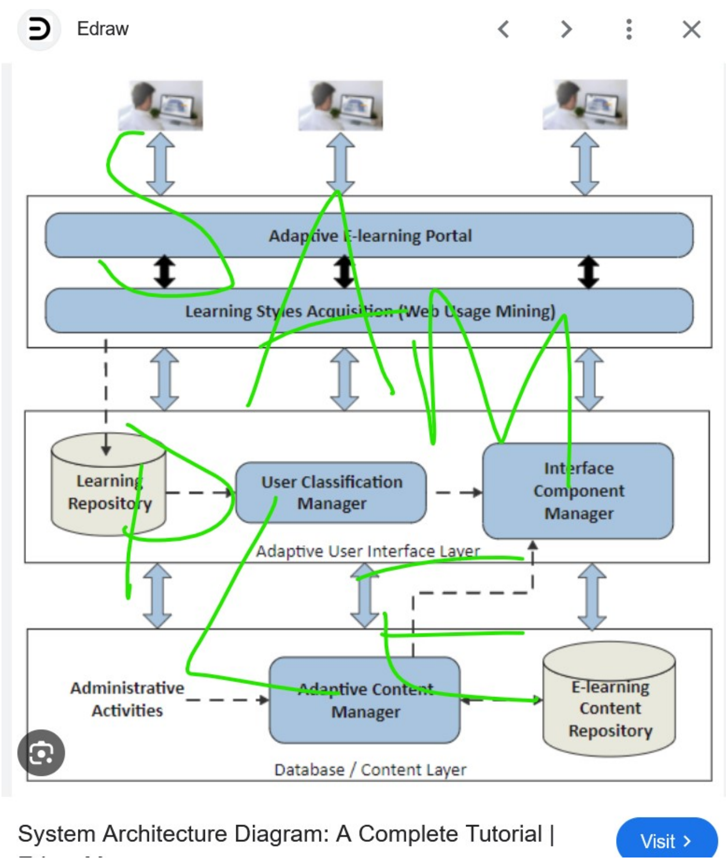

Figure 6.2: System Architecture Diagram

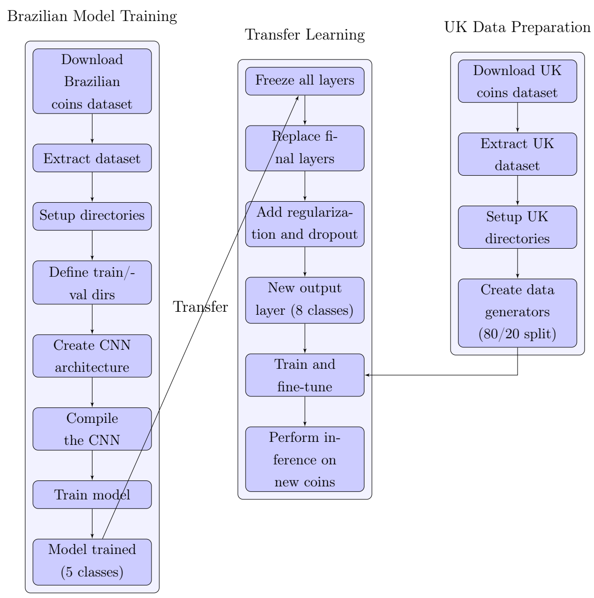

Figure 6.3: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 6.2: System Architecture Code Example

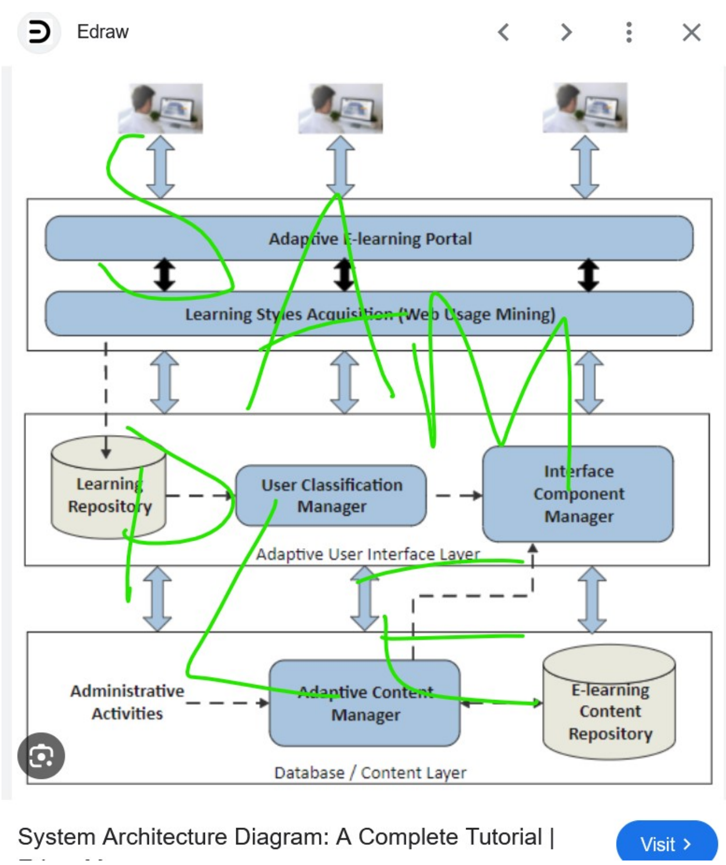

Figure 6.4: System Architecture Diagram

6.3 Photodiode Angular Response

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

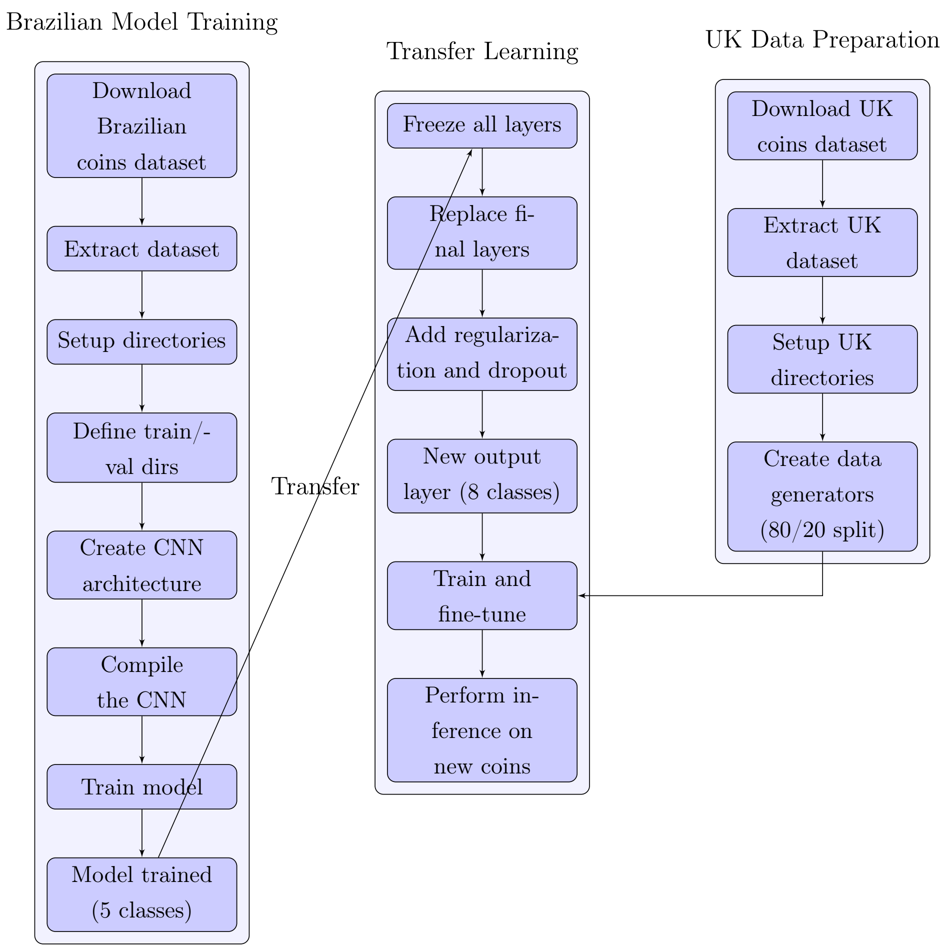

Figure 6.5: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 6.3: System Architecture Code Example

6.4 Enclosure Effectiveness

This section discusses the effectiveness of the Photodiode enlosure.

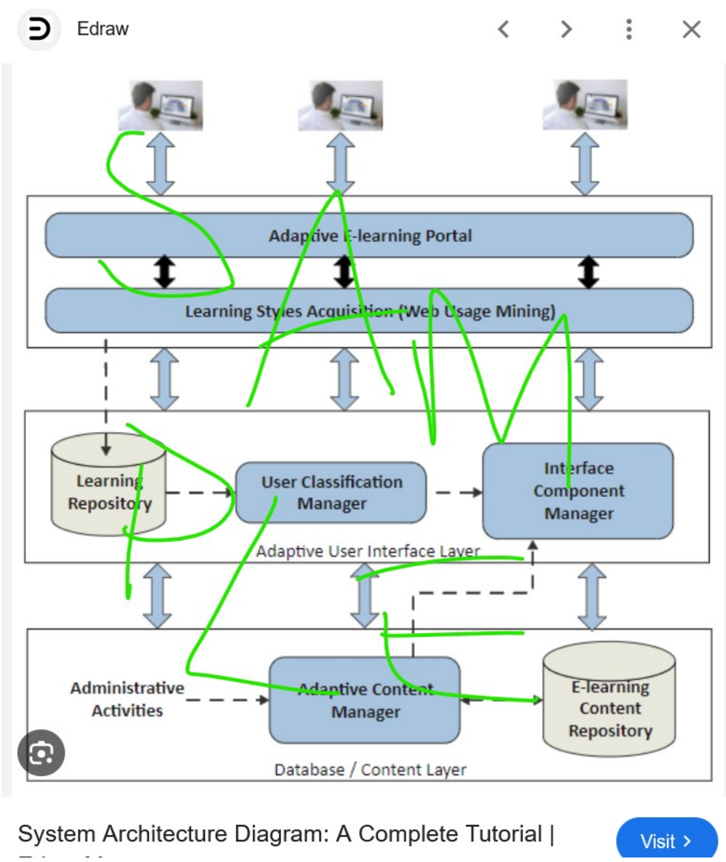

Figure 6.6: System Architecture Diagram

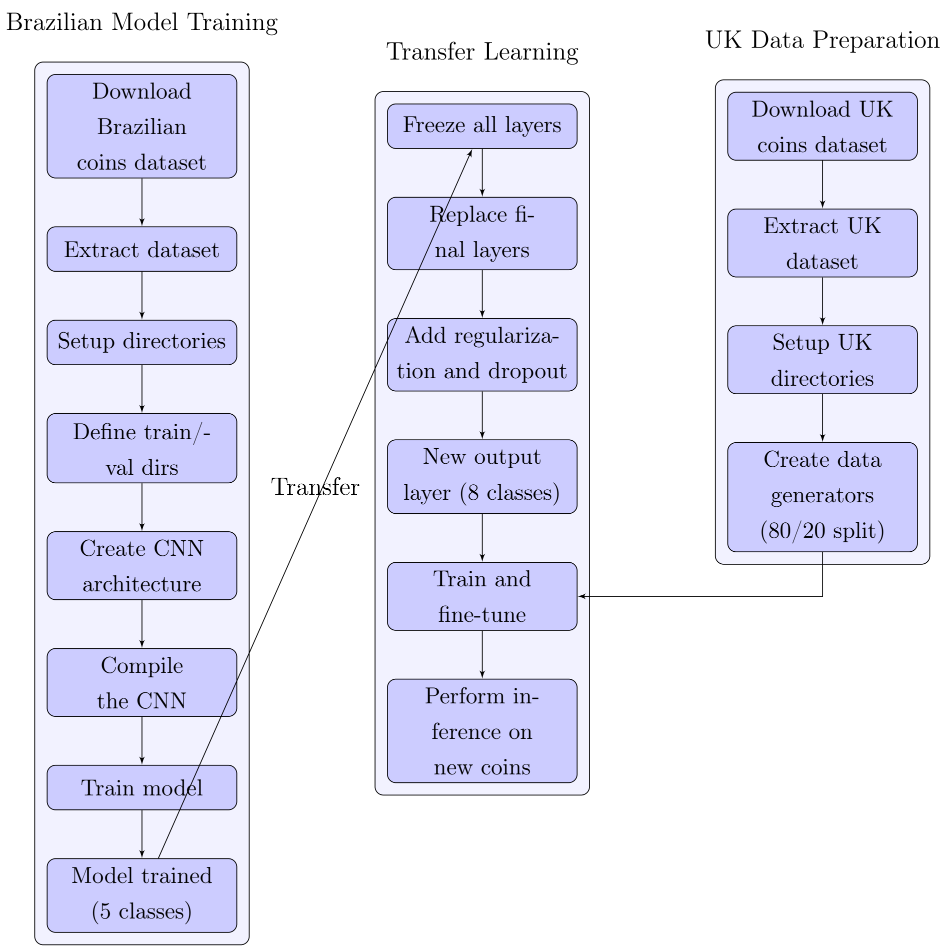

Figure 6.7: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 6.4: System Architecture Code Example

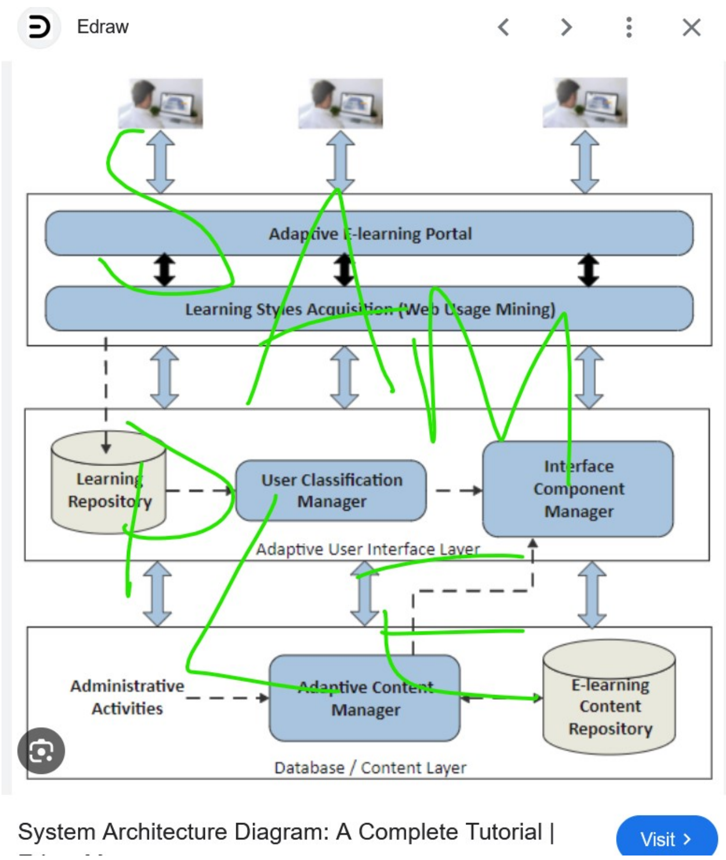

Figure 6.8: System Architecture Diagram

6.5 Data Acquisition System Evaluation

This section provides results related to the Arduino DAQ.

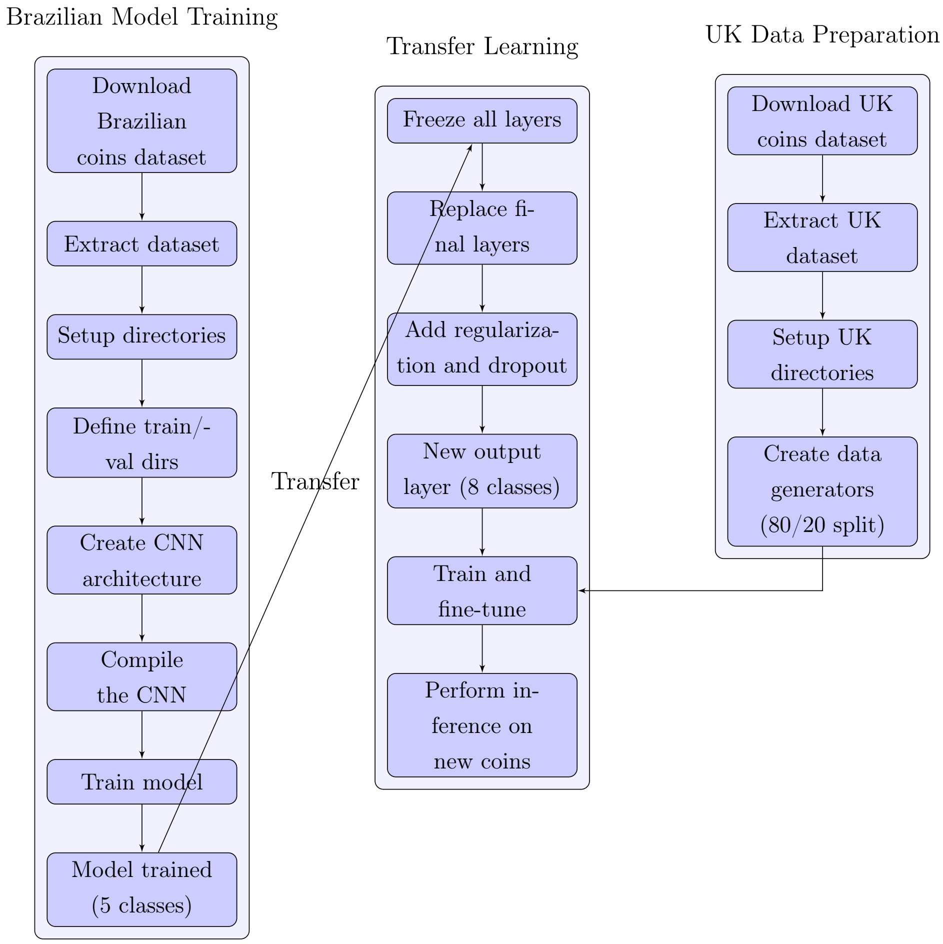

Figure 6.9: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 6.5: System Architecture Code Example

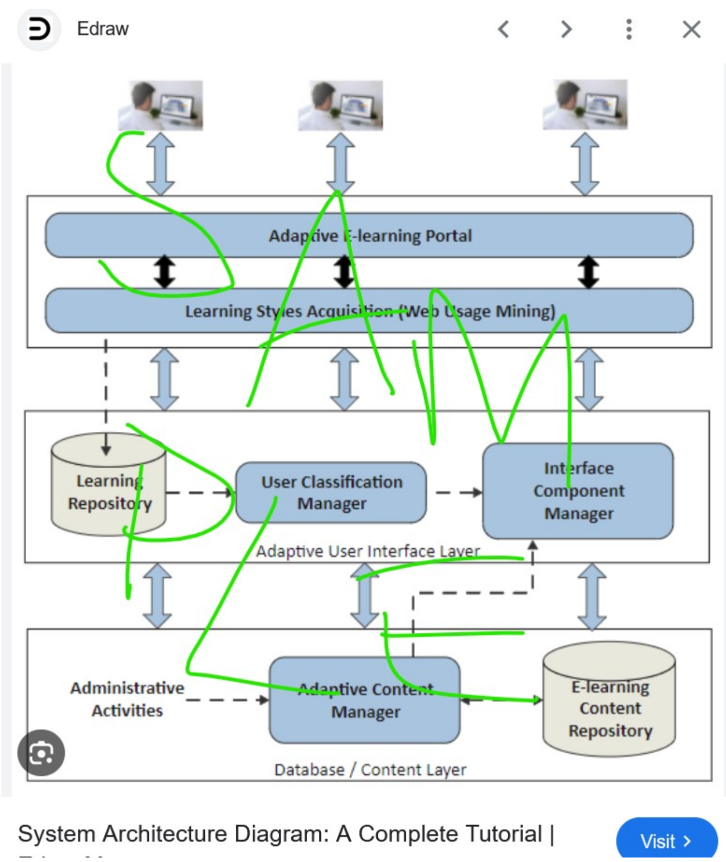

Figure 6.10: System Architecture Diagram

6.6 System Performance Analysis

6.6.1 Operational Constraints Identified

6.6.2 Environmental Factors Impact

```
// Environmental test results
// 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.

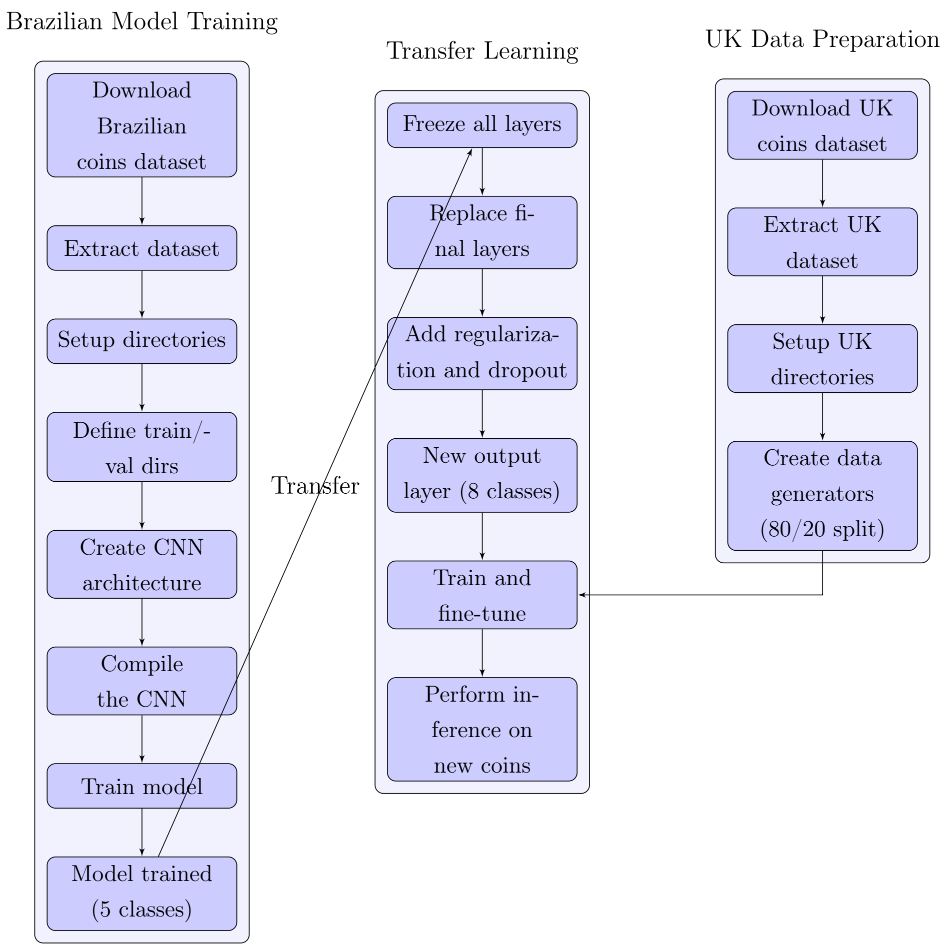

Figure 6.14: System Design Overview Flowchart

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.

```
# Your code here
```

Listing 6.6: System Architecture Code Example

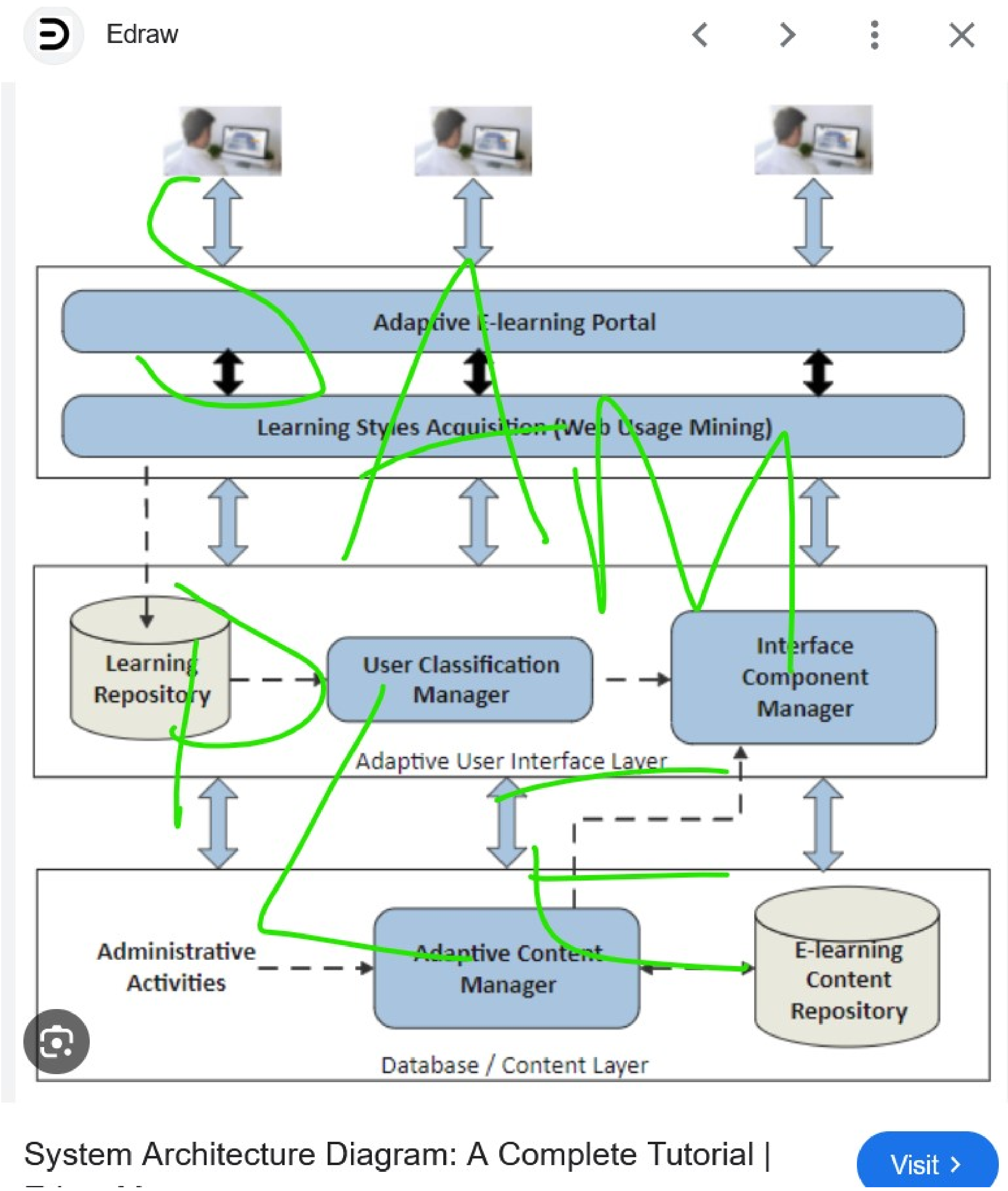

Figure 6.12: Overall System Performance Analysis

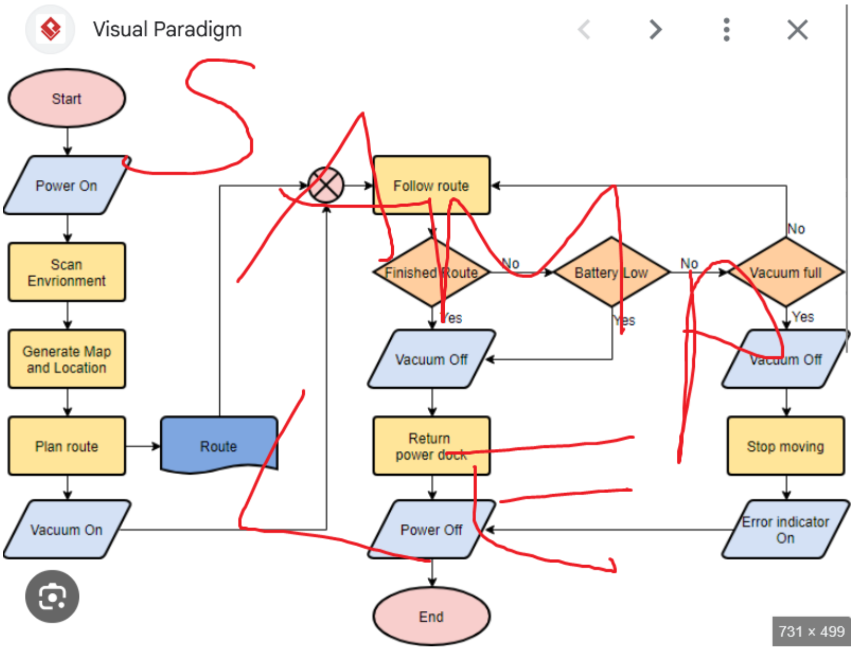

Figure 6.13: Prototype Iteration Comparison

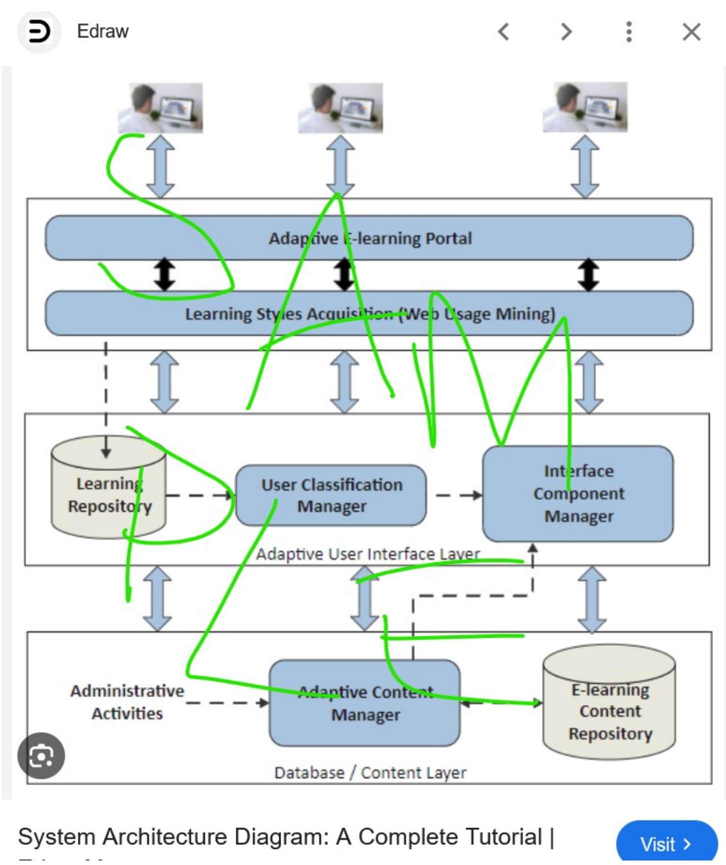

Figure 6.15: System Architecture Diagram

7. Conclusions

8. FutureWork

Bibliography