AI Driven Autonomous Sterring Wheel Using IoT & ML

Submitted in partial fulfillment of the requirementsfor the degree of

BACHELOR OF ENGINEERING

by

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A. P. SHAH INSTITUTE OF TECHNOLOGY

CERTIFICATE

This is to certify that the project entitled **" AI Driven Autonomous Sterring Using IoT & ML "** is a bonafide work of **Sumedh Gadpayle(22106076), Krishna Dongre(22106089), Chavez Anthony(22106038), Ayush Gupta(22106074)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of **Bachelor of Engineering** in **Computer Science & Engineering (Artificial Intelligence & Machine Learning).**

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PROJECT REPORT APPROVAL for B.E.

This project report entitled **"AI Driven Autonomous Sterring Using IoT & ML"** by **"Sumedh Gadpayle (22106076), Krishna Dongre (22106089), Chavez Anthony (22106038), Ayush Gupta (22106074)"** is approved for the degree of ***Bachelor of Engineering*** in ***Computer Science & Engineering (Artificial Intelligence & Machine Learning), 2025-26***.

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DECLARATION

We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

Autonomous vehicle technology represents a major leap in modern transportation, offering the potential for safer, more efficient, and sustainable mobility. However, its adoption is limited by the high cost and complexity of current systems, which often depend on expensive sensors, advanced processors, and proprietary architectures. To address these challenges, this project presents a low-cost autonomous steering control system designed to make self-driving research more accessible to students and small-scale developers. The system employs a Convolutional Neural Network (CNN) to predict steering angles from real-time camera input, which are then physically actuated through an Arduino-controlled stepper motor and steering mechanism. By using affordable components instead of high-end sensors like LiDAR or RADAR, the project demonstrates that reliable autonomous steering can be achieved with minimal hardware investment. This approach not only reduces development costs but also encourages open innovation and experimentation in the field of intelligent transportation. The proposed design serves as a scalable foundation for future enhancements such as braking, acceleration, and object detection, ultimately contributing to the development of more inclusive, sustainable, and cost-efficient autonomous vehicle technologies.

This project aligns with several United Nations Sustainable Development Goals (SDGs). It directly supports SDG 9: Industry, Innovation, and Infrastructure by promoting low-cost and scalable innovation in autonomous vehicle technology, making advanced transportation research accessible to students and small-scale developers. In line with SDG 11: Sustainable Cities and Communities, the project contributes to the development of smart and efficient mobility solutions that can enhance urban transport systems and reduce congestion. Additionally, it addresses SDG 13: Climate Action by emphasizing energy-efficient and eco-friendly design principles, ultimately aiming to lower the carbon footprint of future autonomous mobility systems**.**

Keywords: Autonomous steering, Internet of Things (IoT), Machine Learning (ML), Arduino, Stepper motor, Steering angle prediction, Intelligent vehicles, Low-cost automation.

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ABBREVATION

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Chapter 1

Introduction

Autonomous driving has emerged as one of the most significant applications of artificial intelligence, combining deep learning, computer vision, and embedded systems to replicate human driving capabilities. In this project, the focus is on developing an autonomous steering wheel system that can predict steering angles based on visual input and physically actuate the steering mechanism. The system uses a Convolutional Neural Network (CNN) model trained on video datasets that are converted into individual frames. These frames provide visual road information, and the CNN learns to map them to corresponding steering wheel angles. Once trained, the model can take new video input, process it frame by frame, and predict the required turn direction and steering angle. This approach allows the steering system to mimic human driving behavior by continuously analyzing road conditions and adjusting accordingly.

For hardware implementation, the predicted steering angles are translated into physical motion using an Arduino microcontroller connected to a stepper motor. The stepper motor is coupled with a steering wheel setup, enabling real-time actuation based on the CNN's predictions. This integration of software and hardware bridges the gap between theoretical deep learning models and practical autonomous driving applications. At present, the project concentrates solely on steering, forming the first step toward a larger autonomous vehicle platform. While future enhancements may include braking, acceleration, and object detection, the current work establishes a strong foundation by demonstrating how visual data and machine learning can be used to control steering with accuracy. In summary, this project successfully combines computer vision, CNN-based deep learning, and embedded actuation to create a functional autonomous steering wheel system. By training on video datasets and implementing real-time steering control through Arduino and stepper motor hardware, it provides both a practical demonstration and an experimental framework for further research in autonomous driving technologies.

Chapter 2

LITERATURE SURVEY

2.1 Literature Review

[1] Golluri Ramcharan and Dhunnapothula Raghu, “Arduino based stepper motor speed regulation for robotics applications,” 2024

This paper presents a stepper motor drive using the hybrid two-phase model. The stepper motor changes the pulse signals into angular displacement with some angles. Stepper motors are used to control the speed and are also more reliable for smooth operations. The stepper motor provides constant holding torque with controlled speed ranges from 0 to 6000 range. The closed-loop control technique with park transformation is used to control the speed torque variables in a design range. The simulation and hardware results were discussed in MATLAB\Simulink software. The verified simulation results are motor source voltage, motor source current, motor speed, and torque. The hardware results are also implemented in this paper, the implemented circuit by using Arduino microcontroller.

[2] Dr. Ruchi Pandey, Anand Goswami, Uttam Lal Yadav, and Yogesh Vishwakarma, “Designing and Crafting Stepper Motor Position Control with Arduino Mega 2560,” Feb. 2023, International Journal Of Innovation In Engineering Research and Management)

This paper describes the design of a position-control system for stepper motors using the Arduino Mega 2560 microcontroller. It implements closed-loop control by integrating rotary encoders as feedback devices to precisely monitor and correct motor position errors. The system can independently or synchronously control multiple motors with high resolution, using the Mega’s many I/O and PWM capabilities. The approach aims for smooth rotation under physical constraints and improved accuracy over open-loop systems by reducing step loss or slip.

[3] Amad Narto, Suharto Suharto, and Regga Diko Catur, “The Prototype Electric Steering Gear Based Microcontroller Arduino,” 2023)

This work describes the design and implementation of a demonstrative electric steering gear system using an Arduino-based microcontroller setup. The authors employ a Research & Development methodology to iteratively build and refine a prototype comprising three main modules: the ESP8266 microcontroller, a servo motor for steering actuation, and a Wi-Fi communication module for remote control. Users can adjust steering angle positions via a smartphone interface, with the system responding in real time by moving the steering shaft accordingly. The design is intended as a teaching and demonstration tool, replacing conventional mechanical control levers with smart, networked actuation, and facilitating more precise and convenient control of auxiliary machinery like ship steering systems.

[4] ARM Khairudin, "Design of Stepper Motor Application as Archery Drawer," 2023)

This study presents the design and implementation of an automated archery drawer system utilizing a stepper motor, Arduino microcontroller, and servo motor to simulate the draw and release actions of archery. The system allows users to set the draw length between 12 to 24 cm, with the optimal performance achieved at a 22 cm draw length, resulting in a shooting efficiency of 96.7%. The project aims to provide a practical training tool for archers, enabling them to understand the impact of draw length on arrow power and accuracy, thereby enhancing their skills and reducing the risk of injury associated with prolonged training sessions.

[5] M. S. Mohammed et al., "Low-cost autonomous car level 2: Design and implementation," 2023

Modern cars use autonomous systems to enhance driving, but most conventional vehicles lack Driving Assist Systems (DAS), which are costly and complex to implement due to ECU security. This paper presents an intelligent DAS for real-time steering angle prediction using deep learning (DL) with data collected from real environments. An object detection model warns the driver of obstacles and measures distances. DL outputs feed into an Electronic Power Steering (EPS) system, where the steering angle is measured via a sensor and adjusted automatically. Real-time tests on a 2009 Toyota Corolla using a camera, CAN-BUS messages, and a steering sensor demonstrate effective intelligent steering control and driver assistance.

[6] “Development of Four-Wheel Steering (4WS) with Arduino-Controlled Stepper Motor,” Nov. 2022, International Journal/Conference Paper.

This project aims to develop an alternative to traditional two-wheel steering systems to improve vehicle maneuverability and handling. Conventional steering mechanisms like the Ackerman or Davis systems have limitations in achieving minimal turning radii. To address this, a four-wheel steering (4WS) system is proposed, enabling vehicles to execute turns with a reduced turning radius around their center of gravity. The system incorporates a rack and pinion steering linkage at the rear, controlled by an Arduino Uno microcontroller equipped with a stepper motor. This design allows for enhanced control and maneuverability, particularly in navigating narrow roads or parking spaces. The project provides a comprehensive understanding of 4WS technology, exploring its advantages over traditional systems and its potential impact on the automotive industry.

[7] “Development of Steering Control System for a Small Electric Vehicle,” Nov. 2022, YMER Digital.

This paper presents the development of a steering control system for a small electric vehicle, focusing on the retrofitting of its mechanical steering to an electric power-assisted system. The existing steering mechanism is replaced with a closed-loop stepper motor, specifically a NEMA 23 standard closed-loop stepper motor with a gearbox, controlled via an Arduino microcontroller. The system utilizes onboard 48V DC power to actuate the motor, which is directly coupled to the steering column through specially designed gears. The control algorithm employs the Pure Pursuit path tracking method, with lane data input derived from image processing techniques. The vehicle's performance is evaluated at various speeds (10 km/h, 15 km/h, 20 km/h, and 25 km/h), demonstrating the system's capability to enhance steering precision and assistive control in real-time driving scenarios.

[8] “Electronic Hardware Design of An Autonomous Vehicle,” 2020, IJERT.

This paper presents the design of electronic hardware for an autonomous vehicle capable of real-time decision-making without human intervention. The system integrates sensors to capture environmental data, which is processed using algorithms involving machine learning, artificial intelligence, neural networks, and image processing. The processed data informs the steering, braking, and acceleration mechanisms, enabling the vehicle to navigate safely and efficiently. The proposed hardware aims to enhance the reliability and safety of autonomous vehicles by providing accurate outputs in real-time applications.

[9] A. Rossi, N. Ahmed, S. Salehin, T. Hasnine Choudhury, and G. Sarowar, "Real-time Lane Detection and Motion Planning in Raspberry Pi and Arduino for an Autonomous Vehicle Prototype," Sep. 20, 2020

This paper presents an autonomous vehicle prototype capable of lane detection and motion planning without human intervention. The system utilizes a Pi Camera 1.3 to capture real-time video, which is processed by a Raspberry Pi 3.0 Model B using Python 3.7.4 and OpenCV 4.2. Lane detection is achieved through the Canny edge detection algorithm and Hough transformation, while lane tracking employs the Kalman filter prediction method. The Arduino Uno controls the motor via a PID algorithm, adjusting steering based on the detected lane's midpoint. The steering direction is further refined using the Past Accumulation Average Method and Kalman Filter Prediction Method. Real-time testing in a controlled environment demonstrates the system's effectiveness in lane detection and autonomous motion planning.

[10] R. Thrun et al., "Stanley: The Robot that Won the DARPA Grand Challenge," 2006, Journal of Field Robotics.

This paper details the development and performance of Stanley, an autonomous vehicle that won the 2005 DARPA Grand Challenge by completing a 132-mile desert course in under seven hours. Developed by the Stanford Racing Team, Stanley was equipped with a suite of sensors, including LIDAR, radar, GPS, and cameras, to perceive its environment. Its software architecture integrated machine learning and probabilistic reasoning to enable real-time decision-making and navigation. The vehicle's success demonstrated the viability of autonomous driving technologies in complex, unstructured environments. Stanley's performance marked a significant milestone in robotics and paved the way for advancements in autonomous vehicle research.

Year	Title	Domain	Algorithm	Dataset	Gap
2024	Arduino based stepper motor speed regulation for robotics applications (Ramcharan & Raghu)	Robotics / Motor control / Power electronics	Closed-loop control using Park Transformation with hybrid two-phase model; simulation in MATLAB/Simulink + hardware with Arduino.	Experimental & simulation data: motor source voltage, current, speed, torque; hardware implementation. Speed range: 0 to ~6000 (units presumably pulses or rpm)	Possibly limited: didn't compare with other advanced control methods (e.g. adaptive, fuzzy, neural). Also speed highest of 6000; behavior at very high speed or under load variation maybe not tested.
2023	Designing and Crafting Stepper Motor Position Control with Arduino Mega 2560	Robotics / Position control / Embedded Control	Position control using Arduino Mega 2560 + Rotary Encoder feedback; likely closed-loop control.	Experimental: synchronous control of two stepper motors; using position feedback via encoder; testing for accuracy in position control.	probably limited to simple position control (no load disturbance analysis, speed-vs-accuracy trade-offs maybe not explored). Also, likely no large dataset; only "real requirements" as per specific hardware, no comparative benchmarks. May lack robustness to change in load or external disturbances.
2023	The Prototype Electric Steering Gear Based Microcontroller Arduino	Remote / auxiliary steering gear demo; maritime ships auxiliary machinery control	Research & Development procedural model; uses ESP8266 module for WiFi, Servo Motor for steering direction/angle; control via smartphone app; microcontroller logic.	Hardware prototype: stepper motor + driver; experimental motion of archery drawer; no standardized dataset; measurements are likely mechanical movement, angle, perhaps tension.	algorithmic detail lacking; no feedback control or closed-loop; performance under real archery loads, durability, safety not explored; precision, repeatability under load or over many cycles not well documented.

2023	Low-cost autonomous car level 2: Design and implementation	Autonomous vehicles / driver assistance / automation	Probably uses sensor fusion, planning & control methods; but specific algorithm details not found in summary. Could include vision, steering control, path planning.	Experimental prototype; sensors, hardware; no public large dataset info; likely own collected test trials.	Level-2 autonomy is partial; likely limited test environments; generalization to varied roads/weather not established; reliability / safety not deeply validated.
2022 / 2023	Development of Four-Wheel Steering (4WS) with Arduino-Controlled Stepper Motor	Vehicle steering systems / robotics / embedded control	Use of stepper motors to achieve four-wheel steering; Arduino for control; details of steering angle mapping etc.	Prototype hardware, controlled experiments/bench-tests: steering behaviour etc; no public large dataset.	response under load, speed, dynamic handling not necessarily explored; performance limits under varying speeds or turning radii; no comparison to conventional 4WS systems.
2022	Development of Steering Control System for a Small Electric Vehicle	EV control / steering systems	Likely geometry-based / feedback control of steering; possibly PID or simpler control laws.	Hardware setup; small EV; experimental testing; again not large benchmark dataset.	real-world road conditions, robustness; high-speed or safety scenarios may be missing; detailed control algorithm maybe simplistic.

Chapter 3

Limitations of Existing System

Existing autonomous steering systems face several significant challenges that hinder their adoption, particularly in educational and research settings. One of the primary limitations is the **high cost of implementation**, as most systems rely on expensive components such as LiDAR sensors, high-resolution cameras, and specialized computing hardware. This makes them unaffordable for students, small research groups, and hobbyists who wish to explore autonomous navigation technologies. Moreover, these systems often involve **complex hardware integration**, requiring multiple sensors, microcontrollers, and control units to be connected and calibrated accurately. Such complexity increases setup time, maintenance effort, and the likelihood of system malfunction. Another major drawback is the **limited accessibility of commercial systems**, which are typically closed-source or proprietary, restricting opportunities for experimentation, customization, and innovation in academic environments.

Additionally, most high-end autonomous systems are designed to operate efficiently on powerful GPUs or embedded processors, while **low-cost setups struggle with real-time processing and accurate steering predictions**, thereby limiting their practical usability. The **AI models** used in these systems also face challenges such as **overfitting and poor generalization**, performing well only within the confines of their training data and failing under diverse real-world conditions involving varying lighting, road surfaces, or obstacles. Furthermore, many existing solutions depend on a **single type of input data**, such as camera feeds, without incorporating multi-sensor fusion, which reduces their robustness under adverse environmental conditions like rain, glare, or shadows. Finally, **safety and reliability concerns** remain a critical limitation, as these systems often produce inconsistent results in dynamic or unpredictable environments, posing risks to both the vehicle and its surroundings.

Collectively, these challenges emphasize the urgent need for a **cost-effective, modular, and IoT-integrated AI-driven autonomous steering system** that can function efficiently on low-cost hardware while maintaining real-time responsiveness, adaptability, and operational safety.

Chapter 4

Problem Statement, Objective and Scope

4.1 Problem Statement

As autonomous vehicles move closer to mainstream adoption, steering control remains one of the most critical components of self-driving technology. Accurate and responsive steering is essential for lane-keeping, obstacle avoidance, and overall vehicle stability, directly influencing passenger safety and driving efficiency. However, developing reliable autonomous steering systems often requires costly sensors, complex algorithms, and high-performance hardware, limiting access for students and small-scale innovators. This lack of affordability and openness in current research platforms creates a barrier to experimentation, learning, and innovation.

To address this gap, this project focuses on building a low-cost autonomous steering control system using Convolutional Neural Networks (CNNs) and embedded hardware to predict and actuate steering angles in real time. By simplifying hardware requirements and emphasizing practical implementation, the project aims to make autonomous steering development more accessible, educational, and scalable, laying the groundwork for future advancements in full self-driving systems.

4.2 Objective

Low-Cost Autonomous Steering System

The primary objective of this project is to design and implement a low-cost autonomous steering control system that integrates deep learning, computer vision, and embedded hardware to mimic human driving behavior. The system aims to demonstrate how artificial intelligence can be effectively combined with IoT components to achieve real-time vehicle control without relying on expensive sensors or proprietary systems.

CNN-Based Steering Angle Prediction

A key goal is to train a Convolutional Neural Network (CNN) using video datasets converted into image frames, enabling the model to analyze road visuals and accurately predict steering angles. This allows the system to interpret real-world driving conditions and make autonomous steering decisions similar to human drivers.

Hardware Integration and Control

The project further focuses on translating CNN predictions into physical steering actions through an Arduino-controlled stepper motor connected to a steering wheel mechanism. This integration bridges the gap between software-based predictions and mechanical movement, ensuring smooth and responsive steering control.

Accuracy and Performance Optimization

To enhance system reliability, the project incorporates speed control and noise filtering mechanisms, ensuring accurate, stable, and smooth steering performance under varying conditions. These improvements contribute to the precision and safety of the autonomous control process.

Scalability and Future Expansion

The final objective is to develop a modular and scalable platform that can be extended to include additional functionalities such as accelerator and brake control, lane-keeping assistance, and obstacle detection. This ensures that the system serves as a robust foundation for further research and educational applications in autonomous driving technology..

4.3 Scope

Target Users

The AI-Driven Autonomous Steering Control System is primarily designed for students, researchers, and educators in the fields of Artificial Intelligence, Machine Learning, and Robotics. It provides an affordable and accessible platform for learning and experimentation in autonomous vehicle technology, encouraging innovation without the need for expensive hardware.

Functional Capabilities

The system utilizes a Convolutional Neural Network (CNN) trained on driving video datasets to analyze road visuals and predict steering angles in real time. These predictions are then executed through an Arduino-controlled stepper motor connected to a steering wheel, demonstrating the effective integration of deep learning with embedded hardware for practical steering automation.

System Architecture

The architecture combines computer vision, deep learning, and IoT-based control mechanisms to achieve smooth and responsive steering performance. The CNN processes video input, while the Arduino interprets and actuates the corresponding steering actions. Features such as speed control and noise filtering enhance accuracy and stability.

Scalability and Future Enhancements

Designed for modularity and scalability, the system can be extended to include accelerator and brake control, lane-keeping assistance, and obstacle detection. This flexibility makes it a strong foundation for future research and educational projects in autonomous driving and AI-based control systems.

Chapter 5

Proposed System

5.1 Architecture Diagram Autonomous Driving System

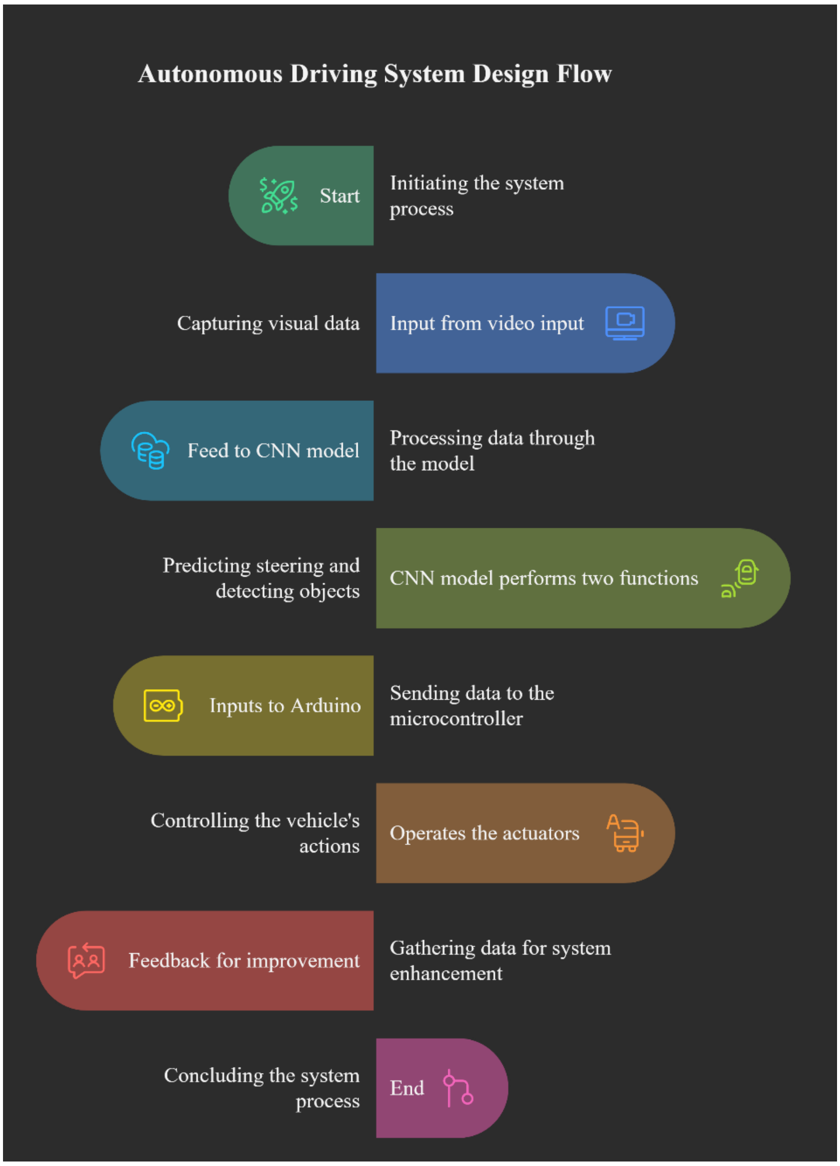


Figure 5.1 Architecture Diagram for AI Driven Autonomous Sterring Using IoT & ML

This diagram shows the Autonomous Driving System Design Flow, where video input is captured and processed using a CNN model to detect objects and predict steering. The results are sent to an Arduino to control vehicle actions, and feedback is gathered to improve the system before concluding the process.

5.2 Data Flow Diagrams:

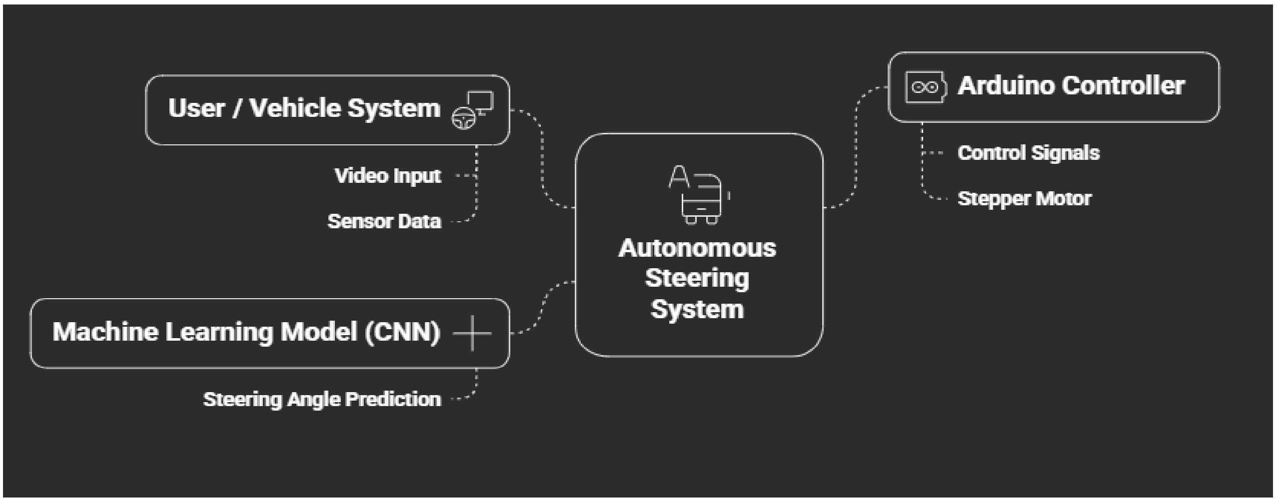


Figure 5.2.1 Level 0 DFD (Context Diagram) of AI-Driven Autonomous Steering System

This diagram (fig 5.2.1) illustrates the Autonomous Steering System, where video input from the vehicle is processed by a CNN model to predict the steering angle. The predicted angle is sent to an Arduino controller, which generates control signals to operate the stepper motor for steering control.

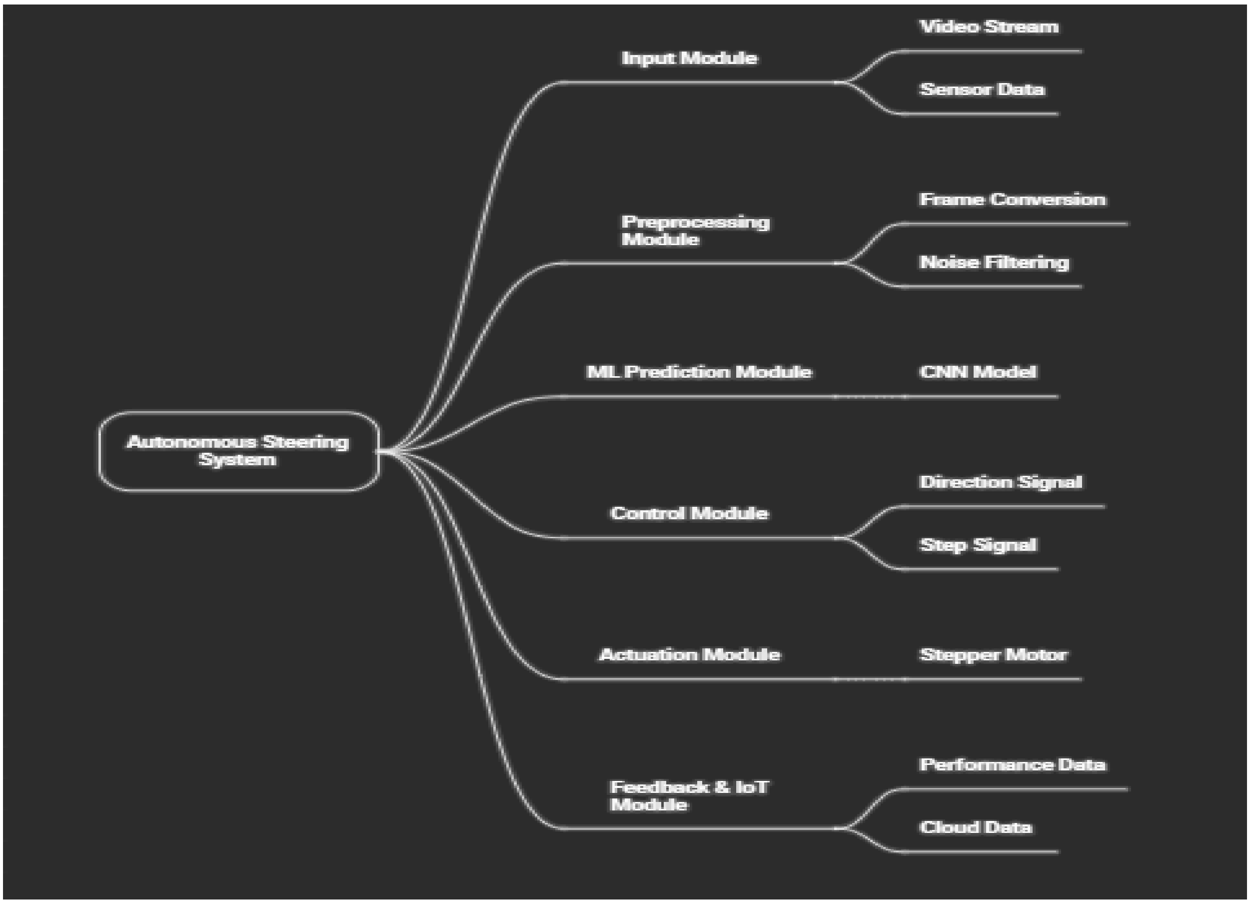


Figure 5.2.2 Level 1 DFD (Context Diagram) of AI-Driven Autonomous Steering

This diagram (fig 5.2.2) represents the detailed flow of the Autonomous Steering System, where the video input is processed through multiple modules. The Input Module captures video frames, the Preprocessing Module filters and converts frames, and the ML Prediction Module (CNN) predicts the steering direction. The Control Module generates direction and step signals, which are sent to the Actuation Module operating the stepper motor. Finally, the Feedback & IoT Module collects performance data for continuous improvement.

5.3 Use Case Diagram:

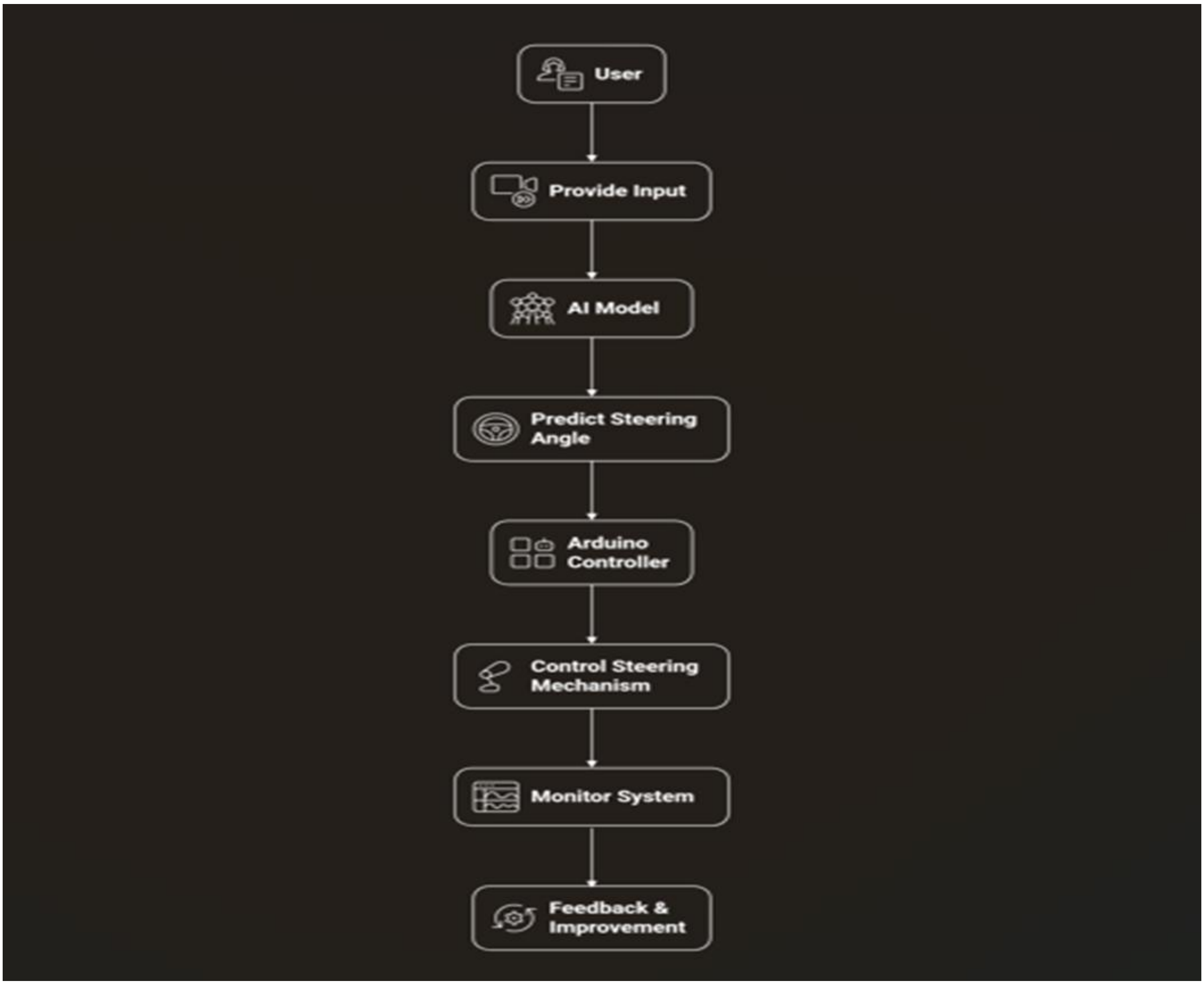


Figure 5.3 Use Case Diagram of AI-Driven Autonomous Steering Wheel Using IoT and Machine Learning

This diagram (fig 5.3) illustrates how the user interacts with the autonomous steering system. The user provides video input, which is processed by the AI model to predict the steering angle. The Arduino controller executes the predicted movement through the steering mechanism, and the system continuously monitors its performance for accurate control.

5.4 Sequence Diagram:

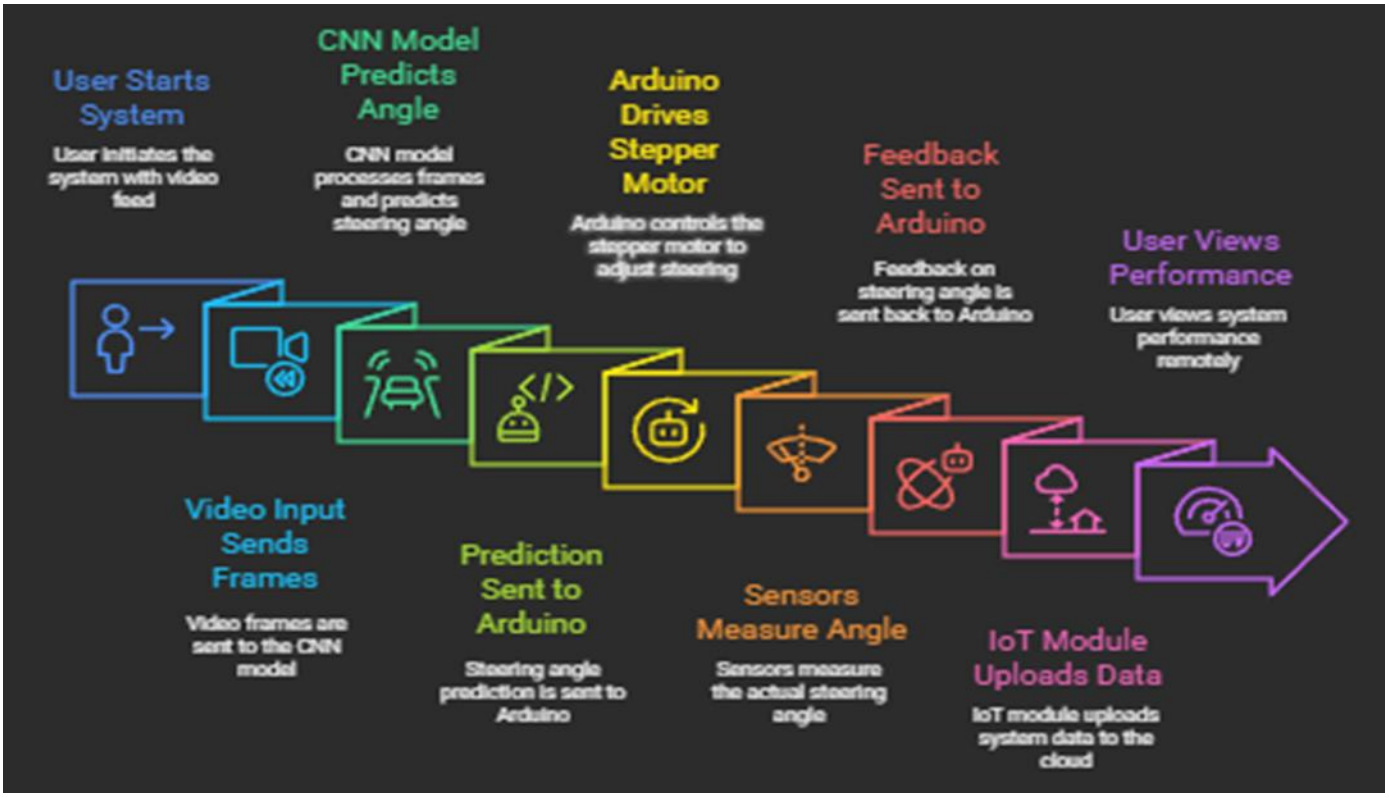


Figure 5.4 Sequence Diagram of AI-Driven Autonomous Steering Wheel Using IoT and Machine Learning

This diagram shows the sequential process of the autonomous steering system. The user starts the system, and video frames are sent to the CNN model, which predicts the steering angle. The predicted angle is transmitted to the Arduino that drives the stepper motor for steering control. The IoT module then uploads the system data to the cloud, allowing the user to monitor performance remotely.

5.5 Activity Diagram:

Figure 5.5 Activity Diagram

This diagram represents the flow of activities in the autonomous steering system. The process begins with capturing video input, followed by preprocessing and prediction using a CNN model. The Arduino controller sends angle commands to rotate the steering wheel, while sensor data is collected and displayed on the IoT dashboard. The system then evaluates performance and updates the model for improved accuracy.

5.6 Algorithm:

Step 1: Start the system and initialize all modules (camera, Arduino, IoT).

Step 2: Capture video input of the road.

Step 3: Convert video into frames and preprocess (resize, normalize, enhance contrast).

Step 4: Load pre-trained CNN model for steering angle prediction.

Step 5: For each frame:

a. Extract road features using CNN layers.

b. Predict steering angle (in degrees).

c. Send the predicted value to Arduino through serial communication.

Step 6: Arduino receives the angle → calculates number of steps required for the stepper motor.

Step 7: Stepper motor rotates steering wheel accordingly.

Step 8: Sensors (IMU, rotary encoder) send feedback data for error correction.

Step 9: IoT module uploads current status to cloud for monitoring.

Step 10: If deviation > threshold → adjust motor angle; else continue normal operation.

Step 11: Repeat until system stops.

Step 12: End process

Key Components of the Proposed Framework:

Analysis:

- Real-Time Performance: The system predicts steering angles and controls actuators efficiently from video input .
- Safety & Accuracy: Focused on steering angle prediction for safe navigation .
- Scalability: Future modules (e.g., lane or object detection) can be integrated .
- Modularity: CNN, Arduino, and actuators are independent and upgradable .

Chapter 6

Experiment Setup

6.1 Software Experimental Setup:

1. **Arduino IDE** – For coding, compiling, and uploading programs to the Arduino Uno.
2. **Python (v3.10 or higher)** – Used for ML model development, data preprocessing, and serial communication.
3. **VS Code** – Integrated development environment for Python scripting and CNN model training.
4. **TensorFlow / Keras** – Frameworks for CNN-based steering angle prediction.
5. **OpenCV, NumPy, Pandas** – For video frame extraction and dataset preprocessing.
6. **Matplotlib, Seaborn** – For model performance visualization.
7. **Git & GitHub** – Version control and collaborative development.

6.2 Hardware Experimental Setup:

1. **Arduino Uno R3 (ATmega328P)** – Central control unit for executing commands.
2. **Stepper Motor** – Provides precise angular motion for steering.
3. **Motor Driver)** – Drives the stepper motor based on Arduino signals.
4. **Power Supply (12V DC, 2A)** – Powers the entire setup.
5. **IoT Module** – Enables wireless monitoring and data transfer.

6. **Supporting Components** – Couplers, brackets, frame enclosure, and emergency stop switch.

6.3 Operating Environment:

1. **Operating System:** Windows 11 / Ubuntu 20.04
2. **Processor:** Intel i5 or higher
3. **RAM:** Minimum 8 GB
4. **Storage:** At least 10 GB free space for datasets and libraries
5. **Internet Connection:** Required for IoT data upload and cloud connectivity

6.4 Development Environment:

1. **Software Tools:** Arduino IDE, Python (with libraries), VS Code
2. **Hardware Interface:** Arduino connected via USB for serial communication
3. **Model Training Environment:** GPU-supported system for faster CNN model training
4. **Version Control:** Managed via GitHub repository

6.5 Machine Learning & IoT Libraries:

1. **TensorFlow / Keras / PyTorch** – Deep learning frameworks for model development.
2. **OpenCV** – Image and video frame processing.
3. **NumPy, Pandas** – Data preprocessing and analysis.
4. **Matplotlib, Seaborn** – Visualization of model accuracy and loss.
5. **pySerial** – Communication between Python and Arduino.

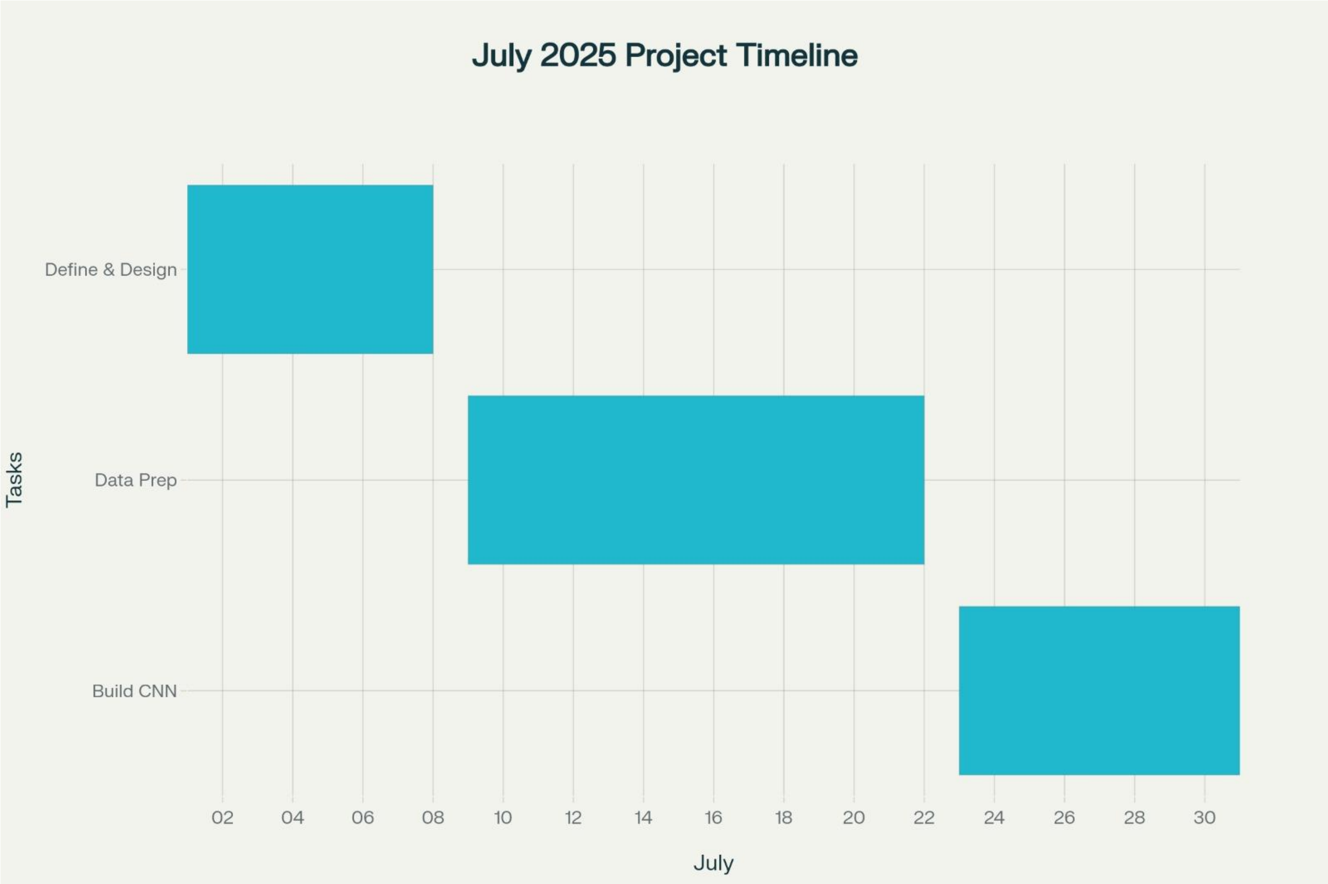
Chapter 7

Project Plan

The project “AI Driven Autonomous Sterring Wheel Using IoT & ML” is planned over a 10-week timeline from July 26, 2025, to October 3, 2025, ensuring a systematic approach from concept to implementation. During Weeks 1–2 (July 26–August 8), the project will focus on defining the problem statement, objectives, and scope while designing the basic architecture diagram to outline the interaction between software and hardware components. In Weeks 3–4 (August 9–August 22), the dataset will be collected and pre-processed, involving image normalization, resizing, and augmentation to prepare inputs for the CNN model. The Weeks 5–6 (August 23–September 5) phase will involve building and training a Convolutional Neural Network (CNN) to predict steering angles from images, followed by testing its accuracy and fine-tuning hyperparameters. Next, in Weeks 7–8 (September 6–September 19), the hardware setup will be established, integrating the Arduino, stepper motor, and IoT module. Motor control code will be written and tested for stable actuation. During Week 9 (September 20–September 26), the trained CNN model will be integrated with the hardware via serial communication to enable real-time steering control, followed by performance testing under simulated driving conditions. Finally, in Week 10 (September 27–October 3), the complete system will undergo final validation, results will be analyzed, and a comprehensive project report with documentation will be prepared for submission. This structured timeline ensures smooth progress from data collection and model training to hardware integration and final demonstration, resulting in a cost-effective and scalable autonomous steering prototype.

Gannt Chart

7.1 Project Timeline of July

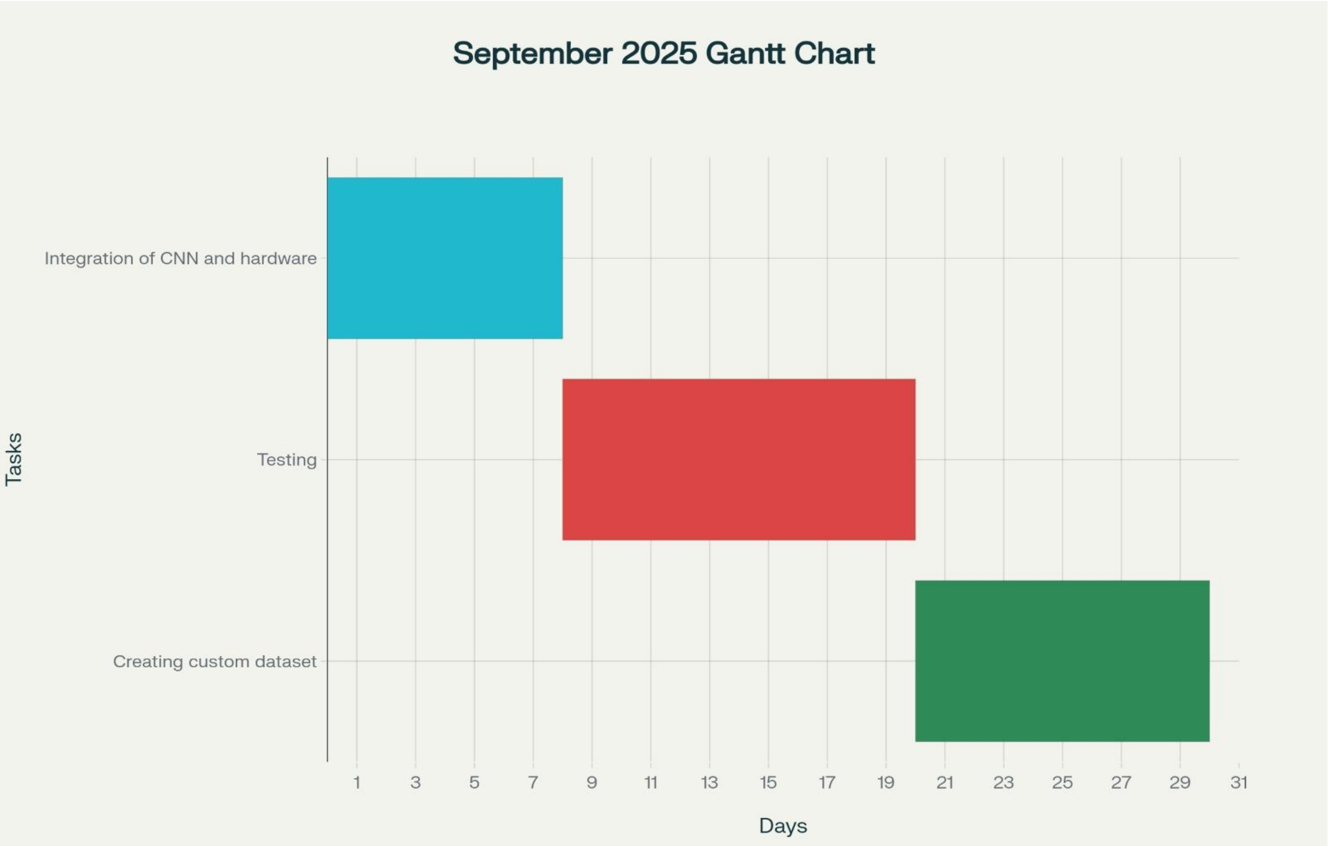


Graph 7.1 July Timeline

7.2 Project Timeline of August

Graph 7.2 August Timeline

7.3 Project Timeline of September



Graph 7.3 September Timeline

7.4 Project Timeline of October

Graph 7.4 October Timeline

Chapter 8

Expected Outcome

Implementation

8.1 Dashboard

Fig 8.1 Dashboard

This interface represents the real-time control dashboard of the Autonomous Driving System. It displays key parameters such as model accuracy, predicted steering angle, and frame rate. The user can start simulations, stream live or stored video feeds, and visualize steering responses through the interactive dashboard for monitoring and testing.

8.2 File upload with different Dataset

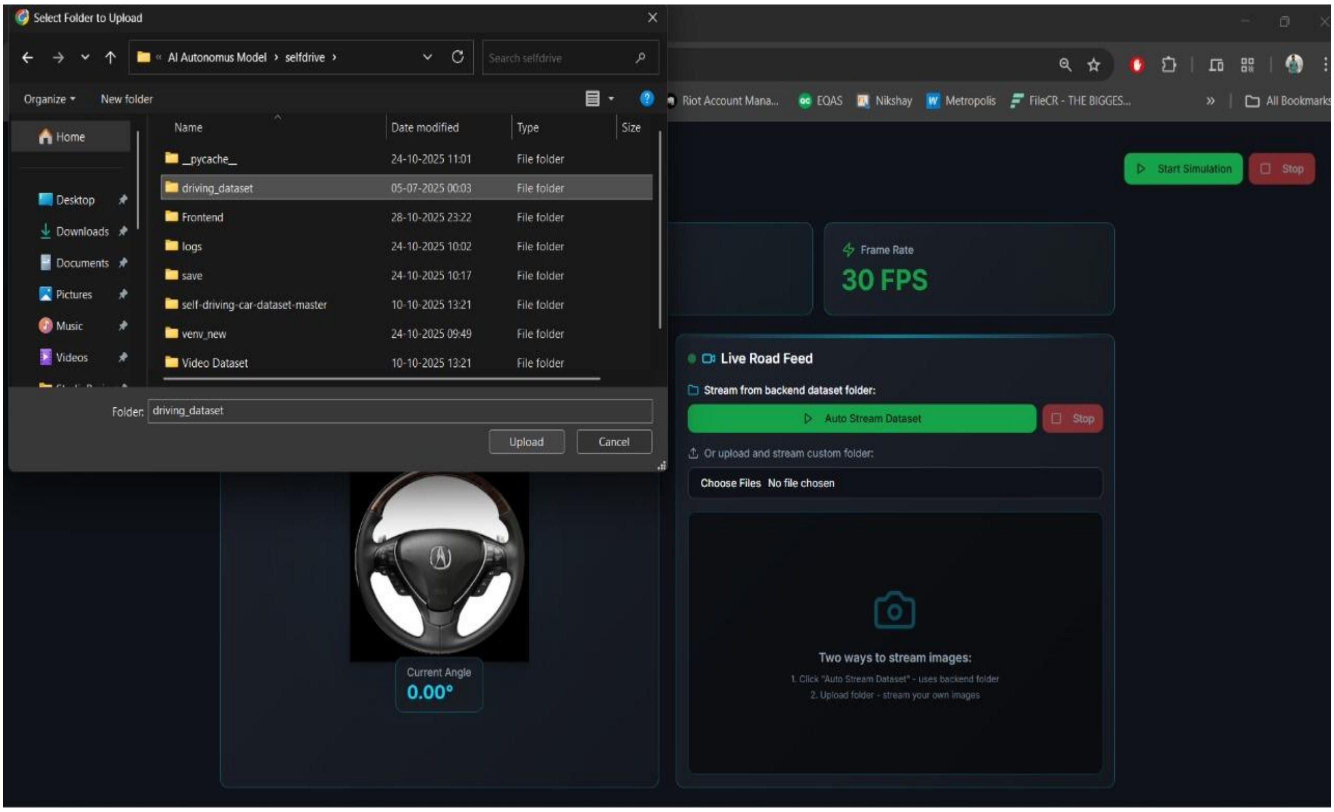


fig 8.2 File upload with different Dataset

This interface shows the process of uploading the driving dataset required for autonomous driving simulation. The user selects a local dataset folder containing road images, which is then streamed in real time for the model to predict steering angles. This allows for flexible testing, either by using the backend dataset or by uploading a custom dataset for performance evaluation.

8.3 Live Simulation

Fig 8.3 Live Simulation

This interface displays the real-time simulation of the Autonomous Driving System. The system streams live road feed from the dataset and predicts the steering angle using the trained CNN.

The dashboard shows key performance indicators such as model accuracy (95%), steering angle (-0.48°), and frame rate (30 FPS). The steering wheel visualization dynamically rotates based on the predicted angle, simulating real driving conditions.

References

[1] Golluri Ramcharan and Dhunnapothula Raghu, “Arduino based stepper motor speed regulation for robotics applications,” 2024, ResearchGate (conference/article preprint).

[2] Dr. Ruchi Pandey, Anand Goswami, Uttam Lal Yadav, and Yogesh Vishwakarma, “Designing and Crafting Stepper Motor Position Control with Arduino Mega 2560,” Feb. 2023, International Journal Of Innovation In Engineering Research & Management.

[3] Amad Narto, Suharto Suharto, and Regga Diko Catur, “The Prototype Electric Steering Gear Based Microcontroller Arduino,” 2023, RSF Conference Series: Engineering and Technology, v.3 i.1.

[4] ARM Khairudin, “Design of Stepper Motor Application as Archery Drawer,” 2023, Perintis e- journal

[5] M. S. Mohammed et al., “Low-cost autonomous car level 2: Design and implementation,” 2023, ScienceDirect.

[6] “Development of Four-Wheel Steering (4WS) with Arduino-Controlled Stepper Motor,” Nov. 2022, International Journal/Conference Paper.

[7] “Development of Steering Control System for a Small Electric Vehicle,” Nov. 2022, YMER Digital.

[8] “Electronic Hardware Design of An Autonomous Vehicle,” 2020, IJERT.

[9] A. Rossi, N. Ahmed, S. Salehin, T. Hasnine Choudhury, and G. Sarowar, “Real-time Lane Detection and Motion Planning in Raspberry Pi and Arduino for an Autonomous Vehicle Prototype,” Sep. 20, 2020, arXiv preprint arXiv:2009.09391.

[10] R. Thrun et al., “Stanley: The Robot that Won the DARPA Grand Challenge,” 2006, Journal of Field Robotics.