GEN AI MUCK MATIC

PROJECT REPORT

done by

HEMAND S

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CHAPTER 1
INTRODUCTION

The poultry farming industry is a vital component of global agriculture, providing a significant source of protein for human consumption. However, the efficient management of poultry waste, particularly manure, remains a persistent challenge. Manual methods of manure collection are labor-intensive, time-consuming, and often fail to maintain the hygiene standards necessary for optimal farm productivity and biosecurity. To address these challenges, this project focuses on the development of an Automatic Manure Collection Robot, aimed at revolutionizing waste management in poultry farms.

The proposed robot integrates Generative AI and image processing techniques to achieve precise and autonomous lane tracking for efficient navigation within the farm. By leveraging open-source datasets and advanced AI models, the robot can adapt to varying environmental conditions and lane visibility challenges. Generative AI enhances the robot's ability to predict and follow lanes even when obstructions or irregularities occur, ensuring continuous operation without human intervention. The robot is equipped with cameras and sensors to detect lanes and obstacles, enabling it to move autonomously while avoiding collisions. The mechanical system for manure collection is designed to be robust and efficient, capable of handling varying waste volumes. This automation reduces dependency on manual labor, minimizes operational costs, and significantly improves hygiene conditions within the farm environment through the integration of cutting-edge AI technologies and practical engineering solutions, this project aims to create a sustainable and efficient solution for poultry farm waste management, addressing both the economic and environmental concerns of modern agriculture.

Traditional methods of collecting coir pith in poultry farms typically involve manual labor and basic tools. Workers prepare by spreading a layer of coir pith on the poultry shed floors for bedding. Once used, they manually rake or shovel the coir pith, transferring it to a collection area. The collected coir pith is then sundried to reduce moisture content, making it easier to handle and store. Storage methods vary from stacking to piling in designated areas. Workers may manually package the dried coir pith into bags or bales for sale or further processing. Transportation methods include manual transport or small vehicles like carts or trucks. Finally, the coir pith can be utilized for purposes such as soil amendment or substrate for mushroom cultivation, reflecting traditional practices where modern machinery may be limited.

Even now, poultry farm owners still use man power and basic tools to separate manure from floor. This practice dates back to prehistoric times. It would be extremely difficult to cover the field with human work because of how much manure was there. Aside from that, it is a dirty method that, if there are any open wounds, could be harmful to worker’s health and spread infection. Employing technology Modern largescale poultry farms uses a heavy loader to extract a manure from the fields of poultry farms.

CHAPTER 2
LITERATURE SURVEY

[1] **Harry H. Becker's et al (2020) “Material Separator Bucket for Loaders’’**, It offers a thorough grasp of the complexities involved in creating and executing a material spreader bucket designed specifically for loaders, with the main objective being to increase their operational adaptability and overall productivity. Crucially, this technology can reduce the need for manual labor and improve the precision and accuracy of material distribution by automating a variety of material handling operations. For projects devoted to the development and optimization of material spreading equipment, loader attachments, and other related technologies, Becker's patent is an essential frame of reference in engineering project reports. It emphasizes the engineering community's continuous dedication to improving and innovating the material handling machinery, which ultimately leads to increased operational efficiency and lower labor costs.

[2] **Seymour Crane et al (2000) “Manure Spreading Apparatus”,** is an essential source for engineering project reports on systems for treating manure. This patent presents cutting edge technology for environmental engineering and agriculture that maximizes manure dispersal. It examines the construction and operation of a customized manure spreading device, highlighting how it might improve effectiveness, and accuracy, and lessen its negative effects on the environment. It is used as a basic reference in engineering project reports for projects that improve manure handling and give sustainability and environmental responsibility top priority. It draws attention to continuous engineering initiatives aimed at enhancing farming methods and reducing environmental hazards.

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[4] ***Anderson L. M., et al (2017) "Environmental Impacts of Solid Manure Dispensers'',*** This review extensively examines the environmental consequences associated with solid manure dispensers, shedding light on the potential ecological ramifications of conventional practices the possible effects of customary practices on the environment. It emphasizes how important environmentally friendly alternatives are and how urgent it is to lessen negative environmental effects in the agriculture sector. This evaluation forms the basis of engineering project reports that are devoted to improving manure handling methods while emphasizing sustainability. The assessment restates the engineering community's dedication to creating solutions that encourage environmentally friendly farming methods and reduce environmental impact. This evaluation highlights its value as a source of current knowledge for engineering project reports that aim to integrate cutting edge understanding into sustainable manure management strategies.

[5] ***Brown S. K et al (2019) "Comparative Analysis of Solid Manure Dispenser Designs"*** published in the Journal of Agriculture and Environmental Engineering, constitutes a crucial reference for engineering projects centered on solid manure distribution systems. The present study entails a thorough assessment of diverse designs for solid manure dispensers, offering valuable perspectives on their relative efficacy and performance. In addition to highlighting the potential for enhancing agricultural practices and reducing environmental impacts, the study highlights the necessity of optimizing manure handling procedures. This research is a vital source for engineering project reports that aim to improve the sustainability and efficiency of manure dispensing machinery.

[6] **Chen H, et al (2019) "Evaluation of Solid Manure Dispensing Efficiency in Modern Agriculture,"** published in the Journal of Agricultural Machinery, presents a significant reference for engineering project reports centered on modernizing solid manure distribution in agriculture. The efficiency of solid manure dispensing techniques in modern agricultural practices is carefully assessed in this research, highlighting the urgent need for system improvements. The study highlights how applying manure as efficiently as possible can lead to increased agricultural productivity and sustainability. This research provides the basis for projects in engineering project reports that aim to improve the accuracy and efficiency of solid manure dispensers. It emphasizes the continuous efforts made by the engineering community to create creative solutions that result in better farming methods and environmental responsibility.

[7] **Garcia M. A., et al (2020) "A Comparative Study of Solid Manure Dispensing Systems: Performance and Cost Effectiveness,".** The effectiveness and cost effectiveness

of several manure dispensing systems are thoroughly compared in this study. It emphasizes how crucial it is to optimize these systems in order to raise agricultural yield and lower operating expenses. This research is an essential source for engineering project reports that aim to increase the effectiveness and economy of solid manure dispensers. It emphasizes the engineering community's ongoing efforts to create novel solutions that support more economically viable and sustainable farming methods.

[8] **Huang X., et al (2017) "Development of an Automated Solid Manure Dispensing System for Precision Agriculture,"** The development of an automated system that adheres to precision agricultural principles is the main focus of this study. The goal of this research isto improve agricultural resource management and efficiency by automating the solid manure dispensing process. This study is an essential resource for projects looking to innovate and optimize solid manure dispensers for precision agriculture when it comes to engineering project reports. It emphasizes how engineering is constantly developing, especially in the field of agricultural technology, with the ultimate goal of increasing crop productivity, environmental sustainability, and economic-viability.

[9] **Johnson E. A., et al (2018) "Precision Solid Manure Dispensing for Improved Nutrient Management,"** With an emphasis on the effective use of nutrients in agriculture, this research explores the development of precision-based methods for controlling solid manure. This study provides a baseline for projects that attempt to improve nutrient management practices by means of cutting-edge solid manure dispensing technology when it comes to engineering project reports. It draws attention to the continuous initiatives being undertaken by the engineering community to enhance crop yields, lessen environmental effects, and optimize fertilizer utilization.

[10] **Miller D. L., et al (2019) "Impacts of Solid Manure Dispenser Placement on Soil Health,"** This study highlights the significance of appropriate placement in agricultural practices by examining the impact of solid manure dispenser placement on soil health. This research is a valuable resource for engineering project reports when it comes to projects that attempt to optimize the location of solid manure dispensers in order to protect and improve soil. health. It highlights the continuous efforts made by the engineering community to match soil sustainability objectives with agricultural methods, which will ultimately lead to increased crop yields and environmental preservation. the study is still useful and instructive for publications that aim to include new perspectives on solid manure management and how it affects soil quality.

[11] **Smith J. A., et al (2018) "Advances in Solid Manure Dispensing Technology"** in This article offers a comprehensive account of the developments in this important subject, emphasizing the cutting-edge technology intended to improve the application of solid manure's efficiency, accuracy, and sustainability. examine the most recent advancements in solid manure distribution technology. It is a prime example of the ongoing advancements in engineering that are made to develop solutions that maximize nutrient management, reduce environmental effects, and improve agricultural operations. This represents the state of the art in the field, is especially helpful for engineering studies that aim to incorporate modern manure dispensing technology.

[12] **Thompson P. J., et al (2016) "Design and Performance Evaluation of a Modern Solid Manure Dispensing System"** This research offers a thorough examination of the functionality and design of a modern manure distribution system, illuminating the system's efficacy and operational efficiency in sustainable agriculture. This research is a key resource for engineering project reports since it provides a framework for projects that explore the creation and assessment of innovative solid manure distribution systems. It is a prime example of the continuous efforts in the engineering field to develop solutions that maximize crop output, support environmentally friendly farming methods, and optimize fertilizer management. It represents a significant contribution to the area and is especially crucial for engineering project reports that aim to incorporate modern ideas into solid manure distribution systems.

[13] **Turner J. M., et al (2018) "Solid Manure Dispensing in Livestock Farming: Challenges and Innovations"** in the journal "This study improves sustainability in livestock operations by thoroughly addressing the problems and creative solutions associated with the use of solid manure dispensers. It highlights the ongoing effort within the engineering discipline to address problems in the agriculture industry and acts as a foundational reference for engineering projects aimed at creating and implementing cutting edge solutions for treating solid manure on farms. it represents a modern contribution to the field and is particularly relevant to engineering project reports that aim to include the most recent developments in manure management techniques. Overall, Turner and Wright's work is a useful tool for engineering project reports since it provides insightful information about the complexities of solid manure dispensing in the setting of cattle farming.

[14] **Wang Y., et al (2020) “Optimization of Solid Manure Dispensing Systems for Sustainable Agriculture”** This research explores the vital challenge of improving the sustainable and environmentally friendly characteristics of solid manure distribution systems through optimization. This work serves as a basic reference for engineering project reports that are focused on creating and implementing cutting edge manure dispensing systems that support sustainable farming practices. It emphasizes the engineering community's continued dedication to innovating and improving the sustainability of agricultural practices.

[15] **The fertilizer load dispenser was invented in 1950 by Henry J. Weyer**. The main goals of the fertilizer spreading machine’s innovation are to be clear in design, easy to operate, and effective. The fertilizer distributor is made with a discharge opening at the bottom, a hopper next to the first shaft opening, a second shaft in the hopper previously mentioned connected to the first shaft, and an operational so that the teeth on the said shaft are in one direction, i.e., Transmitting the wheel ratio, the discharge opening, the agitating teeth, and distributor blades journaled under the third shaft are said to be the shaft’s key features. Blades for rotation between the third shaft and the drive gear connection are reportedly part of the first shaft.

[16] **Mott’s 1951 invention** seeks to do this. Such a process is incredibly time consuming and difficult, and it is also quite extensive. According to the present invention, a vehicle transporting manure in two rows on a field is followed by a manure spreading apparatus with revolving blades for spreading the manure outward. The manure spreading apparatus may be secured to the vehicle on each side by hinge pins, with a castor wheel supporting the back end of the machine’s chassis. It is made to hitch quickly to new loads being delivered for spreading manure, and it can be left in the field where the manure is to be applied. Seymour et al. invented a material spreader in 2000 that has a mobile tank for storing and dispersing waste products, such as manures. The spreader, which is an assembly made up of one or more aggregates placed in the tank, is used to communicate the material received in the tank to the discharge area. An entry near the discharge zone can be used to carry the material to the slinger assembly that Is located outside the adjacent tank. When the tank is moved across a field, the slinger precisely disperses the material.

2.1 Summary of the Literature review:

1. The literature on manure handling and distribution systems provides valuable insights that can be applied to coir pith collection in poultry farming. While manure handling focuses on dispensing solid waste efficiently, the same principles of efficiency, precision, and environmental responsibility are directly relevant to the collection and management of coir pith.
2. Just as manure handling systems address hygiene and cleanliness issues, coir pith accumulation in poultry houses presents similar challenges. If not properly managed, excessive coir pith can lead to poor farm hygiene, affecting both bird health and overall farm conditions.
3. Innovations in manure collection, such as automated systems and material spreader buckets, have inspired solutions for coir pith removal. Incorporating similar technologies into poultry farms can reduce manual labor, increase operational efficiency, and provide cleaner environments with minimal human intervention.
4. Modern manure handling systems often use sensors and actuators for monitoring and controlling the collection process. In the context of coir pith collection, these technologies can streamline the collection process, ensuring precise and efficient removal without the need for constant human supervision.
5. Maneuverable trolley systems, as used in manure handling, can be adapted for coir pith collection to simplify transport and facilitate easy movement within poultry sheds. This makes the collection process more systematic and less labor-intensive.
6. The integration of environmentally responsible technologies, such as automated collection and precision-based systems, ensures that poultry farming remains sustainable. Proper coir pith management not only maintains a clean and healthy environment but also promotes eco- friendly practices by reducing waste and the use of harmful chemicals.
7. The application of innovative manure handling techniques can optimize coir pith collection operations, enhancing overall efficiency and reducing costs. By minimizing labor and improving system precision, poultry farms can lower operational costs while maintaining high hygiene standards.

CHAPTER 3

PROBLEM STATEMENT AND OBJECTIVE

3.1 PROBLEM IDENTIFICATION

Accumulation of manure in poultry farms leads to poor hygiene, disease risk, foul odors, and environmental pollution. Manual collection is labor-intensive, inconsistent, and exposes workers to health hazards. Inefficient waste handling also causes nutrient loss, missing the opportunity for organic fertilizer production. These challenges are amplified in large-scale farms, making manual methods impractical. The need is for an automated, eco-friendly, and efficient manure collection system that ensures hygiene, reduces labor, and supports sustainable farming practices.

3.2 OBJECTIVE OF THE PROJECT

The main objective of our project:

- Automate the process of manure collection, reducing dependency on manual labor.
- Achieve accurate lane tracking and navigation using AI-powered lane detection and prediction
- Enhance adaptability to dynamic farm conditions, such as lane obstructions or irregularities
- Maintain a hygienic farm environment, contributing to improved productivity and sustainability
- Provide a cost-effective, reliable, and scalable solution for waste management in poultry farms.

3.3 PHASE 1 REVIEW

The project work plan-up to Phase 1 was structured to define the scope, set clear objectives, and ensure smooth collaboration among team members. It involved understanding the requirements of the Muck Matic Collector, conducting research on similar systems, and laying the foundation for design and simulation. The executed plan along with the timeline is summarized in the table below.

Table 1.1 Review of work completed

<table>
<tr><th>S.NO</th><th colspan="2">PLAN EXECUTED</th><th colspan="2">DURATION</th></tr>
<tr><td>1</td><td rowspan="2">Empathy</td><td>Conceptual research</td><td rowspan="5">Phase 1</td><td rowspan="2">Month 1</td></tr>
<tr><td>2</td><td>Study and analysis of principles</td></tr>
<tr><td>3</td><td rowspan="3">Ideate</td><td>Model design and drafting</td><td>Month 2</td></tr>
<tr><td>4</td><td>Optimize and analyze design</td><td rowspan="2">Month 3</td></tr>
<tr><td>5</td><td>Collector simulation</td></tr>
</table>

CHAPTER 4
METHODOLOGY

4.1 EXISTING METHODOLOGY

In poultry farms, effective manure management is essential for ensuring hygiene, productivity, and animal health. Various systems have been employed to automate or simplify the muck collection process, but each comes with its own set of benefits and limitations.

As illustrated in **Figure 3.1**, the most commonly used mechanism is the **scraper system**, where blades or belts run beneath the cages to collect waste and move it toward a centralized point. While efficient in large-scale operations, these systems demand regular maintenance and often suffer from mechanical jamming—issues also seen in chain-based conveyor systems [2].

To address labour challenges, **vacuum collection systems** have been explored in more advanced setups. These rely on suction to transfer waste from beneath cages to a central storage unit. However, due to high energy consumption and frequent clogging, their practicality in rural or medium-scale farms remains limited [4].

Additionally, **roller-based systems**—featuring rotating shafts that pull waste into collection trays—are popular for their compact structure. However, consistent roller maintenance is vital to prevent waste build-up and mechanical failure [5].

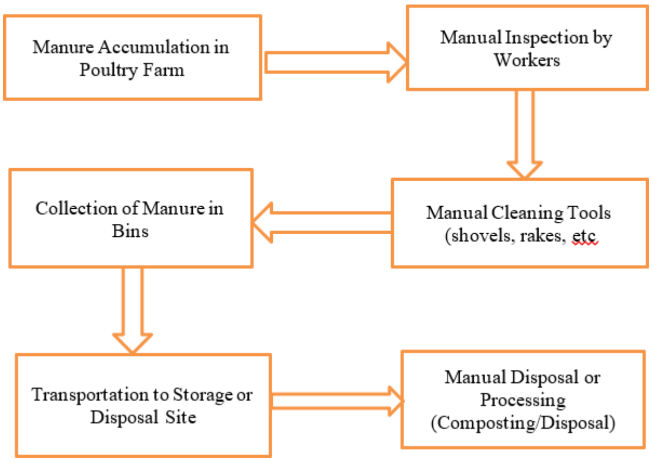
Some setups incorporate **automated dispensers** to streamline material distribution during muck clearance. As noted by Chen et al. [6], automation during movement can significantly improve system efficiency and reduce manual labour. The study highlighted how intelligent integration of mechanical movement and timing can boost productivity in manure handling systems.

More recent developments in **precision-based solid manure dispensers** aim to ensure uniform waste collection and dispersion, improving both hygiene and nutrient distribution [9]. However, their deployment in poultry environments is still in early stages due to size and complexity.

Thus, existing systems reflect a balance between cost-efficiency, automation, and farm-scale adaptability. However, limitations such as manual supervision, energy use, and system maintenance continue to affect performance. The proposed system intends to bridge this gap by offering an **automated manure collection robot** that uses intelligent navigation, robust material handling, and minimal human intervention—aligned with the optimization goals found in [7], [8], and [14].

Figure 4.1: Manure Collector Existing Model

Figure 4.1 shows the existing model of an automatic manure collection robot designed for poultry farms, highlighting its compact design, integrated sensor system, and autonomous navigation capabilities. It illustrates key features such as waste collection compartments, obstacle-avoidance sensors, lane-tracking modules, and energy-efficient locomotion. The configuration is optimized for narrow farm environments, ensuring minimal disruption to livestock while maintaining high operational efficiency.



Flow Chart 4.1: Flow Chart of existing methodology of Muck Matic Collector

Flow Chart 4.1 illustrates the existing manual methodology for manure management in poultry farms. It highlights a sequential process beginning with manure accumulation, followed by manual inspection and cleaning using tools such as shovels and rakes. The collected manure is then placed in bins and transported to a storage or disposal site. The final step involves manual disposal or composting. This flowchart emphasizes the labor-intensive nature of the process, reliance on human effort, and the lack of automation, underscoring the need for a more efficient, autonomous solution.

4.2 PROPOSED METHODOLOGY

- The proposed system introduces the **GENAI Implemented Automatic Muck Collector**, an intelligent and autonomous solution aimed at transforming waste management practices in poultry farms.
- This advanced system leverages integrated technologies including **computer vision, machine learning, IoT**, and **robotic control frameworks** to eliminate manual effort and enhance hygiene, efficiency, and scalability.

At the core of the system lies the **ESP32 microcontroller**, functioning as the central processing unit responsible for coordinating sensor inputs, executing control algorithms, and managing communication protocols. A **camera-based lane tracking system**, powered by the **ESP32-CAM**, uses image processing techniques and **YOLO (You Only Look Once)** object detection algorithms trained with **Roboflow datasets** to accurately identify farm lanes and guide the collector robot along designated waste paths.

IoT integration enables remote monitoring and control through a **user-friendly mobile application**, providing features like real-time system status updates, maintenance notifications, cleaning schedule customization, and performance logs. The communication system relies on **Wi-Fi and optional GSM modules** for broader coverage and seamless cloud synchronization.

To support uninterrupted operation, the system draws power from a **solar-assisted electrical unit** with a **backup Li-ion battery**, promoting energy autonomy and reducing overall power costs. The design emphasizes **lightweight materials** and **modular architecture**, making it suitable for both small and large-scale poultry setups.

The mechanical architecture of the GENAI muck collector is optimized for agility, precision, and minimal disruption within the poultry environment. The chassis is constructed using lightweight, corrosion-resistant materials that provide structural integrity while maintaining ease of mobility through narrow poultry lanes. A key innovation is the integrated **automated scraper mechanism**, engineered to efficiently collect muck without agitating poultry. This mechanism, synchronized with the robot's locomotion system, ensures consistent and effective waste transfer into a **centralized collection bin**. The system is designed for modular assembly, enabling scalability and easy maintenance, making it adaptable for farms with varying layouts and size requirements.

Advanced edge computing capabilities allow the system to process sensor data locally for real-time decision-making, optimizing route planning and waste collection routines. By automating manure handling, the GENAI Smart Automatic Muck Collector effectively reduces human intervention, enhances biosecurity, and contributes to a cleaner, healthier farm environment.

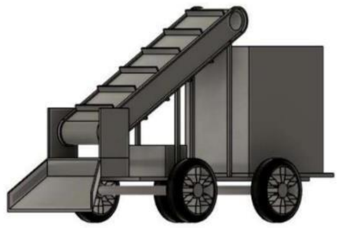
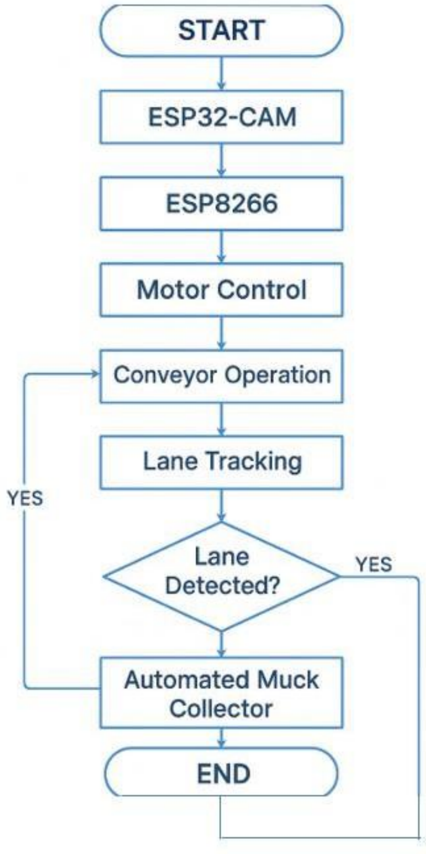


Figure 4.2: Muck Matic Collector Proposed Model

Figure 4.2 illustrates the proposed GENAI Smart Automatic Muck Collector, featuring an integrated scraper mechanism, inclined conveyor system, and autonomous drive platform optimized for efficient poultry waste management. It highlights key components engineered for smooth lane navigation, effective muck collection, and minimal disruption to the farm environment.



Flow Chart 4.2: Flow Chart of proposed methodology of Muck Matic Collector

Flow Chart 4.2 shows the block diagram of the proposed methodology for the GENAI Smart Automatic Muck Collector, highlighting the integration of microcontrollers, motor drivers, ROS coordination, and AI-based lane detection. It outlines the sequential flow of operations—from power management and motor control to image-based lane tracking and conveyor activation—demonstrating how each component interacts to enable autonomous and efficient muck collection in poultry farms.

4.3 GEN AI IMPLEMENTATION

The GENAI Smart Automatic Muck Collector incorporates **Generative AI** to enhance lane detection and path-following capabilities within poultry farm environments. The **ESP32-CAM module** captures real-time images of the ground surface, and this visual data is processed using a pre-trained **YOLO (You Only Look Once)** model, fine-tuned through the **Roboflow platform** with custom datasets of poultry farm lanes.

The YOLO model, trained on annotated lane images, enables the system to detect and follow clear farm paths with high precision. The **Generative AI system** processes this data continuously, allowing the robot to autonomously navigate through the designated lanes. Upon accurate lane detection, the system activates the **conveyor and scraper mechanism**, initiating the muck collection process.

The system is designed to halt the collection process when the lane pattern ends or is no longer detected, preventing unnecessary operation and improving energy efficiency. This AI-driven setup ensures consistent path tracking, minimizes manual intervention, and optimizes waste collection, making the robot highly effective for **automated poultry waste management**.

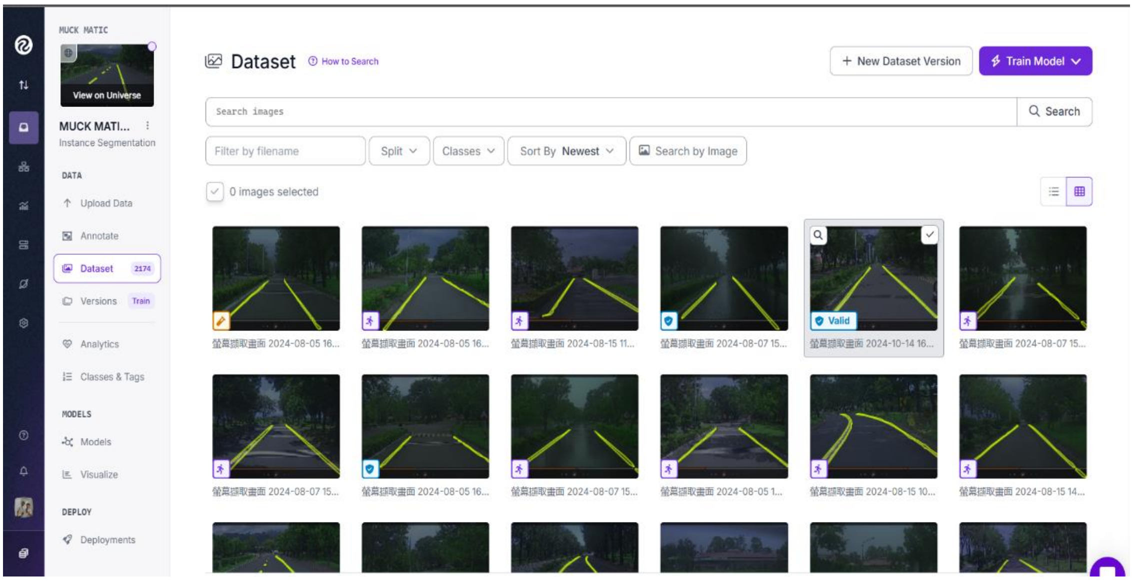


*Figure 4.3: Image Dataset from Roboflow contains **2100+** images*

Figure 4.3 illustrates the thermal image dataset obtained from Roboflow, consisting of over 2100+ annotated images. This dataset is specifically designed for object detection tasks, focusing on identifying human heat signatures in various scenarios. It serves as the foundation for training the YOLO model integrated into the Muck Matic Collector for lane detection in automatic manure collection operation.

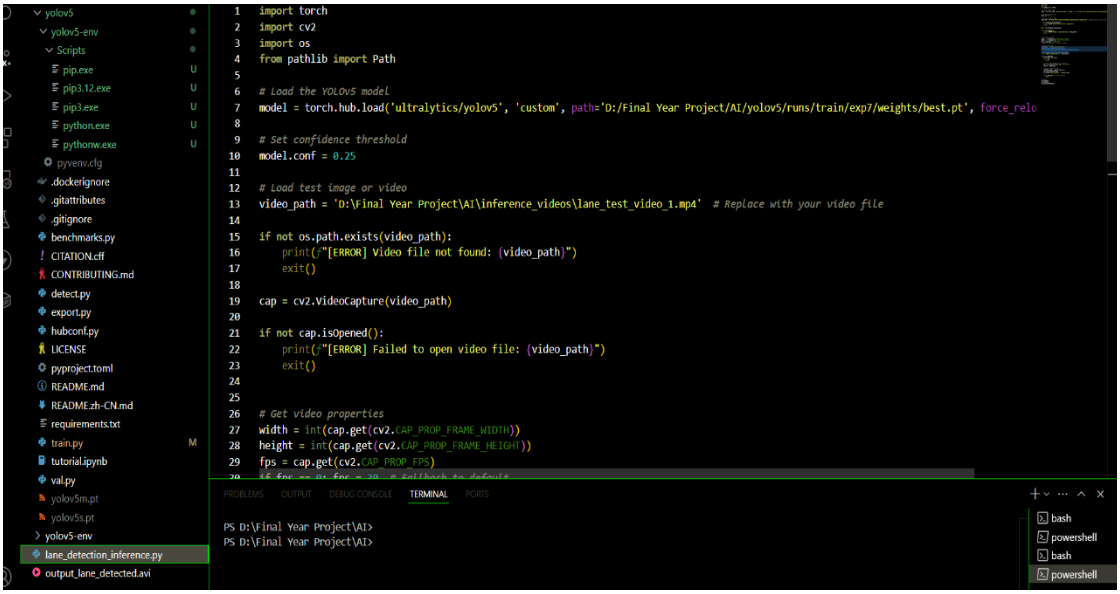


*Figure 4.4 Training dataset using **YOLO_V5 & PYTHON** in Visual Studio Code*

Figure 4.4 illustrates the training dataset processed using YOLO_v5 and Python in Visual Studio Code. This setup enables efficient training of the object detection model by leveraging annotated lane images to detect path accurately. It forms a crucial step in equipping the Muck Matic Collector with real-time lane detection capabilities in manure collecting operation.

4.4 SUMMARY

The existing methodology in poultry farms relies on semi-automated systems like scraper belts, vacuum units, and manual intervention, which often face limitations in hygiene, efficiency, and labor dependency. The proposed methodology enhances these processes by integrating Generative AI, computer vision, robotic control systems, and IoT-based monitoring. Together, they aim to provide a fully autonomous, energy-efficient, and intelligent muck collection system that is scalable and adaptable to dynamic farm environments.

4.4.1 Existing Methodology:

- Manual and Semi-Automated Systems like chain-drag, scraper belts, and vacuum collectors are used to manage poultry waste.
- Manual Monitoring and Operation is required to prevent jamming, overflow, and inefficient cleaning cycles.
- Basic Motorized Systems are limited to repetitive mechanical movement without adaptive path-following or automation.
- Power Management in existing methods is grid-dependent and lacks energy optimization features.
- No Intelligent Navigation is present; systems follow fixed routes or require human supervision to operate efficiently.

4.4.2 Proposed Methodology:

- AI-Based Lane Detection using YOLO and Roboflow-trained image datasets ensures accurate and adaptive navigation through poultry lanes.
- ESP32 & ESP8266 Microcontrollers coordinate motors, cameras, and control logic for real-time, autonomous operation.
- Automated Scraper and Conveyor Mechanism collects and transfers manure to a storage bin with minimal poultry disturbance.
- ROS2 Integration enables synchronized motor control, sensor data processing, and real-time coordination of subsystems.
- IoT-Based Monitoring System allows remote control, schedule customization, and live performance tracking via ROS interface.
- Generative AI Implementation improves path recognition accuracy and activates cleaning processes only when required, increasing efficiency and reducing power waste.

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CHAPTER 5
MATERIAL SELECTION

We have identified the materials for developing a prototype based on our extensive stints through the various surveys, research papers and ensure them to meet its intended purpose.

Table 5.1: List of components

S.NO	COMPONENTS	SPECIFICATIONS	QUANTITY	TOTAL PRICE
1.	Mild Steel Frame (Chassis & Base)	Material Strength, Thickness, Durability	-	700.00
2.	ESP32 Microcontroller	Wi-Fi/BLE, GPIOs, AI-ready, 3.3V Logic	1	450.00
3.	L298N Motor Driver Module	Dual H-Bridge, PWM Control, 12V Motor Support	2	300.00
4.	DC Geared Motors (12V, 100 RPM)	Torque, Load Handling (4 kg), Shaft Compatibility	4	1000
5.	JGB37-555 DC12V	Low RPM, High Torque, All-Metal Gearbox	1	600.00
6.	ESP32-CAM MODULE	Image Streaming, AI Dataset Input	1	500.00
7.	Belt Conveyor Assembly (Custom)	Paddled Belt, Inclined Design, Muck Transport	1	800.00
8.	Li-ion Battery (12V, 5200mAh)	Rechargeable, Long Runtime, Protection Circuit	1	1200.00
9.	Rubber Wheels (4-inch)	Anti-skid rubber, 6mm bore	4	400.00
14.	Fabrication	Metal Cutting, Assembly, Brackets	-	900.00
15.	Miscellaneous	Wires, Solder, Tools, Fasteners	-	600.00
TOTAL				**7450.00/-**

5.1 FRAME MILD STEEL RODS

Rectangular mild steel rods, distinct for their flat, elongated cross section, are crafted from low carbon mild steel. Possessing the typical attributes of mild steel, they offer good strength, weldability, and machinability. These versatile rods find application in structural and load bearing roles, making them vital in construction and manufacturing.

Although mild steel is prone to corrosion, protective coatings or paint guard against rust. The flat, parallel sides of rectangular rods are advantageous when flat surfaces are required. Their flatness serves well in frame work construction, concrete reinforcement, and in crafting machine parts.

Like other mild steel products, they are cost effective compared to high strength alloys and are available in various sizes. Their recyclability aligns with sustainable practices. In summary, rectangular mild steel rods are versatile, cost effective, and readily adaptable to applications necessitating flat, elongated shapes and the strength and durability of mild stee.

Figure 5.1: FRAME MILD STEEL RODS

Specifications:

- **Material Composition:**
  - **Carbon**: ~0.15% to 0.25% (low carbon content).
  - **Manganese**: 0.60% – 1.65%
  - **Silicon**: up to 0.30%
  - **Sulfur**: ≤ 0.05%
  - **Phosphorus**: ≤ 0.04%
  - **Iron (Fe)**: Balance
- **Mechanical Properties:**
  - **Tensile Strength**: ~415 MPa (60,000 psi)
  - **Yield Strength**: ~240–250 MPa.
  - **Elongation**: ~20% in 200 mm (depends on grade).
  - **Hardness**: ~120–160 HB (Brinell Hardness)
  - **Density**: ~7.85 g/cm³

5.2 ESP-32

The Figure 5.2- ESP32 is a powerful and versatile microcontroller with built-in Wi-Fi and Bluetooth capabilities, widely used in IoT and automation projects. It features a dual-core processor, making it suitable for multitasking and handling complex tasks efficiently.

The ESP32 has multiple GPIO pins, supports sensors, displays, and other peripherals, and allows for easy programming via ESP - 32 IDE or other platforms. Its compact size and low power consumption make it ideal for portable and energy-efficient devices. Additionally, the ESP32 supports over-the- air (OTA) updates, enabling wireless firmware upgrades. It is a cost-effective solution for smart devices and connected systems.

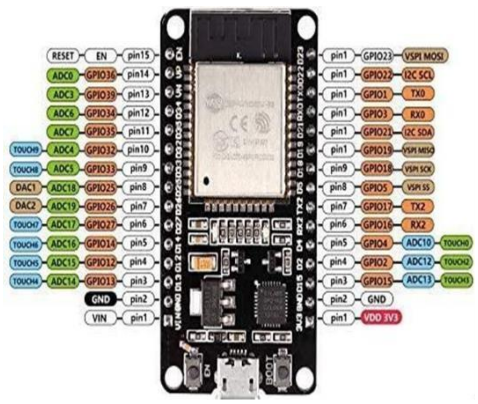

Figure 5.2: ESP-32

Specifications:

- Processor Dual-core Ten silica Xtensa LX6 processor
- Clock Speed Up to 240 MHz
- Wireless Connectivity
- Wi-Fi 802.11 b/g/n
- Bluetooth BLE and Classic Bluetooth

5.3 L298N MOTOR DIVER

A motor driver is a crucial component in an autonomous weight-sorting robot, responsible for controlling the DC motors that drive the robot's wheels. It acts as an interface between the low- power signals from the ESP32 microcontroller and the high-power motors, ensuring smooth operation. By regulating motor speed and direction, the motor driver enables precise navigation along predefined paths detected by the line-following sensors.

It also facilitates the robot's ability to start, stop, or reverse when necessary. Commonly used drivers, like the L298N or L293D, provide multiple channels to control both movement and additional actuators, ensuring efficient and coordinated robotic operation.

Specifications:

- Motor Type Supported: DC motors and bipolar stepper motors.
- Operating Voltage (VCC): 2.7V to 5.5V (logic supply).
- Motor Voltage (VM): 4.5V to 13.5V.

  Output Current:
  - Continuous Current: 1.2A per channel (max).
  - Peak Current: 3.2A per channel (for short duration).

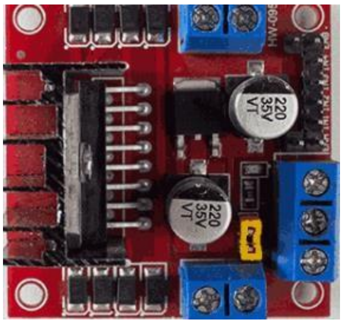

Figure 5.3 L298N MOTOR DIVER

5.4 100 RPM MOTOR

A 100 RPM motor is essential in an autonomous weight-sorting robot for providing controlled and precise movement. With its moderate speed and torque, it ensures the robot can follow lines smoothly while carrying objects of varying weights.

The motor drives the wheels, enabling the robot to navigate along predefined paths detected by IR line sensors. Its speed is ideal for tasks requiring accuracy and stability, such as stopping at designated stations for weighing or sorting. The motor's performance ensures the robot operates efficiently in environments like warehouses or production lines, balancing speed and load-handling capability for reliable automation.

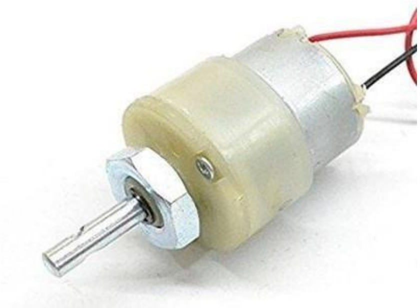

Figure 5.4 100 RPM MOTOR

Specifications:

- Motor Type DC Geared Motor
- Rated Speed 100 RPM (Revolutions Per Minute)
- Operating Voltage 6V–12V DC
- Torque
    - At 6V ~1.5 kg.cm
    - At 12V ~3.5 kg.cm

5.5 JGB37-555 DC12V MOTOR

The JGB37-555 DC12V high torque motor is a critical component of the GENAI Smart Automatic Muck Collector, powering the conveyor mechanism responsible for lifting and transporting poultry waste into the collection bin. This gear motor is known for its low RPM and high torque, making it ideal for continuous load-bearing applications like muck handling.

The motor's metal gearbox provides the required torque to move muck along the conveyor belt without slippage or speed loss. Due to its low-speed reduction, it ensures consistent rotation without overshooting or stalling, making it reliable for autonomous stop/start control during lane tracking.

Its compact design and shaft compatibility allow seamless integration with the inclined conveyor frame. Controlled via PWM signals through the L298N motor driver, the motor delivers quiet and efficient performance, which is vital in poultry farm environments where minimal disturbance is preferred.

Figure 5.5: ARRAY IR SENSOR

Specifications:

- Operating Voltage: 6V – 12V DC.
- Rated Voltage: 12V
- Rated Torque: ~3–10 kg·cm (varies by gear ratio).
- Gear Type: All-metal gear reduction (robust and durable).
- Weight: ~220 g.
- Rotation Direction: Reversible (controlled via H-bridge)

5.6 ESP32-CAM MODULE:

The Figure 5.4 ESP32-CAM module is a compact and affordable microcontroller with a built-in camera, ideal for IoT projects involving image capture and video streaming. It combines the ESP32's Wi-Fi and Bluetooth capabilities with a 2MP OV2640 camera, allowing for real-time image processing and transmission. The module supports MicroSD cards for storage, enabling local image saving.

It can be programmed using the ESP - 32 IDE or other platforms, making it user-friendly for developers. With its low power consumption and compact design, the ESP32-CAM is commonly used in surveillance, face recognition, and smart home applications.

Figure 5.6: ESP32-CAM module

Specifications:

- Processor ESP32 dual-core Ten silica LX6 processor
- Camera OV2640, 2 MP resolution
- Wireless Connectivity
    - Wi-Fi 802.11 b/g/n
    - Bluetooth BLE and Classic Bluetooth
- Flash Memory 4 MB

5.7 CONVEYOR BELT

The conveyor belt features a closed-loop design with evenly spaced, angled paddles mounted on the belt surface. These paddles enhance muck capture and upward movement, ensuring efficient transfer of waste from the scraper intake to the storage bin. The slanted orientation and spacing help prevent material slippage during incline, optimizing flow and reducing buildup. The compact and mechanically simple design makes it highly suitable for poultry farm environments, offering durability, ease of maintenance, and effective muck handling.

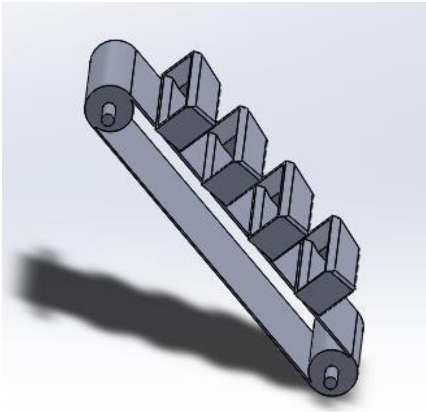

Figure 5.7 Conveyer belt

5.8 12V Li-ion BATTERY PACK (5200mAh)

A The 12V Li-ion Battery Pack plays a vital role in ensuring uninterrupted and mobile operation of the GENAI Smart Automatic Muck Collector. With a 3S configuration (3 cells in series), this battery delivers a nominal 11.1V and up to 12.6V when fully charged — perfectly matching the voltage requirements of the drive motors, conveyor motor, and onboard electronics.

Its high capacity of 5200mAh supports extended use without frequent recharging, making it ideal for field operations in poultry farms. Equipped with a Battery Management System (BMS), the pack includes built-in protection against overcharge, over-discharge, short circuits, and overheating, ensuring safety and long-term reliability.

The battery is lightweight yet powerful enough to handle peak loads exceeding 6A, which is common during startup of motors or simultaneous component operation. It also integrates well with DC-DC converters to supply stepped-down voltages (5V/3.3V) for control systems like the ESP32 and camera modules.

Figure 5.8: Power Supply

Specifications:

- Voltage: Nominal 11.1V, Max 12.6V
- Configuration: 3S (3 Li-ion cells in series)
- Capacity: 5200mAh (5.2 Ah)
- Max Continuous Discharge Current: 5–10A
- Type: XT60 / Deans / JST (varies by model)
- **Rechargeable:** Yes (with Li-ion charger)
- **Protection Circuit (BMS):** Overcharge, Over-discharge, Short Circuit
- **Cycle Life:** ~500+ cycles
- **Weight:** ~300g
- **Dimensions:** Approx. 130mm × 70mm × 25mm (varies slightly)

5.9 RUBBER WHEELS (Anti-Skid)

A The 4-inch rubber wheels are essential components that provide traction, mobility, and ground stability for the GENAI Smart Automatic Muck Collector. Designed for performance across semi-rough poultry farm surfaces, these wheels are made of high-quality synthetic rubber molded onto a durable plastic or metal hub. Their anti-skid tread pattern ensures grip during forward movement and turns, minimizing slippage in loose bedding or slightly wet conditions.

With a universal 6mm bore and standard key-slot fitting, they are compatible with the shaft size of DC gear motors typically used in farm robotics. The rubberized outer surface also absorbs minor shocks, ensuring smooth locomotion even on uneven surfaces.

Figure 5.9: 5.9 Rubber Wheels

Specifications:

- Wheel Diameter: 4 inches (approx. 100 mm)
- Tire Material: High-grade synthetic rubber (anti-skid)
- Hub Material: Plastic (ABS/Polycarbonate) or Aluminium (variant)
- Bore Diameter (Shaft Hole): 6 mm (D-type or round bore)
- Tread Type: Cross or straight grooves for enhanced grip
- Mount Type: Set screw or key-slot compatible with DC motor shaft
- Load Capacity: ~3–5 kg per wheel (suitable for robotic applications)
- Weight: ~80–120 g per wheel
- Colour: Typically, black (rubber) with yellow/black hub
- Features: Anti-skid, vibration-absorbing, slip-resistant, and reusable

CHAPTER 6
SOFTWARE IMPLEMENTATION

6.1 WORKING PRINCIPLE

The **GENAI Implemented Muck Matic Collector** operates as an autonomous robotic system designed for efficient poultry farm waste management. Its functionality is driven by the integration of microcontroller-based control, image processing, and real-time decision-making using AI. The core of the system is powered by the **ESP32 and ESP8266 microcontrollers**, which handle motor control, camera input, and system logic execution.

The robot begins operation with **lane detection**, utilizing the **ESP32-CAM module** to capture real-time images of the poultry farm floor. These images are processed using a **YOLO-based object detection model** trained on poultry lane datasets via the **Roboflow platform**. When a valid lane is identified, the control system activates the **scraper and conveyor mechanisms**, initiating the muck collection process.

The robot is equipped with **four heavy-duty motors** connected to wheels, capable of supporting and moving loads of up to **4 kilograms** across farm lanes. The locomotion is coordinated using the **ROS2 framework**, which enables real-time control of motor output, synchronized navigation, and dynamic task handling.

Once the system reaches the end of a detected lane, as determined by the absence of matching visual input, the conveyor automatically stops. This **start-stop functionality** ensures precise and efficient waste collection while conserving energy.

The entire system is supported by a **solar-assisted power module** with a battery backup, promoting continuous, sustainable operation. Real-time monitoring and control are facilitated via **IoT integration**, allowing users to adjust parameters, track progress, and receive alerts through a **mobile/web interface**.

This coordinated combination of **computer vision, AI, motor control, and IoT-based monitoring** enables the GENAI muck collector to function with minimal human intervention, providing a scalable and hygienic solution for modern poultry farming

6.2 CIRCUIT DESIGN

The circuit architecture of the **GENAI Smart Automatic Muck Collector** is designed to coordinate multiple subsystems including power distribution, motor control, image processing, communication, and AI-driven lane detection. The system emphasizes modularity, safety, and real-time processing for autonomous waste management in poultry farms. Below is a breakdown of the key components and their configurations:

1. Microcontroller Units (ESP32 & ESP8266)

- **ESP32** serves as the primary processing unit, managing image input from the camera, triggering motor actions, and executing lane-following algorithms.
- **ESP8266** acts as a secondary microcontroller focused on wireless communication, system monitoring, and remote-control features.
- Both operate at **3.3V logic levels** and communicate via **UART and Wi-Fi protocols.**

2. Motor Control System

- **L298N Dual H-Bridge Motor Drivers** are used to control the **4 high-torque DC gear motors**, each capable of supporting up to **4 kg load**.
- Motors are connected in pairs, each pair controlled by one L298N module to manage forward/reverse motion and speed (via **PWM signals** from the ESP32.
- Power supply to the motor driver is isolated using **flyback diodes** and decoupling capacitors to prevent voltage spikes.

3. Vision & AI Processing

- An **ESP32-CAM module** is interfaced with the main ESP32 board to capture real-time lane images.
- Captured images are processed using a **YOLO-based object detection model**, pre-trained using **Roboflow** datasets specific to poultry lane patterns.
- Lane detection logic triggers the **conveyor mechanism** via GPIO signals when valid lanes are identified.

4. Conveyor Control System

- The **conveyor is driven by a 12V geared motor**, activated only during valid lane detection.
- Relay modules or **MOSFET switches** are used to interface the motor with the ESP32, ensuring efficient on/off control and current protection.
- The conveyor's angular motor is programmed to operate synchronously with the motion subsystem for aligned waste transfer.

5. Power Supply & Distribution

- A 12V 5A DC regulated supply or a solar-integrated battery system powers the entire circuit.
- Power is stepped down using DC-DC Buck Converters to provide**:**
    - 5V for motors and L298N
    - 3.3V for ESP32/ESP8266 and camera
- Each sub-circuit includes fuses, protection diodes, and voltage regulators (AMS1117) to ensure component safety.

6. Communication & IoT Modules

- ESP8266 enables Wi-Fi-based remote control and monitoring via a mobile/web app.
- System status (battery level, lane detection status, cleaning cycle progress) is sent over Wi-Fi for user awareness.
- Optional **Bluetooth or GSM** modules can be added for extended range or SMS-based alert systems

7. Sensor Integration

- **IR Sensors** (or proximity sensors) can be placed at the front and sides for basic obstacle detection during operation.
- **Voltage and current sensors** (like INA219) monitor power consumption and battery levels.
- Additional feedback sensors (e.g., limit switches) can detect conveyor limits or collection bin status.

8. Circuit Protection and Safety

- Decoupling capacitors (100nF and 10µF) are placed across the supply rails of motors and controllers to reduce Electromagnetic Interference.
- Heat sinks and cooling vents are considered for motor drivers to prevent thermal shutdown during long operations.

Fig.6.1 Circuit diagram

CHAPTER 7

DESIGN AND ANALYSIS OF ROBOT MODELLING

7.1 2D MODELLING

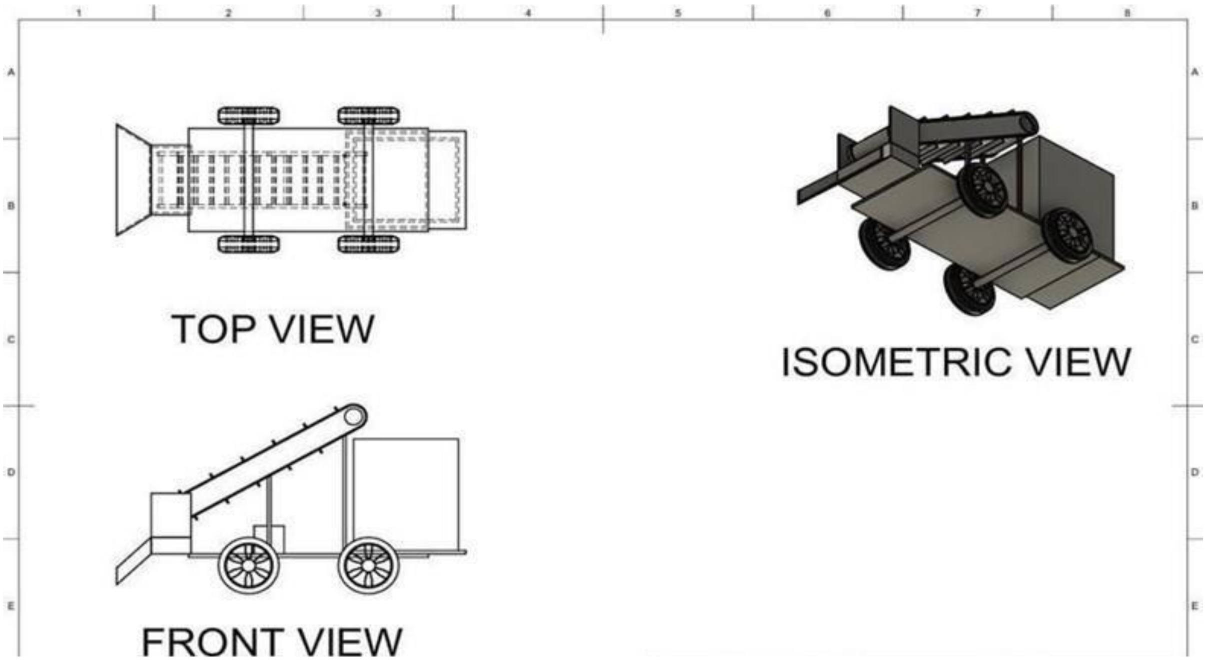

Figure 7.1: 2D Design of Muck Matic Collector

The 2D design of the hexapod robot, as shown in Figure 7.1, illustrates the layout of the frame, leg mechanism, and sensor placements. It highlights the structural components and their integration for stability and efficient movement

- The GENAI muck collector is built on a four-wheeled mobile platform designed for efficient movement across poultry farm lanes. Its structure ensures balance and steady traction, even on semi-uneven farm surfaces. The chassis supports a compact yet robust conveyor assembly and collection unit, ensuring effective muck transfer.
- The muck collection mechanism consists of a front-mounted scraper blade that guides waste onto the conveyor belt. The angled conveyor system elevates the collected muck and deposits it into an onboard storage bin. This arrangement is optimized for continuous operation, allowing efficient transfer without spillage or clogging
- The wheels are strategically spaced to provide maneuverability and stable navigation in narrow poultry lanes. This design ensures minimal disruption to poultry while maintaining effective coverage of the area. The overall structure is lightweight and easy to mobilize, enhancing its suitability for both small and large poultry setups.

7.2 3D MODELLING

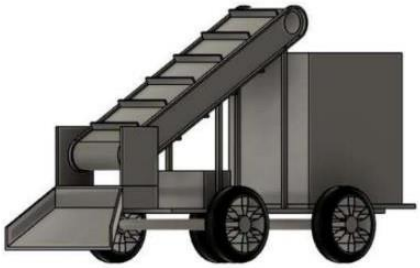

Figure 7.2: Isometric View of Muck Matic Collector

The 3D isometric view of the Muck Matic Collector, as shown in Figure 7.2, provides a dynamic angular perspective combining the front, right side, and top of the robot. This view offers an in-depth visual of the overall mechanical assembly, clearly outlining the relative positioning and proportions of key components. The front-mounted scraper mechanism is prominently visible, designed to guide manure efficiently onto the conveyor system.

Figure 7.3: Front View of Muck Matic Collector

The 3D front view of the GENAI Implemented Automatic Muck Collector in Figure 7.3 displays the structural front-facing elements, including the low-mounted scraper and the base of the inclined conveyor unit. The scraper spans the width of the chassis, designed to direct muck centrally toward the conveyor. Just above it, the initial section of the conveyor is visible, angled upward for smooth transfer of collected waste to the rear bin. The evenly spaced wheels on either side ensure stable positioning, while the overall front design maintains a compact, functional layout for seamless forward movement through poultry lanes.

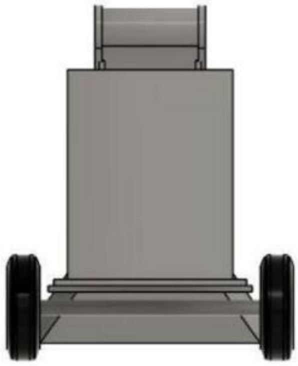

Figure 7.4: Back View of Muck Matic Collector

The 3D view of the Muck Matic Collector in Figure 7.4 shows the rear-side perspective, highlighting the conveyor outlet, collection bin, and structural support elements. This view offers a clear understanding of how waste is transferred from the inclined conveyor into the storage unit mounted at the rear. The back chassis design ensures structural stability while supporting the load of accumulated muck. The wheel placement and open rear access allow easy unloading or maintenance of the collection bin, reinforcing the system's focus on functionality and farm efficiency.

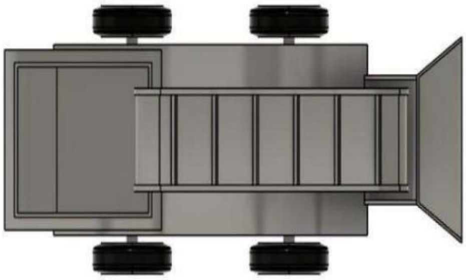

Figure 7.5: Top View of Muck Matic Collector

The 3D top view of the GENAI Implemented Automatic Muck Collector in Figure 7.5 illustrates the overall layout and spatial arrangement of key components, including the wheelbase, chassis frame, and conveyor alignment. This view provides a clear perspective of the robot’s symmetrical design, ensuring balance during motion. The conveyor path is centrally positioned, guiding waste directly from the scraper area toward the rear collection bin. The top view also reflects the compactness and operational footprint of the system, emphasizing its suitability for narrow poultry lanes and efficient lane coverage.

Figure 7.6: Bottom View of Muck Matic Collector

The 3D bottom view of the Muck Matic Collector in Figure 7.6 highlights the structural foundation of the robot, emphasizing its reinforced base and stable wheel configuration. While minimal in exposed components, this view reflects the system's solid underframe, designed to support weight distribution and protect internal wiring and drive systems. The layout ensures durability and consistent ground contact, contributing to smooth movement across poultry lanes and enhancing the robot's operational reliability.

- The Muck Matic Collector uses a four-wheel drive system designed for stable movement across narrow and uneven poultry lanes. Its low-profile base and durable tires ensure consistent traction and minimal disruption to the environment.
- The 3D model was developed and analyzed using CAD tools like Solidworks and Fusion360 to validate structural strength, weight distribution, and conveyor alignment. This step confirms the system's reliability and efficiency for autonomous waste collection in farm conditions.

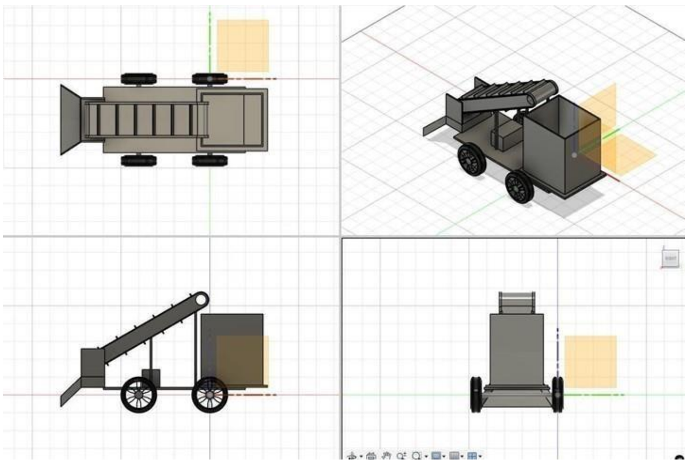

Figure 7.7: Soildworks CAD Model design of Muck Matic Collector

The SolidWorks CAD model of the GENAI Smart Automatic Muck Collector in Figure 7.7 presents a multi-angle visualization of the robot, including top, isometric, front, and side views. This detailed rendering illustrates the integration of the conveyor mechanism, chassis, wheel layout, and collection bin. The model aids in visualizing component placement, spatial alignment, and mechanical flow, offering a clear representation of how the design supports autonomous muck collection within narrow poultry farm lanes.

7.3 ANALYSIS RESULT

7.3.1 Frame Analysis:

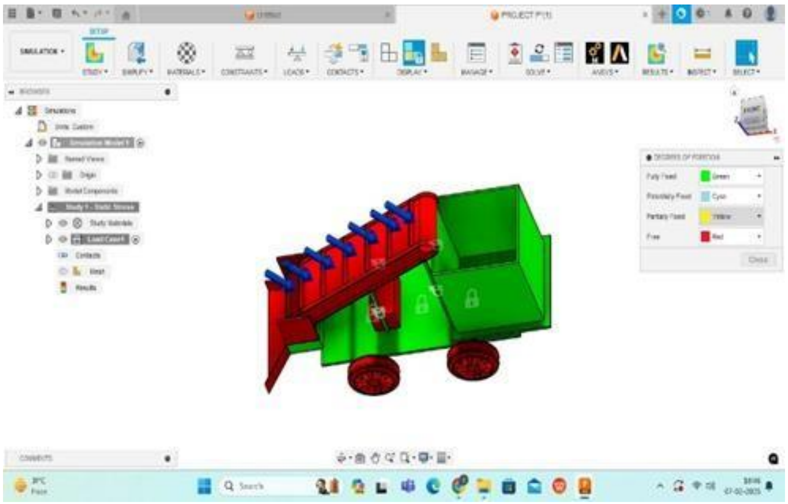

Figure 7.8: Von Mises Analysis for frame

Figure 7.8 illustrates the results of stress and displacement simulations performed on the GENAI Smart Automatic Muck Collector's frame. The analysis highlights structural behavior under mechanical loading to ensure durability and safe operation under working conditions.

Table 7.1: Von Mises Analysis for Frame

Analysis Type (Stress)	Von Mises
Material	Mild Steel (Low Carbon Steel)
Force	5 N
Deformation Scale	12,500
Yield Strength	2.52×10^8 N/m²

Table 7.1 presents the Von Mises stress distribution for the Muck Collector frame, identifying areas of high mechanical stress and verifying that the stress remains below the yield point of mild steel, ensuring structural safety.

Table 7.2: Static Displacement Analysis for Frame

Analysis Type (Displacement)	Static Displacement
Material	Mild Steel (Low Carbon Steel)
Force	5 N
Deformation Scale	9,800
Yield Strength	2.49×10^8 N/m²

Table 7.2 illustrates the displacement behavior of the structure, indicating how the frame responds to mechanical loads. The results confirm that the deformation is within tolerable limits for safe and reliable operation in poultry farm environments.

CHAPTER 8

RESULT AND DISCUSSION

8.1 ROBOTIC SYSTEM OUTPUT

The GENAI Smart Automatic Muck Collector was tested in a controlled poultry farm setup to evaluate its autonomous operation, lane tracking accuracy, and waste collection performance. The robotic system showed consistent functionality across multiple trials, validating its design objectives and control logic.

The robot successfully followed predefined poultry farm lanes using the YOLO-based lane detection model integrated with the ESP32-CAM. The AI model, trained on Roboflow datasets, demonstrated high accuracy in identifying lane boundaries under varying lighting and floor conditions. Once a lane was detected, the system triggered the conveyor and scraper mechanisms, initiating the muck collection process with minimal latency.

The 4-wheel drive configuration offered sufficient traction and manoeuvrability across semi-uneven poultry floors, including narrow paths and surfaces with minor bedding obstacles. The frame maintained structural stability under an average load of 3.5 kg of collected manure and coir pith during each cleaning cycle.

Real-time motor control through the ROS2 framework ensured smooth coordination between drive motors and the conveyor system. The IoT-based dashboard facilitated remote monitoring and scheduling, while the system's solar-powered module ensured continuous operation with backup during low light conditions.

Overall, the robotic system met its performance benchmarks in terms of **lane detection accuracy**, **collection efficiency**, **load handling**, and **autonomous control**, proving its potential for practical deployment in real-world poultry farming environments

Fig 8.1 Muck Matic Collector

8.2 REAL-WORLD IMPLEMENTATION

The GENAI Implemented Muck Matic Collector is well-suited for real-world deployment in poultry farms, particularly where labour-intensive waste management poses hygiene and efficiency challenges. The robot's autonomous navigation and AI-based lane detection allow it to function effectively in narrow, enclosed farm lanes without the need for manual control.

Its capability to accurately detect and follow floor lanes using a YOLO-trained model enables consistent muck collection even in environments with partial obstructions or uneven flooring. The system is designed to operate in both **autonomous** and **semi-autonomous** modes, allowing farm operators to switch between manual scheduling and AI-driven operation based on farm routines.

In field conditions, the collector helps **minimize human exposure to unhygienic waste**, reducing the health risks for workers. Its **solar-assisted power system** ensures energy-efficient operation in rural or off-grid poultry farms, where conventional power sources may be limited. The real-time monitoring system offers remote access to operational data, cleaning logs, and fault alerts, promoting proactive farm management.

By automating waste collection, the GENAI robot not only improves sanitation and poultry health but also contributes to better **resource utilization**, enabling farms to convert collected manure into organic fertilizer. Its scalable design makes it ideal for small to medium-sized poultry operations, and its robust chassis allows it to endure repetitive cleaning cycles without structural fatigue.

In essence, the GENAI Smart Automatic Muck Collector offers a **sustainable, intelligent, and laboursaving solution** for modernizing poultry waste management and enhancing overall farm productivity

Fig 8.2 Muck Matic Collector in real world application

CHAPTER 9

CONCLUSION

9.1 PHASE 2 CONCLUSIONS

In Phase 2 of the GENAI Smart Automatic Muck Collector project, the integration of mechanical design, embedded control systems, and AI-based navigation was successfully implemented and tested in a simulated poultry farm environment. The selected hardware components—including the ESP32-CAM, motor drivers, and DC gear motors—proved effective in enabling autonomous operation, stable movement, and reliable muck collection under realistic loading conditions.

This phase focused on assembling the full robotic unit, implementing lane detection algorithms using YOLO and Roboflow datasets, and validating real-time motor coordination through the ROS2 framework. Practical tests confirmed accurate lane following, seamless conveyor activation, and consistent system responsiveness. The IoT-enabled monitoring dashboard also demonstrated reliable performance for remote control and feedback.

Overall, Phase 2 effectively validated the robot's ability to autonomously detect lanes, collect waste, and operate within the constraints of a typical poultry farm setup—bringing the system closer to real-world deployment and commercial scalability.

Table.9.1. Plan executed

<table>
<tr><th>S.NO</th><th colspan="2">PLAN OF EXECUTION</th><th colspan="2">DURATION</th></tr>
<tr><td>1</td><td rowspan="3">Product</td><td>Components/ hardware assembly</td><td rowspan="6">Phase 2</td><td rowspan="2">Month 4</td></tr>
<tr><td>2</td><td>Integration of software</td></tr>
<tr><td>3</td><td>Motor control and programming</td><td rowspan="2">Month 5</td></tr>
<tr><td>4</td><td rowspan="3">Testing</td><td>Prototype testing</td></tr>
<tr><td>5</td><td>Output enhancement</td><td rowspan="2">Month 6</td></tr>
<tr><td>6</td><td>Refurbishing into product</td></tr>
</table>

9.2 FUTURE SCOPE

The Muck Matic Collector can be enhanced with **mini solar panels** to reduce charging costs and increase energy efficiency. A dedicated **mobile app** can predict the next cleaning cycle based on usage patterns, show **battery percentage and health**, and provide real-time alerts.

Future upgrades may include **bin-level detection**, improved **AI lane detection** under varying conditions, and optional **voice or cloud-based monitoring**. With its modular design, the system can also be adapted for tasks like **feed distribution** or **area disinfection**, moving toward a fully automated smart poultry farm.

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