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An Automated Mechanized Robot for Handling Ricebags

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Abstract

A novel technology that overcomes the difficulties of manual labor has been created to increase productivity in large-scale food storage facilities. With an emphasis on rice bags in particular, this creative approach seeks to seamlessly replace human interaction in duties like picking, storing, moving, and monitoring food bags. The system uses an integrated approach that includes precision grippers, scissor lifts, Cartesian robots, autonomous guided vehicles (AGVs), and an advanced artificial intelligence-driven control system. Especially, the technology known as Simultaneous Localization and Mapping (SLAM) plays a crucial part in guaranteeing the smooth operation of the system. While Cartesian robots precisely perform complex jobs, autonomous mobility from the AGVs enables efficient and accurate movement within the storage space. Scissor lifts add to the system's flexibility in managing different storage arrangements. Rice sacks can be handled carefully and under control thanks to precision grippers. Artificial intelligence algorithms are employed by the overarching control system to facilitate the smooth coordination of various constituents. By combining these cutting-edge technologies, the system not only simplifies operations but also drastically lowers the need for manual labor, opening the door for a more effective and cutting-edge method of managing food storage.

Keywords: autonomous mobility, SLAM, precision grippers, scissor lifts, Cartesian robots, AGV, and simplified operations.

INTRODUCTION

In India, the rice sector is essential to maintaining both economic stability and food security. In this case, effective rice bag handling is essential since it affects the distribution and supply chain directly. The creation and application of an automated palletizer system intended for rice bag stacking and un-stacking is covered in this abstract. Utilizing cutting-edge robotics and automation technology, the system optimizes the handling procedure, increasing efficiency and decreasing reliance on human labor. The majority of rice mills and storage facilities in India presently handle rice bags by hand, which is a labor-intensive operation. In addition to decreasing operational efficiency, this labor-intensive method puts the workers' health and safety at risk. However, the automatic palletizer system provides a long-term answer to these problems. This innovative system is capable of stacking and de-stacking rice bags with precision and efficiency. It employs computer vision and machine learning algorithms to identify and locate rice bags, ensuring proper alignment and arrangement. The use of robotic arms and conveyor systems facilitates the quick and accurate placement of bags onto pallets or into storage, significantly reducing the time and labor required for these tasks. Moreover, the system enhances the overall safety of the operation by minimizing human involvement in physically demanding and potentially hazardous tasks. Rice bag handling with automatic palletizers has the potential to completely transform India's rice sector. Because this method minimizes damage to rice bags during handling, it can result in more production, lower labor costs, and better-quality products. Additionally, it supp orts a Rice bag. Using automatic palletizers for processing rice has the potential to revolutionize the rice industry in India. This technique reduces the possibility of handling-related damage to rice bags, which can lead to increased productivity, less labor expenses, and higher-quality output. It also encourages workers in the rice mills and storage facilities to work in a safer and healthier environment. The solution can further improve warehouse management and logistics by optimizing space use and stacking patterns. The incorporation of automated palletizers into the Indian rice business signifies a noteworthy advancement in the modernization and optimization of the sector's efficiency. It is consistent with the nation's continuous endeavors to use cutting-edge automation and robotics technologies across diverse sectors to satisfy the needs of an expanding populace and changing market conditions. The entire system is essentially divided into four main subsystems: an automated guided vehicle (AGV) that can place or pick objects inside any roof; a scissor lift mechanism that can rise to a height of 6.8 meters and enable a cartesian robot to pick items at high points; a cartesian robot equipped with precision grippers that can pick and place rice bags from their current accurate location to the required location; and finally a control system that uses an image processing algorithm and open CV to control all the subsystems.

METHODOLOGY

This project's main goal is to create an automated guided vehicle that can pick up and transport rice bags from warehouses to wagons and back again. The robot's design takes into account the limited area in the current conventional go down infrastructure. The system's design calculations must be completed with consideration for every subsystem. As shown in the following fig. 1 The total system is divided in the several subsystems.

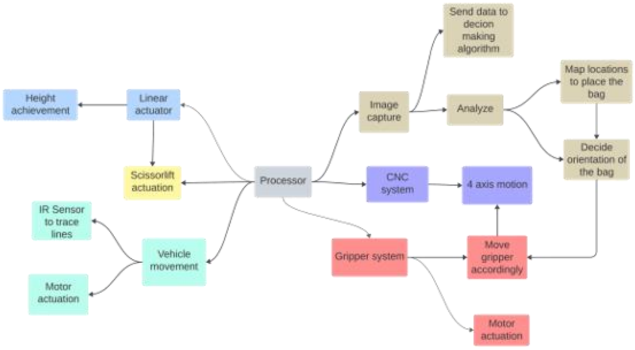

Fig. 1 Methodology of the System

A. *Mechanical Design*

1. Scissor Lift:

The Department of Food and Public Distribution, Ministry of Consumer Affairs Food and Public Distribution, has offered a problem statement that can be solved all at once using inspiring stacks like scissor lifts, hydraulics, and cartesian bots mixed with claws. The basic lifting mechanism that the suggested solution contains is an effective scissor lifting technique backed by a sturdy base. The most effective method for raising heights is the scissor lift, which can extend the length to almost anywhere between 3 and 9 meters. The hydraulic cylinders that force themselves outwards for upward movement provide the platform its slanted ascent, which causes the legs to push apart and raise the platform. In addition to the built-in scissor lift base, two parallelly facing plates that move upward with the aid of hydraulics are used to provide an extra height gain. By reaching the final few meters of height, this method helps us. This mobile Automated Guided Palletizer is designed to move goods from wagons to warehouses and the other way around. This vehicle's dimensions are planned and built to make it easy to overcome the main restriction of the gangways and spaceless halls present in both structured and unstructured warehouses. The base of the hydro mechanical actuation is located on the board faced above the scissor lift. The plank functions as the system's storage space in addition to being the base. The floorboard with the claws helps to stack and un-stack the sacks by enabling motion in the x-axis direction. Meeting the necessary requirements, this claw efficiently grasps the load and moves it in accordance with the construction of a single unit, which is typically arranged in the form of 12+8 or occasionally even 13+ 13+ 8. The science of pulleys controls this motion along the x-axis. Moreover, mobility along the y axis means that reaching height is never again a problem. The base is constructed with a big storage area compared to the breadth of the complete system, which allows for the simultaneous carrying of about 12 sacks. The delicate yet effective claws that have replaced the hooks in usage ensure that the bag is not damaged, which prevents grain spills in the long run. With many bag options, such as jute bags that weigh 585 grammes per gunny, plastic bags that weigh 735 grammes per gunny, and smart gunny bags that weigh about 400 grammes per gunny, the i-stacker can handle almost any kind of bag and can carry up to 700 kg of cargo. Furthermore, this automated vehicle can be employed for days when charging and discharging are needed, accommodating both road-fed and rail-fed methods. In this area, automation surpasses the data that indicate between 1500 and 6000 tons of food are lost to waste from manual handling. For convenient monitoring and maintenance, the number of bags stacked and the total number of bags in a specific trip down are counted and updated in the dashboard.

Scissor Lift Specifications;
Scissor lift arm dimensions (in prototype) lxb: 30x3 cm
Number of scissor lift arm pairs used (in prototype): 6pairs (12 scissors)
Number of scissor lift arm pairs to be used (in product): Stainless steel high grade.
Material used for Scissors lift arm (in prototype): Aluminum sheet (2.5mm thickness).
Material to be used for Scissors lift arm (in product): Stainless steel high grade
Weight of each arm of dimension is 30x3cm

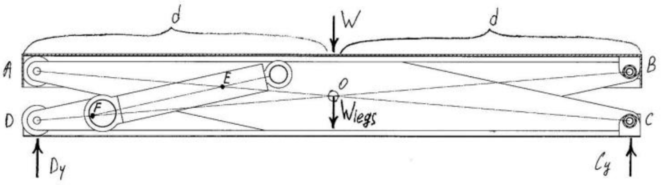

Fig.2 Free body diagram for the lowest position

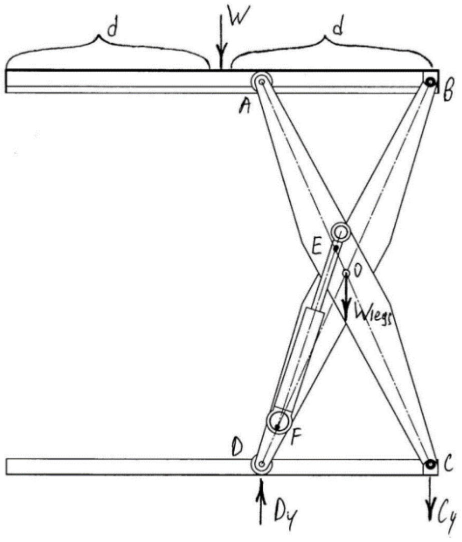

Fig 3 Free body diagram for the highest position

Mass on lift = 8 kg

Maximum Mass on Lift = 10kg

Mass of Top Frame = 3Kg

Mass of Each link = 600 g x 12

= 7200 g

Mass of links of cylinder mounting = 1.5kg

Mass of Cylinder = 4kg

Total Mass = 4 + 1.5 + 7.2 + 3 + 10

Total Mass = 25.7 - 30kg

Total Load = 25.7 x 9.8

= 250 – 300N

Table 1 From Analysis, it is found that a combination of twelve scissors can be able to lift weight of 4-6KG also scissor lift which consists of twelve pairs of scissors (each scissor of size 30x3 cm as mentioned above) is able to achieve a height of 60cm-75cm at a maximum inclination of 45 degrees. From analysis, it is found that safe angle for the scissor lift is 40-45 degrees inclination from horizontal axis, because when angle of inclination is more than 45 degrees, the sliding end of the scissor will cross the midpoint of whole scissor arrangement which leads to change in Center of Gravity of the whole system which causes loss in stability so it is concluded that while increasing the height of scissor lift, sliding end of scissor lift should not cross the mid-point. Six pairs (12 scissors) to achieve height of 70cm (about 2.3 ft) at maximum inclination of 40-45 degree from horizontal axis rather than using different number of scissors and different inclination angles.

Each Scissors has 3 connecting points, in which miniature bearings of inner diameter 4mm are placed which helps in avoiding friction between points while scissor lift height increases and decreases.

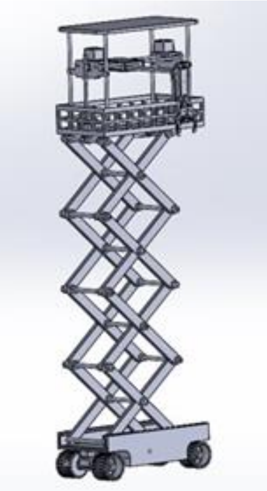

Fig 4 Extended Robot Isometric View

Fig. 4 show the design of the systems in isometric and orthogonal views of the scissor lift in the extended positions of 6 meters. After achieving the height of 6 meters the scissors are locked with hydraulic circuit and dynamic braking systems.

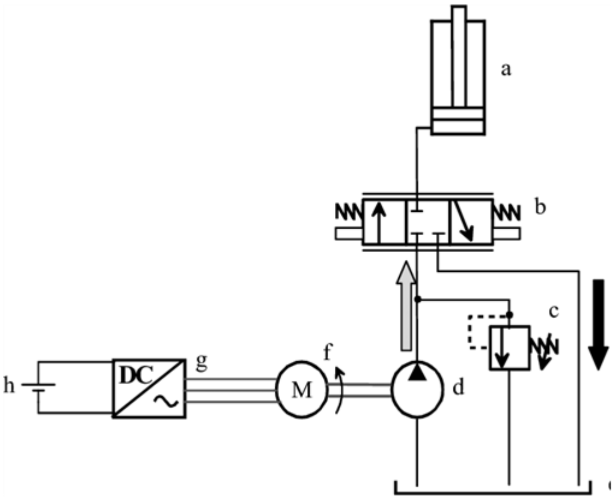

Fig. 5 Hydraulic circuit driving scissor lift mechanism.

Fig. 6 Hydraulic cylinder designed for the system.

A series of regulated movements are required for the hydraulic circuit of a scissor lift to function: The fluid is pressurized by the hydraulic pump and directed to the double-acting cylinders by the directional control valves. The cylinders' flow direction can be adjusted to raise or lower the platform as desired. The platform is held in place by the valves shifting to the desired height, and the lift's position is preserved by the check valves preventing fluid backflow. All things considered, the hydraulic circuit powering a scissor lift mechanism provides accurate control, stability, and dependability while lifting big objects or securely raising people to different heights. To guarantee appropriate operation and safety, the hydraulic system must undergo routine maintenance and monitoring. The solenoid operated DCV in the hydraulic circuit above can be remotely regulated and is able to run on a 24 DC power supply. The hydraulic cylinder is 400 mm (about 1.31 ft) in stroke and 70 mm (about 2.76 in) in diameter. The system uses a gear pump type hydraulic pump that runs at 116 bars. In the hydraulic system, the hydraulic oil tank has a capacity of about 40 litres. The maximum piston force and the hydraulic cylinder diameter were taken into consideration while determining the pump pressure value of 116 bar.

2. Cartesian Bot:

A gantry robot, or Cartesian robot system, functions in a three-dimensional space that is specified by Cartesian coordinates (X, Y, and Z). Explained in Fig. 8and 9. Cartesian robots use linear motion along each axis, as opposed to multiple-joint robots, which allows for precise and controlled movements. Due to their versatility, these robots are frequently used for pick-and-place jobs, assembly, material handling, and loading and unloading machines. A moving carriage containing the end effector, a stationary base, and vertical and horizontal beams forming a gantry make up the usual structure. Cartesian robots are excellent at activities requiring a high degree of precision and accuracy because of their simple linear movements. Fig 7 & 8shows the movement of gantry robot, Coordinates make programming easier to understand and more approachable for users of different skill levels. For applications requiring precise linear motions inside a predefined space, Cartesian robots provide affordable options, despite the potential for limited flexibility due to their set workspace. The incorporation of a cartesian robot structure enables the bags to move in three dimensions as they are picked by the claw. The grasped claw on one end of the structure, intended to pick up bags weighing between 50 and 75 kg, is coupled to this system, which simulates CNC action. Stepper motors linked to the rods for each axis are used to activate the construction.

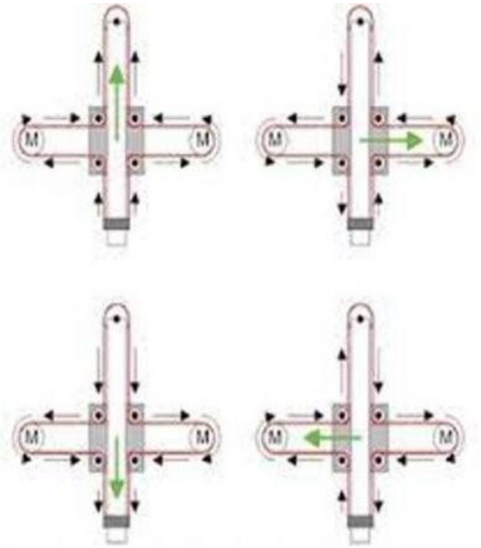

Fig. 7 – Cartesian Bot Movement Methodology

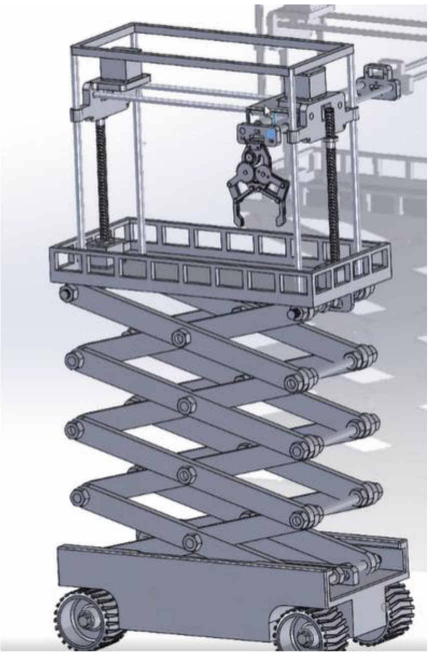

Fig. 8 – Cartesian Bot Actuation in Design

3. Picking claws:

The bags may be easily picked up and placed with the help of the flexible, effective claw mechanism, which also ensures that no bags are tampered with or damaged during the process. The flexibility provided by the claws is striking. The claw can be adjusted to preserve the stability of the stacked pieces. The claw's grasping components, which resemble spider and needle grippers, are part of its design. This guarantees that the bags, once selected, remain whole until they are properly positioned.

4. Four-wheel mechanisms:

By providing power to all four wheels at once, the Four-Wheel Drive (4WD) mechanism is an advanced automobile system that improves traction, stability, and performance. Modern off-road vehicles, sports automobiles, and utility vehicles all use this feature, which helps to increase control and maneuverability in a variety of driving situations. The operation, advantages, and applications of the Four-Wheel Drive mechanism are highlighted in this abstract, which offers a thorough review of its main features. In order for each wheel to receive torque independently, the Four-Wheel Drive system distributes power to both the front and rear axles. A transfer case, which can be operated manually or electronically, controls this power distribution. When all four wheels are engaged, traction is improved, particularly on difficult situations like mud, snow, or uneven ground. Delivering improved off-road performance is one of the main benefits of the 4WD mechanism. The car can travel across uneven ground, steep incline, and slick surfaces with more stability and fewer risks of becoming stuck if all four wheels are engaged. Because of this, 4WD is the best option for off-road aficionados, intrepid travelers, and utility vehicles used in harsh conditions.

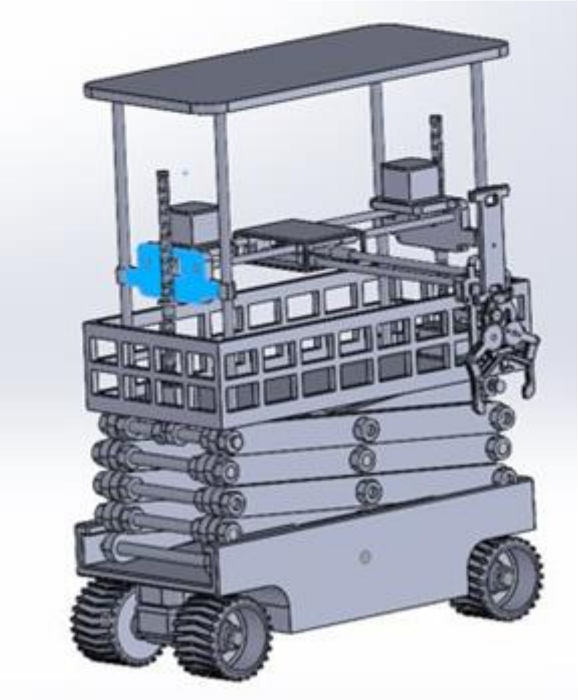

Fig. 9 Mechanized robot with 4WD design

As Shown in the Fig. 9 the Four-Wheel Drive system enhances the vehicle's handling and stability on a variety of road conditions. 4WD improves the vehicle's grip and responsiveness in inclement weather, including rain or snow, which lessens the chance of skidding or losing control. For drivers looking for a safe driving experience in erratic weather, this function is especially helpful.

Electronic control system improvements have aided in the development of four-wheel drive technology, enabling instantaneous switching between two-wheel drive and four-wheel drive modes. By allowing drivers to engage 4WD only when essential and save energy during normal driving situations, this versatility improves fuel efficiency.

To sum up, the Four-Wheel Drive system is an adaptable automotive technology that significantly improves the performance, stability, and versatility of vehicles. It is a crucial component of the automotive industry because of its broad range of applications, which go beyond off-road enthusiasts to include a variety of vehicles. Given that 4WD continues to influence modern vehicle design and functionality, it is imperative that both automotive engineers and end users comprehend its guiding principles and advantages.

B. Electrical Design:

For rice bag stacking and de-stacking, automatic palletizers with complex electrical and electronics design are essential to the smooth operation of the systems. Important technological aspects of this design include:

I) Control Systems:

An automatic palletizer's complex control systems are its essential component. These systems coordinate the entire process by utilizing microcontrollers and programmable logic controllers (PLCs). They process data from a variety of sensors and Human-Machine Interfaces (HMIs), running algorithms to provide smooth bag recognition, organized stacking, and accurate control over the actions of robotic or lifting mechanisms.

II) Sensor and Vision System:

The system uses a plethora of sensors, including as load cells, photoelectric sensors, and proximity sensors, to closely monitor a variety of factors. Accurate placement, exact alignment, and bag recognition are made possible by vision systems, which combine cameras and computer vision algorithms.

III) Human Machine Interface:

Providing an intuitive interface for system management, ongoing monitoring, and effective troubleshooting, HMIs are essential for operator 20 engagement. In the operational environment of India, HMIs that are easy to use are essential for enabling operators to monitor the system and make real-time adjustments.

IV)Electrical Wiring and Power Distribution:

The wiring, cabling, and power distribution configurations within the system are all precisely outlined in the electrical design. This careful planning guarantees the safe and dependable delivery of electrical power to all parts, including actuators, control systems, and motors.

V) Safety Systems:

Recognizing that safety comes first, the design incorporates safety sensors, interlocks, and emergency stop buttons. These elements comply with strict industry safety regulations and act as a barrier to safeguard both people and the system.

VI)Energy Efficiency:

Optimal power usage is given top priority in the electrical and electronics design in response to the growing emphasis on sustainability. This entails implementing power-saving features in the control system and deploying energy-efficient components.

VII) Remote Monitoring and Diagnostics:

Since many rice mills are located across large geographic areas in India, it is essential to have remote monitoring and diagnostic capabilities. This cutting-edge feature reduces downtime by facilitating real-time system status monitoring and enabling the remote detection and resolution of issues.

VIII) Scalability and Futureproofing:

Scalability was considered throughout the design process to ensure that it could be easily expanded upon or altered in the future. In the ever-changing Indian rice business, where operational requirements are subject to change over time, this anticipatory function is invaluable. The electrical and electronics systems' intricate designs seen in automatic palletizers are an example of a complex, interdisciplinary project requiring knowledge of automation, electrical engineering, and control systems. These complexly engineered systems are essential to guaranteeing the dependability and effectiveness of rice bag handling, which is why they are so important to the food supply chain's optimization.

C. Software Integration:

In the modern paradigm of robotic palletizers designed for the stacking and de-stacking of rice bags, artificial intelligence (AI) software automation plays a crucial role. These cutting-edge AI-powered solutions combine the best aspects of data analytics, computer vision, and machine learning to improve the accuracy, speed, and versatility of handling rice bags in the complex Indian industrial environment. The following is a detailed explanation of the technical nuances that define AI software automation in automatic palletizers:

I) Bag Recognition and Classification:

AI software meticulously recognizes and classifies rice sacks by utilizing computer vision. Through close examination of images obtained with specialized cameras, the system can identify subtle characteristics such bag size, kind, weight, and other data that are essential for the accurate handling of bags by robotic objects or lifting mechanisms.

II) Optimized Stacking Patterns:

22 Rice bag stacking patterns that maximize efficiency are meticulously determined by AI systems. Pallet dimensions, weight, and size are among the criteria that the programmed takes into account while creating the best configurations to increase pallet capacity and strengthen stability.

III) Dynamic Adjustment:

AI software enables flexible real-time palletizing, which is crucial considering the regular variations in bag sizes and weights in the Indian rice market. This dynamic response ensures accurate stacking under different settings.

IV)Predictive Maintenance:

The system uses artificial intelligence (AI) to prognosticate maintenance needs by analyzing sensor data and consumption trends. This proactive strategy reduces downtime, extending the palletizer equipment's operational life.

V) Quality Control:

Automated artificial intelligence procedures inspect rice bags for flaws or contamination, rerouting inferior bags to specific locations. Palletized stacks are guaranteed to include only flawless bags according to this rigorous quality control system.

VI)Data Analytics and Reporting:

AI software collects and analyses a vast amount of data related to palletizing activities. It compiles this data into reports that show system performance, productivity, and efficiency, enabling data-driven decision-making and process optimization.

VII) Integration with Warehouse Management Systems:

Order fulfilment, dynamic inventory management, and real-time tracking of inventory levels are made possible by AI software's seamless integration with warehouse management systems (WMS). This guarantees that goods are carefully prepared for shipment in compliance with consumer demands.

VIII) Remote Monitoring and Control:

Automatic palletizers powered by AI provide remote control and monitoring capabilities. Operators can make changes from anywhere in the world since they have access to real-time data. This feature is very helpful for rice mills located in isolated areas.

IX) Scalability:

The inherent scalability of AI software allows facile expansion to accommodate burgeoning operational demands. As the Indian rice industry undergoes growth, the system seamlessly adapts to handle augmented volumes of rice bags with unwavering efficiency.

Finally, AI software automation in automatic palletizers represents the highest level of innovation in the rice sector. Palletizing is not just a way to make things run more smoothly; it also serves as a foundation for improved quality assurance, lower labour costs, and higher safety requirements. Given the vast market dynamics of a country like India that consumes a lot of rice, integrating AI-driven systems becomes essential for satisfying and even exceeding market needs.

D. Autonomous Path Planning:

The increasing complexity of production processes and the need for improved safety, adaptability, and efficiency in industrial settings have led to the demand for autonomous path planning in industrial robots. This abstract delves into the crucial function of autonomous path planning within the field of industrial robotics, clarifying its importance, obstacles, and revolutionary influence on contemporary industry. Industrial robots play a critical role in increasing production and accuracy by automating complex and repetitive activities. But to make the best use of these robots, they must be able to maneuver through constantly shifting settings and overcome unforeseen challenges. This problem is tackled by autonomous path planning, which gives robots the intelligence to choose the best, most collision-free routes to complete jobs on the fly. The dynamic character of manufacturing processes is a major motivator for the use of autonomous path planning. Robots must be able to navigate through challenging and dynamic settings as manufacturing lines become more adaptable and flexible to meet market needs. Industrial robots with autonomous path planning can work alongside humans and around barriers with efficiency. They can also adjust to changes in the workplace configuration without requiring manual reprogramming.

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RESULTS AND DISCUSSION

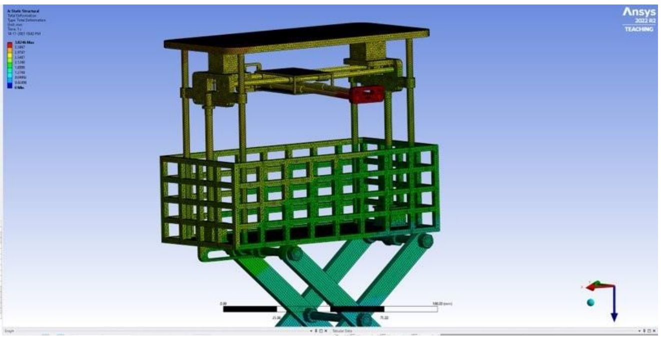


Fig. 10 Mechanical Analysis of the Structure

The mechanical analysis is done with the actual dimensions and actual load conditions. Which will more effective for making it into a product at real time situations. Fig. 10 Shows the analysis window of Ansys Software tool. The stress and strain results are discussed in the following.

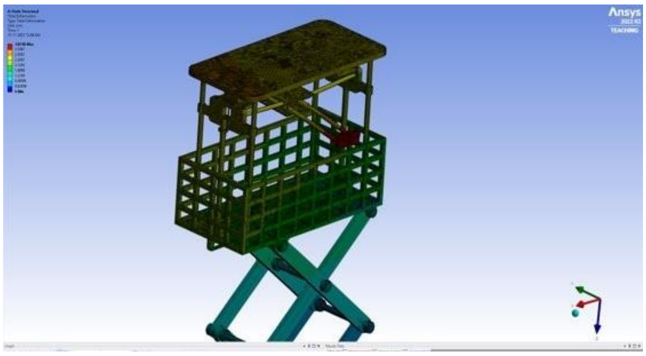


Fig. 11 Total stress in design

The total Stress is resulted as 2.93 MPa which is minimal for this heavy load and weight conditions. Fig. 11 shows the total stress that is obtained for the real time load as 750 kgs, which is equivalent to 15 rice bags.

Fig. 12 Total strain in design

The total strain of the system is also analysed with the same real time conditions, As shown in the Fig. 12, The resulted total strain is about only 3mm which is very low as the system extends up to 0.9 metres outside.

In this automation, cartesian robots emerge as a key component, offering dependable, high-throughput, and configurable stacking and de-stacking processes. In large-scale rice mills, their capacity to establish optimal stacking patterns, safety measures, and integration with conveyor systems make them important. There is a tendency toward automation in the rice processing business, as evidenced by the large use of Cartesian robots in major Indian factories like LT Foods and KRBL. Control systems, sensors, wiring, human-machine interfaces, and safety features are the main areas of attention for electrical design, which guarantees a reliable and energy-efficient operation. AI-driven software automation improves quality control and remote monitoring by strengthening the system's precision, adaptability, and predictive maintenance capabilities. The integration of path planning, computer vision, kinematic modelling, sensors, safety features, communication protocols, instruction, programming, and remote monitoring is highlighted in the electronic control’s approaches. These studies provide valuable perspectives on the conception, advancement, and utilization of palletizing robots, providing a thorough grasp of the current state-of-the-art in this domain.

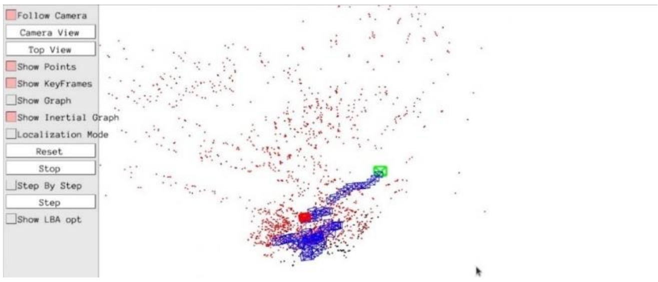
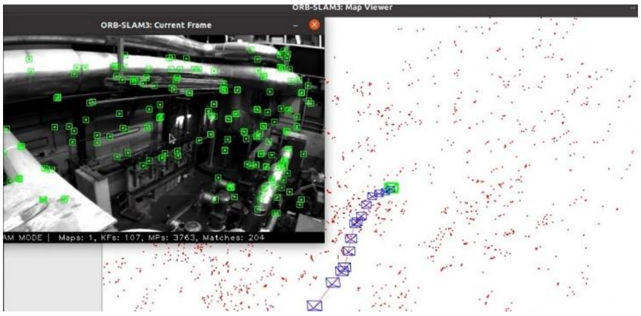


Fig. 13 SLAM simulation

When integrating autonomous path planning into industrial robots, safety is of utmost importance. The capacity to create paths free from collisions lowers the possibility of mishaps and improves cooperation between humans and robots. Advanced path planning algorithms on robots enable them to proactively identify and avoid impediments, creating a safer working environment for both human operators and machines. Autonomous path planning directly leads to improvements in manufacturing process efficiency. These systems minimize cycle durations, lower energy consumption, and improve overall operational efficiency by optimizing the trajectory of robotic motions. This is especially important in sectors like electronics manufacturing and automotive assembly lines where speed and accuracy are critical. The use of advanced algorithms, real-time data processing, and reliable sensing technologies are obstacles in the implementation of autonomous path planning. In order to guarantee the dependability and efficiency of autonomous path planning systems in industrial environments, several obstacles must be overcome.



AM MODE | Maps: 1, KFs: 107, MPs: 3763, Matches: 204

Fig. 14 Realtime object Detection

In summary, current manufacturing environments require greater adaptability, safety, and efficiency, which is why autonomous path planning is necessary for industrial robots. Intelligent path planning algorithms enable industrial robots to work in harmony with humans by enabling them to navigate intricate environments and adapt to changing conditions. Autonomous path planning will be essential in determining how intelligent and flexible industrial robotics become in the future as technology develops

Fig. 13 and 14 Shows the output of autonomous path planning simulation with SLAM. An important technological achievement in the rice sector is the installation of an automatic palletizer system in India that uses precision grippers, scissor lifts, AGVs, Cartesian robots, and an AI-driven control system to stack and de-stack rice bags. The labor-intensive nature of handling rice bags is addressed by the system, which provides a revolutionary way to improve productivity and reduce the dangers to worker safety involved in physical labor. This system uses a variety of technologies, including as computer vision, sophisticated robotics, and AI-driven automation, to ensure exact movements and optimal stacking patterns after thorough research. A more efficient process is achieved by the use of pick-and-place mechanisms, layer formation, conveyor systems, orientation modification, pallet moving, and optimized stacking patterns. A variety of lifting mechanisms are available to accommodate different bag sizes and weights that are commonly used in the Indian rice industry. These mechanisms include vacuum lifting, clamp-based lifting, forklift-style lifting, pneumatic or hydraulic lifting, robotic arm lifting, and counterbalanced lifting. In this automation, cartesian robots emerge as a key component, offering dependable, high-throughput, and configurable stacking and de-stacking processes. In large-scale rice mills, their capacity to establish optimal stacking patterns, safety measures, and integration with conveyor systems make them important. There is a tendency toward automation in the rice processing business, as evidenced by the large use of Cartesian robots in major Indian factories like LT Foods and KRBL. Control systems, sensors, wiring, human machine interfaces, and safety features are the main areas of attention for electrical design, which guarantees a reliable and energy-efficient operation.

AI-driven software automation improves quality control and remote monitoring by strengthening the system's precision, adaptability, and predictive maintenance capabilities. The integration of path planning, computer vision, kinematic modelling, sensors, safety features, communication protocols, instruction, programming, and remote monitoring is highlighted in the electronic controls approaches. These studies provide valuable perspectives on the conception, advancement, and utilization of palletizing robots, providing a thorough grasp of the current state-of-the-art in this domain. In summary, the introduction of an automated palletizer system in the rice sector of India represents a social as well as a technological advancement, with benefits including increased productivity, decreased reliance on labour, and increased safety. The integration of these sophisticated technology has the potential to completely transform the rice sector, in line with India's overall industrial automation trend. The system has the potential to positively affect the technological and social aspects of India's rice sector as it develops by bringing about safer working conditions, cost savings, and higher production.

SUMMARY AND FUTURE SCOPE

An innovative development in the rice sector is the automatic palletizer that was introduced in India to stack and de-stack rice bags. It integrates AGV, Cartesian robots, and AI-driven control systems. This approach increases efficiency, lowers human labor, and improves safety; it has been proven by research from multiple studies. The future looks bright for improving the electrical layout, automating additional tasks with AI, and deploying Cartesian robots in more rice mills. The system's performance in government warehouses points to an increasing trend in industries toward automation. This innovation fits in with India's larger industrial automation trajectory while also addressing present issues and offering potential for improved productivity, cost-effectiveness, and safer working environments.

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