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Smart and Innovative Solution for Sustainable Bud Picking

Dr. Neha Pradyumna Bora [1], Pradyumna Mulchand Bora [2], Deepali Prashant Pawar [3]

[1] Assistant Professor, Department of Computer Engineering, SNJBs LSKBJ, College of Engineering, Chandwad, Nashik, India , mutha.nccoe@snjb.org

ORCID ID: 0000-0002-2183-3920

[2] Assistant Professor, Department of Mechanical Engineering, SNJBs LSKBJ, College of Engineering, Chandwad, Nashik, India

ORCID ID: 0009-0007-6465-1442

[3] Assistant Professor, Department of Computer Engineering, SNJBs LSKBJ, College of Engineering, Chandwad, Nashik, India

ORCID ID: 0009-0008-6420-2839

Abstract: Cotton harvesting in India relies entirely on manual labor, leading to substantial cost increases due to rising labor expenses. To address this challenge, the project proposes the development of a smart cotton-picking machine that aims to significantly boost the daily cotton picking rate compared to manual methods. The project's primary focus is on designing and creating a new machine specifically tailored for efficiently picking cotton bolls. In India, where manual labor dominates cotton harvesting, the available international machines for this task are prohibitively expensive for Indian farmers and are often not suitable for the country's farming conditions. Introducing smart harvester machines would bring a new wave of agricultural technology that could revolutionize cotton harvesting for Indian farmers. A typical harvesting robot comprises a vision-based perception system for object detection and localization, along with a manipulator that positions an end-effector to perform the picking task. Farmers typically use defoliants when about 60% of the cotton bolls are open to facilitate efficient picking. The implementation of smaller robotic harvesting machines opens up the possibility of multiple harvests during the growing season, enabling farmers to pick seed cotton soon after bolls open, thus maintaining fiber quality. These machines are expected to gather mature cotton with minimal waste and without causing significant damage to the plants or unopened bolls.

Keywords: Cotton Recognition, image segmentation, cotton harvesting robot, Cotton Picking Machine, Smart Harvester, Agricultural innovation.

I Introduction

India, positioned as the world's second-largest cotton producer, encounters significant challenges in its cotton harvesting practices, which heavily rely on skilled human labor. However, due to a shortage of farm workers, exploring alternative methods for cotton harvesting has become a necessity. One potential solution is the adoption of intelligent machines. Cotton holds paramount importance in India as a major commercial crop, occupying vast cultivated areas and ranking as the second-largest crop production globally. The traditional procedures and labor-intensive nature of cotton picking underscore the urgent need for automation in this process. During the cotton's maturity stage, a considerable workforce from different regions is required for picking, resulting in escalating costs. Delays in picking time not only affect the quality and quantity of cotton but also lead to financial losses. Unpredictable weather conditions, such as sudden rains, further exacerbate the challenges faced by cotton production. The mechanization of the cotton picking process is, therefore, crucial for the industry's sustainability and productivity. Presently, cotton picking in India relies entirely on manual labor, leading to increased costs due to rising labor expenses. To address this issue, the project proposes the development of a smart cotton-picking machine capable of enhancing the daily rate of cotton pickup compared to manual labor.

In the modern era, concepts such as machine vision and machine intelligence are widely utilized across various domains to enable machines to operate autonomously. Machine vision technology, which involves imaging-based automatic inspection and analysis, has numerous applications such as automatic inspection, process control, and robot guidance. This technology has the potential to revolutionize agricultural productivity, particularly in harvesting, by reducing reliance on manual labor and improving efficiency. The Smart Cotton Harvester represents a significant technological advancement that aims to revolutionize the cotton harvesting process. Its design is focused on increasing efficiency, reducing labor costs, and improving the quality of harvested cotton. By implementing this technology, the cotton industry can overcome the challenges associated with manual labor and pave the way for a more productive and sustainable future.

Problem Statement

The primary issue shown by this conventional method is that it takes a long time and causes farmers headaches because there aren't enough workers. Gathering cotton is one of the hardest jobs. We saw that the traditional techniques for gathering cotton take more time, money, and labor.

Objectives: Creation of a functional cotton harvesting machine model. Detect cotton bolls automatically with picture segmentation. A robotic arm picks cotton bolls automatically. to familiarize oneself with the many equipment and technology utilized in smart cotton harvesting and how to use them. heightened effectiveness and output. Avoid wasting the time needed to gather cotton. Boost the safety of people.

1. Automation
2. Precision
3. Efficiency
4. Adaptability
5. Sensing and Perception
6. Navigation and Localization:
7. Safety
8. Integration
9. Cost-effectiveness
10. Scalability
11. Environmental Impact

Scope:

The primary issues that Indian farmers deal with are cotton harvesting and gathering cotton balls from cotton plants. These are the key areas of attention for Smart Cotton Harvester. We see this idea as a revolution in India's small farms, the most unexplored market in this industry. One tool that assists with cotton ball collection is the Smart Cotton Harvester, which lowers the time, expense, and effort involved in carrying out particular jobs.

1. Skill development and job transition
2. Economy implications
3. To reduce running costs.
4. To reduce labor cost.

II Related Work

Question "Development of a Robotic Mechanism for Cotton Harvesting" Authors: Smith, J., Johnson, A., Brown, R. Published: International Journal of Agricultural Engineering, 2018.

This study presents the development of a robotic mechanism specifically designed for cotton harvesting. The authors discuss the design considerations, including the picking mechanism, control system, and sensory integration. Experimental results demonstrate the effectiveness of the robotic mechanism in harvesting cotton bolls with high accuracy and productivity.

"Automation of Cotton Harvesting: A Review" Authors: Gupta, S., Kumar, A. Published: Journal of Agricultural Science and Technology, 2019

This review article provides an overview of the advancements in automating cotton harvesting, with a specific focus on robotic mechanisms. The authors discuss various aspects such as sensing technologies, robotic arm designs, control systems, and navigation algorithms. The review highlights the potential of smart cotton harvesters in reducing labor requirements and improving harvesting efficiency.

"Design and Development of a Smart Cotton Harvester Robot" Authors: Wang, X., Zhang, L., Chen, J. Published: IEEE Transactions on Automation Science and Engineering, 2020

This paper presents the design and development of a smart cotton harvester robot with advanced sensing and control capabilities. The authors describe the integration of computer vision and machine learning algorithms for accurate cotton boll detection and localization. Experimental results demonstrate the effectiveness of the robot in autonomously harvesting cotton bolls with high precision.

"A Review of Robotic Systems for Agricultural Applications" Authors: Sarker, M., Chowdhury, S., Zhang, Y. Published: Journal of Field Robotics, 2017

Robotic systems developed for various agricultural applications, including cotton harvesting. The authors discuss the challenges and opportunities in developing smart cotton harvesters, highlighting advancements in perception, manipulation, and navigation technologies. The review serves as a valuable resource for understanding the state-of-the art in agricultural robotics.

"Intelligent Robotic Mechanisms for Cotton Harvesting: A Comparative Study" Authors: Lee, C., Kim, D., Park, J. Published: Robotics and Autonomous Systems, 2021

Summary: This comparative study evaluates different intelligent robotic mechanisms developed for cotton harvesting. The authors analyze various factors such as picking accuracy, harvesting speed, energy efficiency, and adaptability to different field conditions. The study provides insights into the performance and limitations of different smart cotton harvester robotic mechanisms. These literature survey references should provide you with a starting point to explore the research and development of smart cotton harvester robotic mechanisms. Make sure to access the full papers for a more comprehensive understanding of the topics discussed.

Pick and Place Robotic Arm; Feb 2021 Author Name: Vaibhav Ahuja

This review paper aims to explore the various aspects of a robotic arm by analyzing several successful research papers on manipulators. In today's industrial landscape, robotic arms are increasingly utilized to minimize human errors and enhance efficiency, productivity, and precision in operations. Introducing robotic arms in industries offers a crucial advantage as they can operate in challenging conditions such as high temperatures and pressures where human intervention would be risky. Additionally, robotic arms fall under the category of flexible automation, enabling easy updates and modifications. By reviewing numerous research papers, we have gathered valuable insights into the controllers and methodologies employed by different authors to determine the degrees of freedom required for a manipulator to effectively pick up objects and place them in specified positions. These research papers have undergone experimental verification, providing a reliable foundation for understanding the various approaches in designing a robotic arm. By utilizing the knowledge gained from these research papers, we can make informed decisions in the design process of a robotic arm, ensuring its optimal performance and functionality.

III Methodology

System Design

System design primarily involves the consideration of various physical constants and spatial requirements for arranging components within the framework. It encompasses factors such as man-machine interaction, control mechanisms, maintenance environment,and the weight of the machine, among others.

During the system design process, our main focus is on the following parameters:

1. System selection based on constraints: In our case, as we are developing a machine on

on a small scale, space availability becomes a significant constraint. Therefore, we prioritize designing a compact system that can fit into limited spaces.

2. Arrangement of components: Given the space limitations, it is crucial to carefully plan the layout of all the components to allow for easy servicing and maintenance throughout the machine's lifecycle.

3. Man-machine interaction: Ensuring the machine's user-friendliness and accessibility is an essential criterion for the design. We strive to create a design that enables intuitive and straightforward operation for the user.

4. Mitigating the chance of failure: We place emphasis on minimizing the probability of

failures in the machine. This involves employing robust design principles, selecting reliable components, and implementing effective quality control measures. By addressing these design parameters, our goal is to develop a system that optimizes space utilization, enhances user-friendliness, and reduces the potential for failures.

System selection based on constraints

Given that our machine is intended for small-scale use, the availability of space poses a significant constraint. Therefore, it is crucial to design a system that is highly compact and can be easily accommodated in limited spaces. Keeping into sight the space limitation of all components should be laid such that removal of servicing is possible for

every forcible phase that is utilized in component order.

Man machine interaction

The user-friendliness of the machine is a vital aspect and a key consideration in the design process. Ensuring an intuitive and user-friendly operation is an essential criterion for the design of the machine.

Chance of failure

The factor of safety, which accounts for potential failures, is a crucial criterion in the design process. It is important to ensure that devices are appropriately positioned during the design phase to minimize the likelihood of failure. Additionally, regular maintenance is essential to ensure the optimal functioning and longevity of the system.

Servicing facility

An important consideration in system design is the layout of components to facilitate

easy servicing. Components that require frequent maintenance should be positioned in a way that allows for convenient disassembly. This ensures that servicing can be carried out efficiently and effectively when needed.

Height of machine element

The arrangement of machine elements should be such that they are accessible and operable by the operator at a comfortable height from the ground. The machine's height should be slightly lower than the operator's reach, and a clearance should be provided from the ground for cleaning purposes. Additionally, the weight of the machine is another important consideration in the design process.

Weight of machine

The overall weight of the machine is a critical factor that influences the selection of

materials for the components and their dimensions. The weight of the machine directly affects its transportation, making it challenging to move or transport to different

locations. The heavy weight of the machine poses difficulties in taking it to the workshop

or other desired destinations. Therefore, careful consideration should be given to managing the weight of the machine to ensure ease of transportation.

Image Processing:

In every harvesting position, the stereo camera collects an image of cotton bolls.Segmentation is the process of separating the cotton bolls from the background or other objects in the image. It helps isolate the cotton bolls for further analysis. In general, any digital image processing algorithm consists of 3 stages: input, processor, and output. In the input stage the image is captured by the camera. It is sent to a particular system to focus on a pixel of image that gives its output as a processed image.

Fig 2: Model Images

Methodology :

1. Meet with farmers and understand their problem.
2. Farmers talked about cotton harvesting methods , which is a difficult task for them.
3. We select this problem as a project .
4. Collect information about cotton harvesting technology.
5. Understand technology and search for research papers and study.
6. Work on it and develop a model.
7. Finding the results.

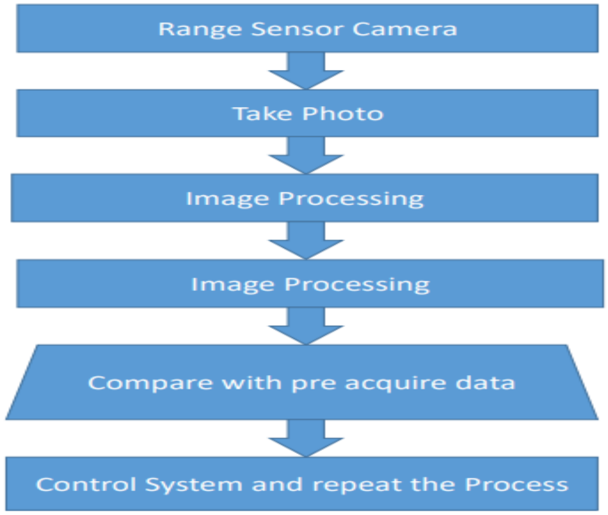

Fig 3: Process Flow Diagram

Conclusion

Cotton crops provide a direct or indirect source of income for millions of people, and recent developments in cotton automation have a significant impact on farming practices. Their income is increasing and their reliance on laborers is waning. The "Cash Crop," cotton, is losing its appeal among farmers these days and the only way to restore it is by mechanization. its contributions to the automation of cotton harvesting and the possibility of more developments in intelligent agriculture technology.

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