Solar powered Rover for Seed Sowing

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Abstract— Solar powered seed sowing rover is a unique system which introduces a Solar-Powered Autonomous Rover for optimizing seed sowing in varying soil moisture conditions, focusing on sustainable and tech-driven agriculture. This paper's impact on the development of Solar energy powered eco-friendly rover, integrating a moisture sensor for intelligent seed placement. A robust mechanical structure and advanced control system enable autonomous navigation and precise seed dispensing, promoting healthier crop growth. The system uses GPS guidance for efficient coverage of farming areas. Real-time data from sensors and cameras allow farmers to monitor soil conditions and customize seed distribution based on moisture levels. This integration of renewable energy, autonomous navigation, and data-driven decision-making empowers farmers to enhance crop yield and promote sustainable agriculture. The rover avoid the complete human interference from field path to complete seed sowing at equal distance, Overall this paper represents a significant advancement in leveraging renewable energy and technology for precision agriculture, benefiting farmers and the environment through enhanced crop growth and resource conservation.

Index Terms— Agriculture, Autonomous, GPS, Rover, Sensor

I. INTRODUCTION

According to projections, the global population is anticipated to exceed 8 billion by the year 2035, leading to a surge in global food consumption. To address this challenge, there's an urgent need to systematically enhance the entire planting process to optimize growing capabilities and meet the escalating demand for food.

Agriculture is embracing automation in both agricultural product manufacturing and field cultivation techniques. Subjective processing has emerged as a practical technology in agricultural services, facilitating the understanding, analysis, and response to diverse circumstances to improve efficiency. Proximity sensors, humidity sensors, and image sensors are key technologies being employed, often combined judiciously to provide comprehensive information. Soil analysis, as an example of high-resolution data, plays a crucial role in this context. Proximity detection, requiring sensors to be in close contact with the ground, aids in characterizing soil composition below the surface at specific locations within a field, as demonstrated in [1]. While experienced farmers are familiar with traditional multi-row planting equipment as in [2], recent studies explore the integration of automation and robotics in the seed sowing process. The focus is primarily on the development and utilization of smart agricultural robots to enhance precision and efficiency in agricultural practices.

The Solar-Powered Seed Sowing Rover signifies more than just technological prowess; it represents a paradigm shift in agricultural practices, ushering in an era of enhanced efficiency, productivity, and environmental stewardship. This groundbreaking invention is poised to make a significant impact on global agriculture by addressing common restrictions faced by farmers in traditional sowing methods, refer to reference number as in [3]:

- Inconsistent distribution of seeds in the crop field.
- Gaps between plants due to inconsistent seed distribution.
- Dead seeds resulting from incorrect seed placement depths in the soil.

The Solar-Powered Seed Sowing Rover promises to revolutionize agricultural practices by offering precise planting capabilities, optimizing seed distribution, and reducing wastage. Its potential impact on global agriculture is vast, as it embodies a beacon of hope for a sustainable future, where innovation and environmental responsibility are intertwined.

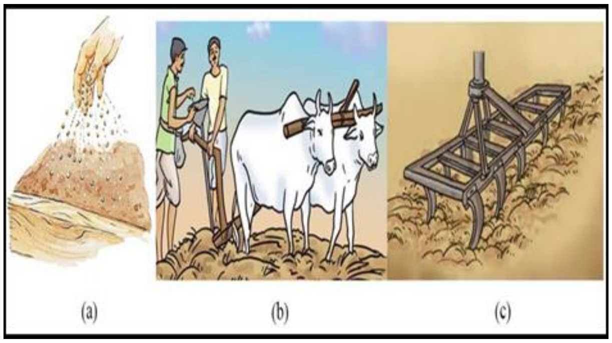


Figure 1. Classical methods of sowing seeds-(a) Hand Method -(b) cow sowing -(c) Tractor sowing machine

Classical methods of sowing and spraying, depicted in Fig 1, are prevalent across the country but result in low yields, as evidenced in [4]. Additionally, factors such as insufficient energy availability and low mechanization rates further hamper crop productivity. Delays in various agricultural processes including sowing, harvesting, threshing, and inadequate nursery preparation exacerbate the issue, leading to reduced crop productivity. Given the rapid pace of industrialization and the consequent population growth, agricultural modernization is imperative to meet escalating food demands, as noted in reference no [4].

To address these challenges, various agricultural mechanisms have been developed to expedite the seed distribution process in the crop fields. The manual planter as in [5], requires farmers to operate it, utilizing wheel rotation to activate the seed release mechanism. In contrast, electric seed planters utilize diesel engines or electric motors to drive internal mechanisms and are commonly mounted on tractors. However, these systems suffer from low energy efficiency, necessitating substantial labor or reliance on fossil fuels for operation.

II. LITERATURE WORK

As there is currently inadequate equipment to support farmers, the implementation of new technologies is imperative to empower them and meet the global demand for food.

"Reference [6]" authored by H. Pota, R. Eaton, J. Katupitiya, and S. D. Pathirana, highlights the necessity of sowing bulk seeds due to the shortage of skilled sowers. Factors such as planting distance and plant population significantly influence crop yield. The use of mini computers, particularly the Rasp Pi Pico, facilitates communication between input and output devices, aiding in optimizing agricultural processes.

"Reference [7]" discusses automatic tillage and sowing mechanisms, emphasizing the utilization of solenoids for automatic sowing. Soil moisture sensors integrated with Rasberry Pi and internet applications enable real-time monitoring of soil water levels. Rasberry Pi Pico serves as a communication interface with the rover, while internet systems enable farmers to remotely communicate with robots, thereby automating processes and alleviating the burden on farmers
.

"Reference [8]"shows the focus is on the development of GPS-guided automatic movement and seed placement. The research delves into studying specific distance parameters and feeding this information to the Rasp Pi Pico to precisely place seeds in the terrain based on GPS coordinates. The paper extensively explores the functionality of GPS systems in guiding the robot's movements and seed placement.

These references collectively underscore the importance of technological innovation in agriculture, ranging from bulk seed sowing to automated tillage and GPS-guided seed placement. Through the integration of advanced technologies like the Rasp Pi Pico and internet connectivity, farmers can enhance productivity and meet the demands of a growing population more efficiently.

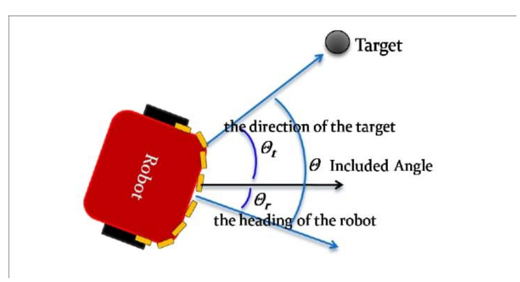


Figure 2. An included angle of the direction of the target and the heading of the robot

The above research articles have helped us to understand the different aspects induced by research on agricultural rovers. The rover designed in the literature search above has many issues with the rover's movement, sowing, power issues and other accuracy concerns. These questions are effectively addressed in this task. This work alsosheds light on the future range of robot.

III. THEORY OF SEED SOWING

Sowing seeds involves placing them beneath the soil to facilitate germination and plant growth, whereas planting involves placing propagules like seedlings, roots, tubers, leaves, or cuttings in the soil for growing plants. Propagules may be directly sown or transplanted. Various methods of sowing seeds are employed in agriculture, including:

- Drilling
- Dibbling
- Broadcasting
- Sowing with bamboo plough

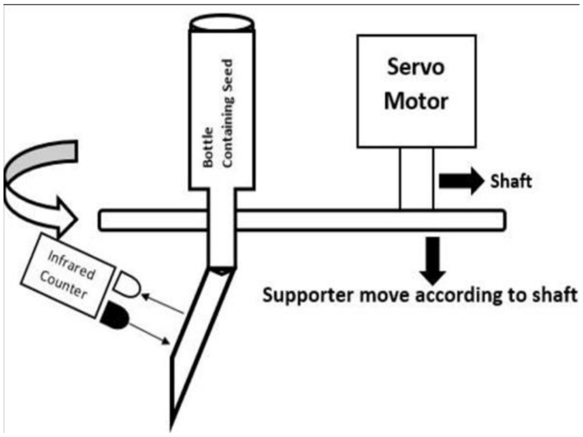


Figure 3. Seed dropping mechanism from seed container along with infrared based seed counter

Despite the availability of these sowing techniques, conventional methods present limitations such as the inability to achieve uniform seed distribution by hand, inadequate control over sowing depth, and high labor requirements. These limitations often result in uneven seed placement depths, which can adversely affect plant growth and overall crop yield.

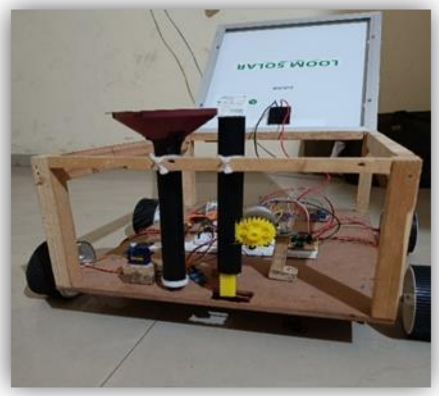
The technique which we have develop is that all seeds are collected in a vertical bottle which is mounted on a robot and filled by the farmers as required and dropped using a servo motor to flip the slider and drop seed one by one as shown in Fig. 3. Thereis an infrared sensor mounted on this mechanism which counts every seed and dropped precisely according to the need of a farmer. Our technique to sow a seed in a soil with the help of seed sowing mechanism and servo motor.

IV. DESIGN & DECELOPMENT OF A PROPOSED ROVER

Artificial Intelligence (AI) is significantly influencing various aspects of human life, offering improved performance and reducing the need for direct human involvement. Our proposed rover design represents a large-scale model aimed at showcasing superior capabilities, particularly in achieving precise seed placement beneath the soil and ensuring accurate seed spacing. Utilizing advanced AI algorithms and sensor technologies, our rover can detect soil conditions effectively, determine optimal seed placement depths, and maintain consistent seed spacing with remarkable accuracy. This enhanced precision contributes to maximizing crop yield potential.

Furthermore, the autonomous operation of the rover minimizes the necessity for constant human oversight, leading to increased efficiency and reduced labor requirements. By demonstrating these advanced features and capabilities, our rover exemplifies the transformative impact of AI in agriculture, paving the way for more efficient and sustainable farming practices.

With the help of AI in rover, we are able to save so much of time, labor cost in the field of farmers .All work get automatically done by the machine with the help of its artificial intelligence.



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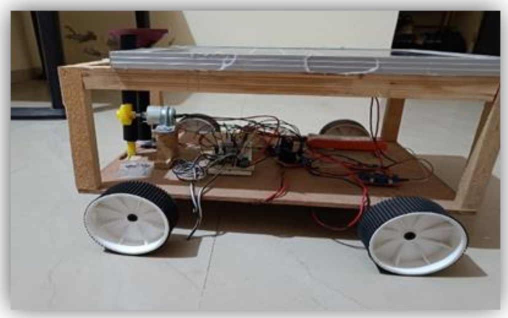


(b)

(c)

Figure 4. Wood Rectangular pipe based rover chasis
-(a) front view of rover showing seed mechanism
-(b) side view of chasis
-(c) Base view of chasis consists of 4 DC motors

Construction:

The rover frame has been meticulously designed to accommodate the payload frame, measuring 19 inches in length, 7 inches in width, and 12.5 inches in height. Crafted from lightweight wood, this frame offers robust support for traversing tough terrains, ensuring stability and preventing rollovers. Equipped with four DC motors per tire, the rover demonstrates remarkable agility over rugged landscapes.

For efficient seed distribution, a cylindrical seed funnel has been incorporated, utilizing a 1.5-liter PET bottle due to its lightweight, cost-effectiveness, and accessibility. The payload includes the seed funnel, with a shaft connected at the base for controlling the opening and closing of the seed dispensing pipe, thereby regulating seed flow. Additionally, a sensor is attached to the rotating shaft to facilitate vertical movement in the soil, enabling real-time monitoring of soil moisture levels at specific position.

Block Diagram:

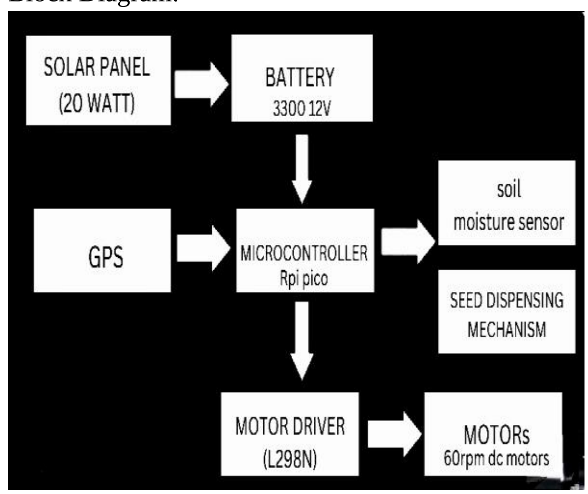


Figure 5 .Block Diagram

The block diagram illustrates the comprehensive electronics components integrated into the rover system. At its core lies the Rasp Pi Pico microcontroller, serving as the primary controller alongside DC motors, sensors, and auxiliary components. Solar panels are connected to a 3300mAh 12V LiPo battery, serving as an energy storage solution. A charging circuit provides +12V power to the Rasp Pi Pico, while the battery system supplies power to control the DC motors via the L298N motor driver module. Furthermore, the GPS module interfaces with the Rasp Pi Pico, providing directional information to the rover. This enables the rover to navigate the field based on specified distance parameters, guiding its movement and directing it to designated stoppage and destination points. The seed dispensing mechanism is controlled by the Rasp Pi Pico, utilizing soil moisture values to regulate the opening and closing of the seed valve shaft through a servo motor.

V. ELECTRONIC COMPONENTS

The electronic system of the rover comprises a microcomputer and drive circuits necessary for connecting various mechanical components, as depicted in Fig 4. At the heart of this system lies the Rasp Pi Pico microcontroller, serving as the primary controller and the brain of the entire electronic setup. Its selection was based on its high processing power and versatile peripheral attachment capabilities, facilitating the implementation of control algorithms. When deployed on the field, the rover intelligently navigates its surroundings to cover all areas, aided by GPS detection of field boundaries [9]. The Rasp Pi Pico utilizes motor drivers connected to DC motors to control rover movement, with each motor driver incorporating an H-bridge power MOSFET linked to the Rasp Pi.

- Rasp Pi Pico:

The Raspberry Pi Pico is a cost-effective, high-performance microcontroller board equipped with flexible digital interfaces. It features a dual-core Arm Cortex-M0+ processor running at speeds of up to 133MHz. With no built-in storage, external flash memory is utilized for program storage. It offers 26 multifunction general-purpose input/output (GPIO) pins and provides a power supply of 5V via a USB-C connector. Micro Python programming language, along with the Thonny IDE, is utilized for programming.

- DC Motor Driver L298N:

The L298N is an H-bridge driver capable of handling high current loads. It can supply up to 1A at voltages ranging from 4.5V to 36V. Designed to drive inductive loads such as solenoids, relays, DC motors, bipolar stepper motors, and other powerful motors, it ensures efficient application of current or high voltage.

- Servo Motor:

Servo motors are precision actuators employed in applications requiring accurate angular displacement. Equipped with a feedback sensor, they measure the deviation between the set and required angles to ensure precise positioning.

- Power Source (3300mAh 12V Li .Po Battery):

The power source for the entire system is a 3300mAh 12V LiPo battery. It delivers a surge of energy to power the circuitry, including all attached components. The battery management system (BMS) ensures the safe operation of the battery pack, which comprises three series-connected 18650 Li-ion cells, capable of handling up to 20A of current.

- Solar Panel:

A 20-watt solar panel is utilized to harness solar energy, providing a sustainable power source for the rover's operation.

- DC Motors:

Four DC motors are employed for driving the rover's wheels, designed to operate at 12V and deliver a nominal speed of 60 RPM.

This comprehensive electronic system, encompassing the Rasp Pi Pico microcontroller, motor drivers, servo motors, power source, and solar panel, forms the backbone of the rover's functionality, enabling precise control and efficient operation in agricultural settings.

VI. FUNCTIONING OF THE PROPOSED ROVER

The working principle of the design is shown in figure 6. The design allows the rover to move in any direction and is intelligently controlled by the microcontroller Rasp pi pico, thus making the entire planting process automatic.

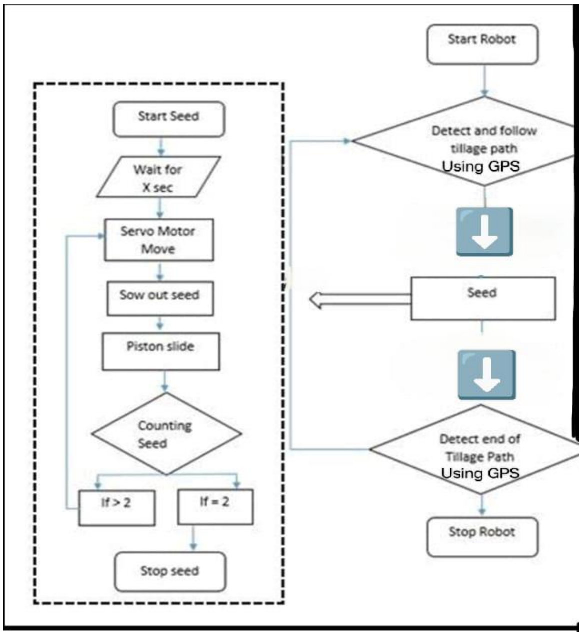
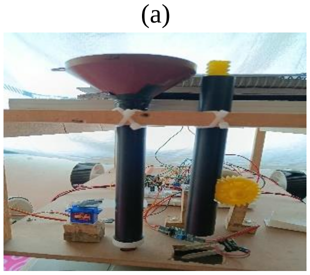


Figure 6. Flow chart of functioning of proposed rover

The rover begins to move forward and the seeds are planted evenly in balance. Seeds are stored in Erlanmar seed vials so they can easily enter the hopper via the included hose. The seeder works well and uses servo motors to complete the work of the seed. It has a two-stroke slider that controls the opening of the hole into which the seeds will be poured. After each seed falls, an infrared sensor is used to count the number of seeds that have passed through the hopper and reached the hole.

(a)

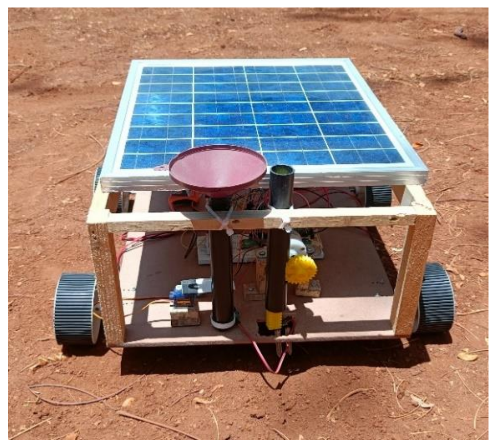


(b) (c)

Figure 7. - –(a) Seed droping mechanism (b) Servo motor controlling shaft valve -(c) Soil moisture sensor inside soil

When the rover deviates from the desired direction of movement due to change in soil tillage method, the GPS system provides ideas for rasp pi. Pico did it. & Guide the rover's movement according to distance and direction coordinates, help the rover decide the direction of movement, so that the controller allows the device to actually move.

The A and B motors are on the left side of the rover, and the C and D motors are on the right side of the robot. With the help of GPS area management, it can detect the end of the area and turn the rover in different travel directions. This allows the rover to plant seeds in subsequent zigzag lines, called casing lines.



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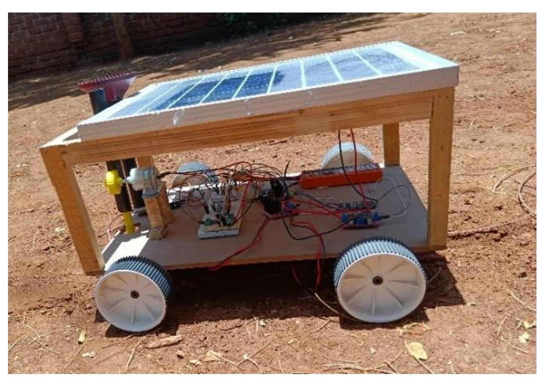

(b)

Figure 8. –(a) Top view rover in field –(b) side view of rover in field

VII. RESULTS AND DISCUSSION

We did a trial where we tried planting different seeds and determined the depth required for each type of seed in the field and the distance between the seeds. Dimensions of digging holes for seeds, but the current state of our rover does not allow the tradition of digging for seeds, which may come in handy in the future.

Table 1 shows the comparison of seed type, size, required planting and required depth.

Table 1. Seed Analysis and their Comparisons

Type of seed	Length(m)	Width(m)	Diameter(m)	Spacing(inch)	Depth (inch)
pea	0.0059	0.005	0.005	5-7.5	5
Tomato	0.006	0.006	0.004	6.5-8	5
Sunflower	0.0092	0.0051	0.003	6-7	3
chia	0.002	0.001	0.008	3.5-5	4
flax	0.0046	0.0027	0.001	4.5-6	5

In Our experiment we also get that soil moisture varies continuously for different species of seeds.The desired soil moisture content depends on the field capacity (FC) and the permanent wilting point (PWP).

Figure 9. Water requirnment for plant in different soil textures

Figure 9 illustrates the capacity of soil to retain water once excess moisture has drained away, indicating the equilibrium between water and air within the soil's pores. Insufficient oxygen is available when the soil's moisture content is excessively high, which can negatively impact plant growth. The Permanent Wilting Point (PWP) denotes the temperature threshold at which plants begin to wilt and perish due to inadequate water supply. Both the Field Capacity (FC) and PWP are contingent upon the soil type, underscoring the necessity for a thorough analysis to determine the optimal soil moisture range. Additionally, an essential metric is the Total Available Water (TAW), representing the disparity between soil moisture content at FC and PWP. Above FC, crops can only sustain themselves for a brief period of 1-3 days, while below PWP, crops are unable to absorb the requisite water for survival.In[14] provides a list of standard soil moisture content for various soil types.

Table 2. Soil Moisture threshold for specifics Ground texture

Ground texture	FC(%)	PWP(%)	TAW(%)
sand	12	5	7
Loamy sand	18	8	10
Sandy sand	23	10	13
loam	29	13	16
Silt loam	32	16	16
Sandy clay loam	38	17	21
Sandy clay	34	19	15
Clay loam	31	19	12
Silty clay loam	30	16	14
Silty clay	42	21	21
clay	42	23	19

It is important to note that the majority of flowers, trees, and shrubs require moisture levels between 21%

- 40%, while all vegetables require soil moisture between 41% and 80%.

VIII. FUTURE WORK

In the future, the mobile station can also be equipped with drilling equipment and water pipes to make farmers' lives easier. We can also equip our rovers with more powerful operating systems that can use intelligent calculations, including machine learning algorithm to improve rover's real time performance in field navigation.

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