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Design and fabrication of smart seed sowing robot

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A R T I C L E I N F O

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A B S T R A C T

In agriculture, there is a need for a technology that is more easily understood, implemented and used by the farmers. Equipment that requires less human effort and time with less cost of implementation is much required for success in the agricultural industry. Seed sowing robot is a device that helps in the sowing of seeds in the desired position hence assisting the farmers in saving time and money. Seed sowing is one of the main processes of farming activities. It requires a substantial amount of human efforts and also time-consuming. This project aims to design and fabrication of the smart seed sowing robot for the mentioned task. This smart seed sowing robot consists of one robotic arm to sow the seeds from the seeds container. The robot arm is controlled through the mobile application to get the desired positions of the arm. Once all the positions are set, the arm sows the seed automatically after the switching button ON. The wheel of the robot also controlled through the mobile application. Thus, this system completely automates the seed sowing process using a smartly designed mechanical system. This robot reduces the efforts and the total cost of sowing as the seeds.

1. Introduction

Nowadays, demand for farming equipment which requires less human efforts and time are increasing day by day. In addition, due to the development of internet of things (IoT) and robotics farming equipment has also become smarter. Pundkar [1] developed a high precision pneumatic planters of many verities of crops, for a wide range of seed sizes which result in uniform distribution of seeds alongside the travel path. Whereas Naik, N. S. et al. [2] fabricated prototype of an autonomous agriculture robot which is specifically designed for seed sowing task and concluded that this agribot is capable of seed sowing at optimal depth and at optimal distances between crops and their rows. P.P. Shelke [3] investigated the application of bullock cart drawn planters for seed sowing in the field. The author also presented the gap distance of the planting plant population which severely affects the optimal production of the crop. Ramesh, B. et al. [4] develop automated crop farming equipment for multiple farming activities such as plowing, seed sowing, spraying pesticides, monitoring of soil and plants. Umarkar, S., and Karwankar, A. [5] develop an agribot for reduction of cost of working and also for reduction of time of digging for sowing the seeds. In addition, that article also presents the development of a mobile application for controlling the motion of the developed agribots [6,7]. Bute, P. V. et al. [8] presented design, development, fabrication, and automation of seed sowing machines. The author concluded that the developed agribot is capable of performing automatic digging and seed showing. Whereas, [9] carried out the design and development of low-cost portable seed showing machine. This article incorporated multiple cropping, broadcasting, seed planter machine, Dibbling, Seed meter mechanism in the developed machine. However, [10] presented design and prototyping of a robotic vehicle with seed selector and concluded that the robot is also designed in such a way that it will not only be used for the seed sowing process of maize crops but will also be used for some other crops like Bean, Cotton, and Grain.

This article aims to present the design, development, and fabrication of smart robots which significantly reduces the human efforts and time of seed sowing activities by the farmers. Additionally, this smart robot also reduces dependency on human resources in the agricultural sector and the wastage of seeds. The designed and fabricated robots are controlled by the IoT system. The working principle is based on the motion of the stepper motors, dc motors, interfacing with the ultrasonic sensor, and a linear actua-

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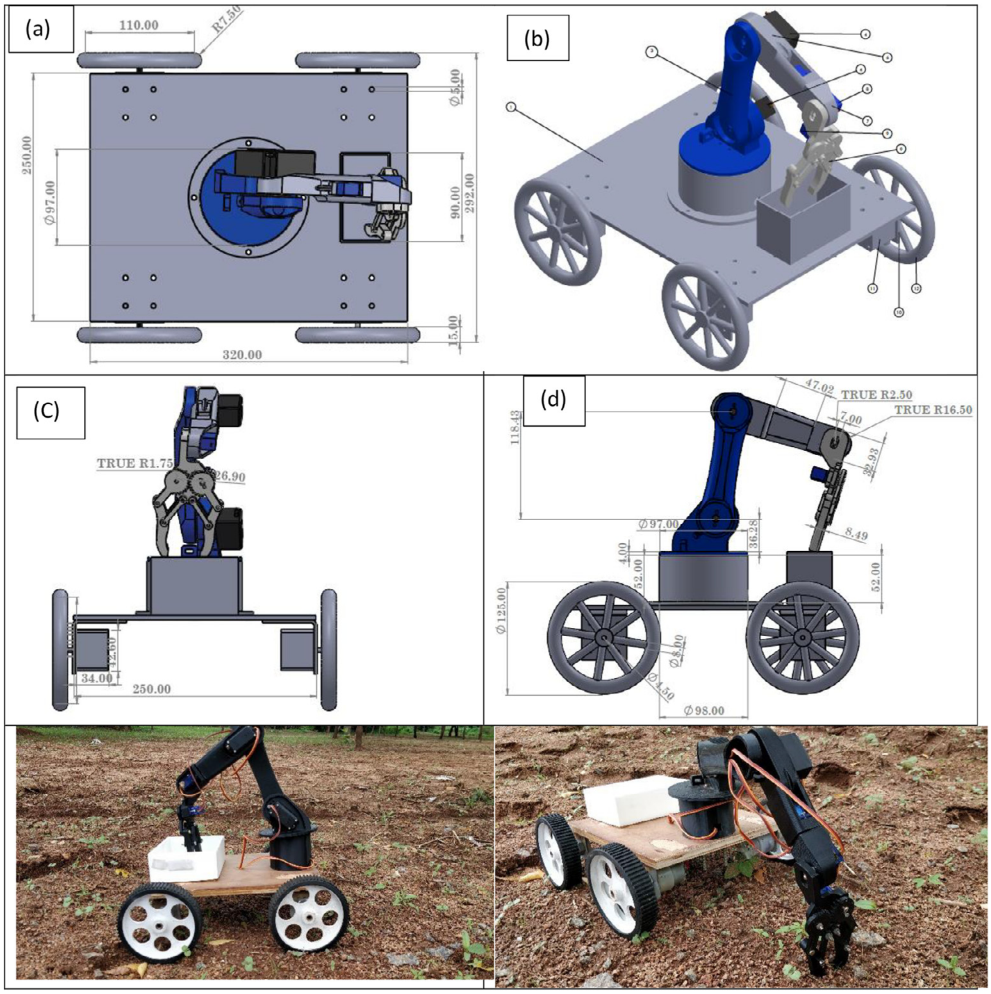

Fig. 1. (a)-(e) Three dimensional CAD model of the different components of Smart seed sowing robot and actual 3D printed robot (a) Top view of the smart robot (b) Isometric view of the smart robot, (c) Front view of the smart robot, (d) Side view of the smart robot, (e) and (f) Testing of the fabricated robot in the field.

tor which is used for opening and closing of the valve required for the dispersion of seeds among other examples.

2. Materials and method

2.1. Design and modeling various components using a CAD package

Initially, various dimensions of the smart seed sowing robot are assumed based on the different dimensional constraints of the robots. After considering various design aspects of the robot, then different parts of the seed sowing robot are designed using CAD package PTC CREO 3.0.1. The appearance of the fabricated smart seed sowing machine was given utmost importance for more convincing and attractive. Various geometrical models of the fabricated smart seed sowing machine are listed in Fig. 1 a-e.

The design of this smart seed sowing robot is based on the different modules which include sensing device, actuator, seed handling unit, microprocessor, stepper motors, servomotors, communication, and data processing unit. The block diagram of the various components of the robot is presented in Fig. 2. The circuit diagram of the main control unit is presented in Fig. 3 and the mobile interface is presented in Fig. 4. The specific at automatic way of ion of the smart seed sowing robot is presented in Table 1. The mechanical properties of the 3D printed components are presented in Table 2.

3. Functions of different components

3.1. Design Calculations

Calculations of the distance between two plants

The gear ratio of the stepper motor shaft and wheel is maintained 1 so that the gear can withstand a greater torque, minimizing errors. the gear ratio of 1:1 means that the engine and the transmission's

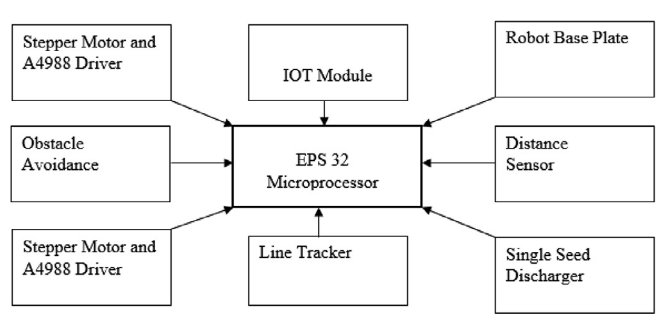

Fig. 2. Block diagram of the smart seed sowing robot.

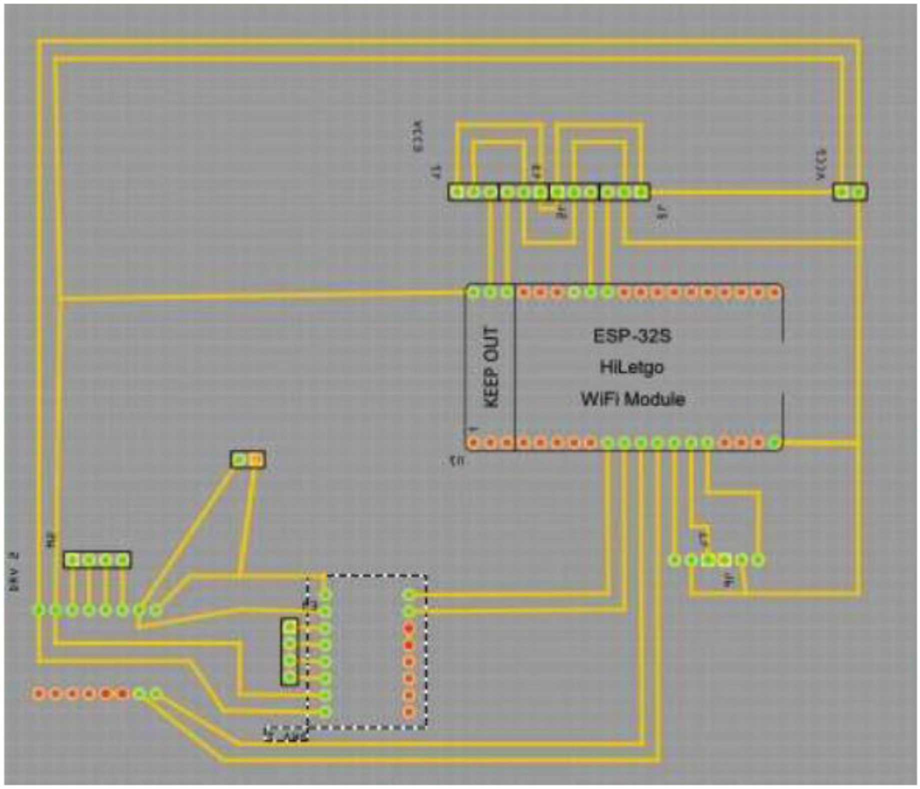

Fig. 3. Circuit diagram of the main control unit.

Fig. 4. Mobile application interface.

output rotate at the same speed. Therefore, one revolution of the all-wheel will rotate half the revolution to the robotic arm.

The distance traveled by the rear wheel is represented by D.

Given, the radius of the rear wheel (R) = 55 mm

$$D = 2 * p * R \tag{1}$$

D = 2 * π * 55

D = 345.4 mm (approx.)

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Table 1
Specifications of the smart seed sowing robot.

Component	Specifications / Dimensions
Dimensions	Length-320 mm, Width-250 mm, Height-400 mm, Wheelbase-55 mm, Ground clearance –110 mm.
Stepper Motor	Step angle- 1.8° full step 0.9° half-step, Voltage & Current –12 V at 400 mA, Holding Torque –2000 g-cm, Detent Torque- 220 g-cm max, Weight- 0.24 kg (0.5 lbs.), Max continuous power- 5 W, Shaft diameter- 0.197 in. (5 mm), Motor height –1.5 in.
Wheel configuration	Front –2, Rear – 2
Turning Radius	0.5 *m*
Turning angle	360^0
Power transmission	Stepper and servo motor drive
Hopper limit	2 kg of medium size seeds

Table 2
Mechanical properties 3D printed components.

Mechanical Properties	Values
Modulus of Elasticity	2.7 GPa
Density	1.3 g/cm^3
Tensile Stress at Maximum Load	50 MPa
Impact Strength	14.2183 KJ/m^2
Flexural Strength	158 MPa

From this, clearly, the distance between two successive distances of seed sowing is large. In order to maintain the required gap distance, the robot arm will move back and forth.

3.2. Single seed discharger

In this, the release of the single seed from the hooper to hole made in the ground is done by the single seed discharger unit. This unit is connected with an air suction connection and is attached to low pressure generator that is held up to a grain discharger, where dropping sequence from grain to grain is controlled by an electric motor, and the deposition distance from grain to grain is controlled. This unit picks a single seed from the bulk seed coming down and places it in the desired place of the hole in the soil to avoid the congestion of the crop after development. This action is calibrated with the movement of the robot so that each hole will be sown by the single seed at the required sowing speed. The optimal sowing speed can be maintained in calibration with hole distance, speed robot, and selection of the single seed from the hopper.

3.3. Lane tracker and follower

Seed sowing in the particular hole and moving towards another hole is based on the line follower robots. In this study, this smart robot follows the lane of the different rows and columns of the field. For this purpose, two ultrasonic sensors were integrated on both sides of the smart robots. The stepper motor driver controls the motion of the robot according to the signal received from the controller.

3.4. Obstacle avoidance process

To avoid the collision of the robot from the unwanted obstacle, ultrasonic sensors are used which is the prime need of any mobile robot. The ultrasonic sensor sends the signal to the objects falling on the way of the robot while sowing seed in the field, the sensor will record the distance between the obstacle and the robot. Consequently, the controller will stop the movement of the robot for further seed sowing.

4. Result and discussion

After taking the complete testing with various types of seed, the yielding rate of seed sowing was higher as compared to the conventional seed sowing machine. During, testing of the robot, different types of seeds have been sowed in a proper sequence according to different rows and columns marked in the field which results in proper germination of seeds. The rate of seed sowing with different types of seed is mentioned in Table 3.

Figure 5 shows the rate of seeding for different types of seed in the field during the primary testing of the robot. It is concluded that the sowing of the sesame takes the highest time as compared to other types of the seed mentioned in Table 3. This is due to the difficulty in gripping the sesame seed owing to the shape and size of the sesame seeds.

5. Conclusion

All the components of this smart seed sowing robot are designed and fabricated in the house with the aim to have hands-on training of fabrication of various components using 3D printing technology and the use of IoT components. All the components were designed using CAD software PTC Creo 3.0. In addition, this project also aimed at the automatic way of seed sowing in the field. The seeds have been sowed in a proper sequence according to different rows and columns marked in the field which results in proper germination of seeds. This smart and automated sowing of seeds using a robot reduces the labor requirement and also reduces human ergonomics.

Table 3
Test results of seed sowing.

Sl. No.	Types of Seed	Problems if any	Solution	Seedling rate
1	Ground Nut	Drop without any problem	Start servo motor to open-end	10 sec/ 2ft
2	Corn Seed	Too many seeds drop at a time	Setting the servo angle to a smaller value	8 sec/2ft
3	Red Gram Dal	Difficult to pick the seeds	Decrease the Wrist fingers distance	15 sec/2ft
4	Sesame	Difficult to pick the seedsMoreover, Drop the Seeds	Change the wrist finger shape	36 sec/2ft
5	Almond	Difficult to pick the seeds	Increase the Wrist fingers distance	26 sec/2ft
6	Soya bean	Drop without Any Problem	Start servo	26 sec/2ft

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CRediT authorship contribution statement

Pankaj Kumar: Conceptualization, Investigation, Project administration, Software, Supervision, Validation, Visualization, Writing - original draft. **G. Ashok:** Resources, Data curation, Methodology, Formal analysis, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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