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Design and Structure of Multi-Purpose Agricultural Robot

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***Abstract*: This paper presents a project on Agricultural multipurpose robot aimed at designing, implementing and testing an autonomous multipurpose vehicle with efficiency and economic operations for tilling, sowing seeds, spraying fertilizers, and sprinkling water simultaneously. It operates on solar power and is fully automated and can be used in arid and semi-arid lands with ease by single individual. This vehicle moves through the crop lines and performs tasks, thus reducing requirement of manual intervention.**

Key words: Autonomous robot, agricultural robot, agribot, mechanical implant for agriculture

INTRODUCTION:

Agriculture is main stay of many nations across the globe. There are multiple interventions by many scholars to utilize technology and mechanical intervention into agriculture. In the early 1920's itself there were attempts to implement robotics to help improve agriculture. These were primitive models that required use of cable connection to operate the machine. Revolutionary attempts in the field of applying robots to agriculture continued to develop especially after 1980s as technological advancement in the field of computer science and engineering made machine vision (MV) guidance possible.

Machine vision is nothing but integration of many technologies, software, hardware products, systems engineering, applied mechanical engineering actions, methods and expertise. It is integration of these technological advancements to resolve real world issues and problems on hand. Our design and structure of Agricultural Robot is one such attempt to help the farmers reap the benefits of technological advancement and to get benefits.

An "**agricultural robot"** is a robot deployed for agricultural purposes. It utilizes MV applications to identify required tasks assigned and shall do as per given schema to achieve results. Robots are mainly applied in the field of agriculture in weed control, seeding, and harvesting. Soil analysis and environmental monitoring are other areas where Robotics and AI are helping the farmers. In the coming years there is an expectation of exponentially increased market for robotics in agriculture applications that would touch over USD 10 bn [1].

What is our Agricultural Robot all about? Having mentioned that the market for robotics is set to increase many fold in the coming years, and the limitation of current versions of applying robots in mostly harvesting stage and weed control, it is important to showcase a design and a model of our robot that has multipurpose usage- ***namely in tilling, seeding, closing the pits & leveling, spraying fertilizers and also sprinkling water simultaneously. Thus, it helps the farmers' in increasing their productivity, reduce cost of operations, lower maintenance and increase their overall development.***

Many of the versions that are available in market or are being developed elsewhere globally have one limitation that they all are making robots to work in predefined way of work. So, specific tasks that are often repeatable and can be programmed were only being addressed. Most of these machines require either electricity or battery to operate. Our robot is designed solely to minimize the labor of farmers in addition to increasing the speed and accuracy of the work. It performs the elementary functions involved in farming i.e. ploughing the field, sowing of seeds and covering the seeds with soil, spray fertilizer, sprinkle water et al. The robot is autonomous and provides the facility for optional switching of the ploughing system when required. This is adjustable manually to suit the land conditions. It operates on solar power and can be handled by single individual.

DESIGN OF THE AGRICULTURAL ROBOT:

Following inputs would summarize what we intend to achieve by developing this robot:

1. This project is a 4-in-1 robot which is designed to complete simultaneous tasks automatically
2. The basic frame of the robot is made of mild steel of 25 mm thickness with the dimensions of 510 X 450 X 360 mm accordingly. This forms the basic frame.
3. Ploughs are made up of brass alloy to perform digging, with the length of 50 mm and thickness of 20 mm. The steel flaps are used to cover the soil pits once the seeds are dropped in to the soil.
4. Seed container is made of stainless steel of 5mm thickness as shown in the figure. The water and pesticide/ fertilizer container are placed in the robot as represented in the model diagram.
5. Wheel diameter is 56 mm.
6. Solar panel is placed at a height of 80 mm at an inclination of 15 degrees. The solar panel is placed in such a way that the robot can collect the required energy for its functioning directly from sun light.

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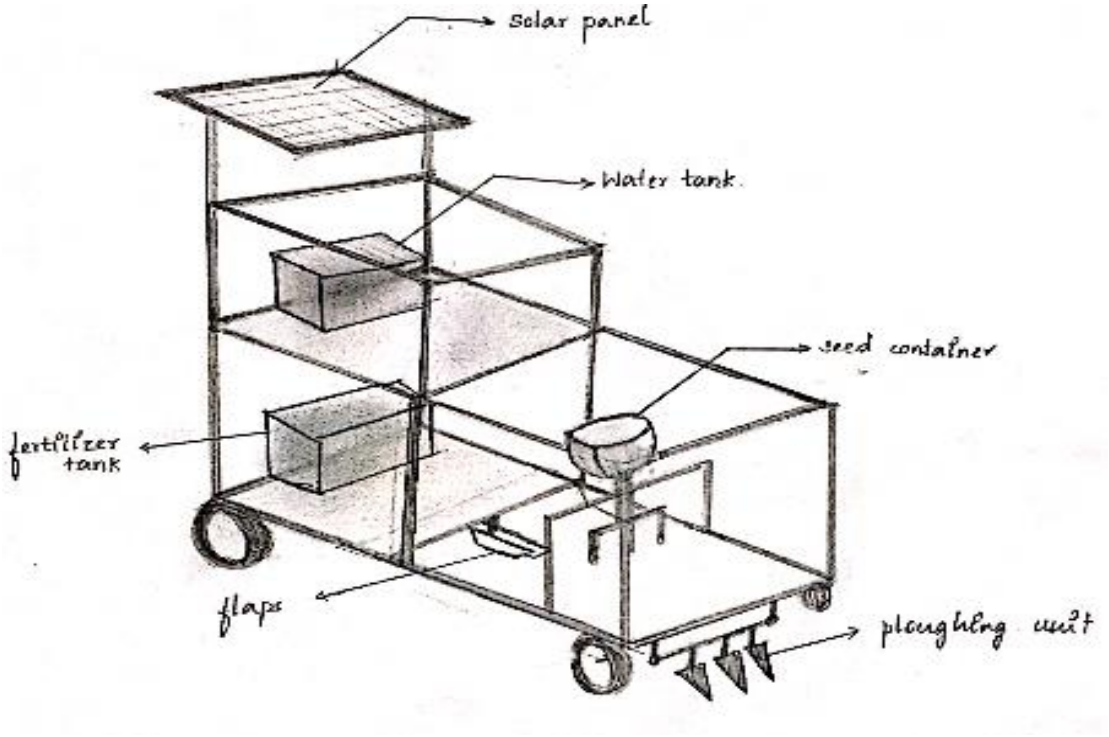

Fig 1: Diagrammatic representation of the Agricultural Robot-prototype

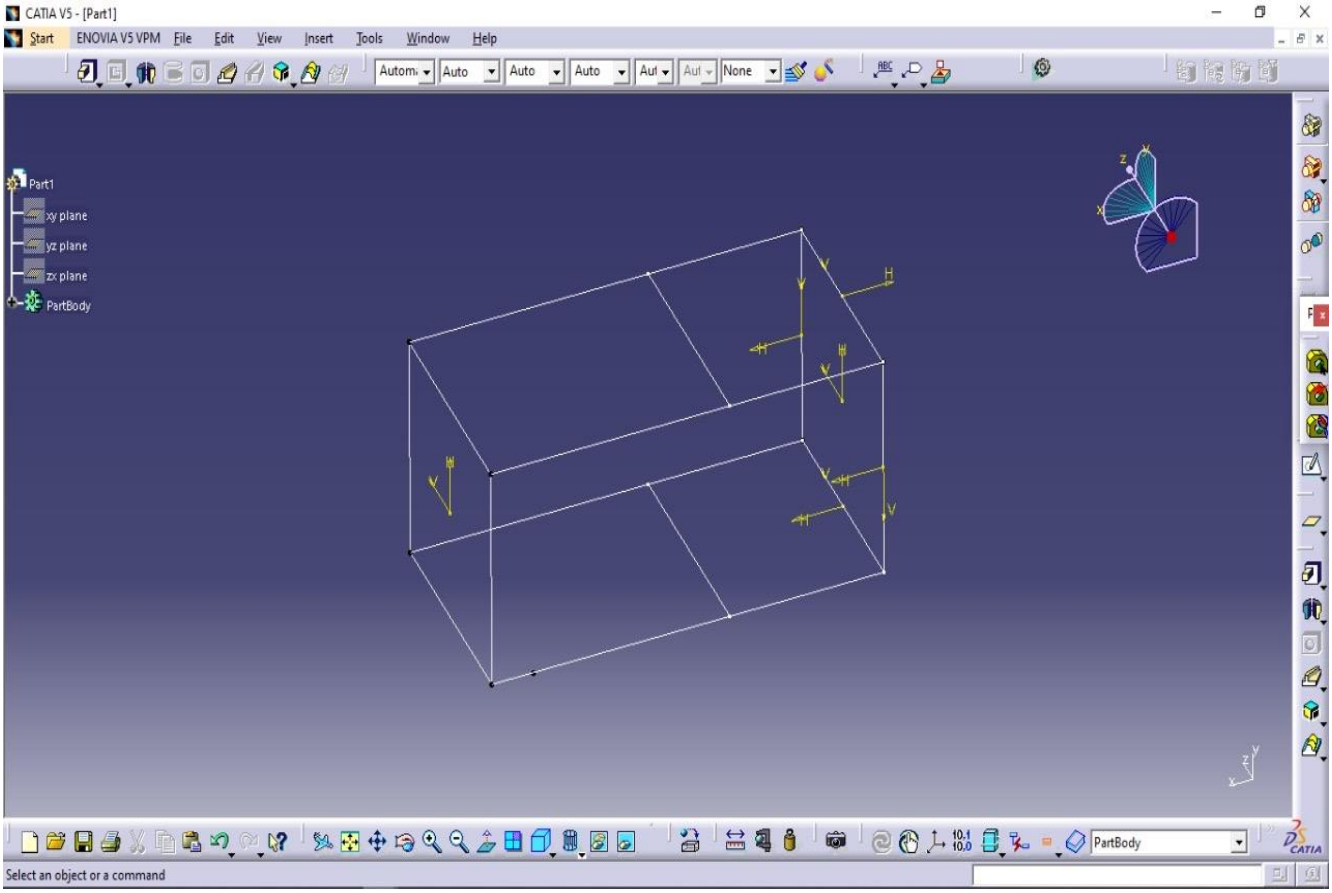

Fig:2 Basic structural framework of agricultural robot in CATIAV5

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Fig 3: Functional prototype of agricultural robot

Technical Details of agricultural robot- Prototype model:
Dimensions: 510x230x210mm
Weight: 6kg
water tank capacity: 1.5 liters
Fertilizer tank capacity: 1 liter
Frame Material: Mild steel
Thickness: 15mm
Solar Panel: Polycrystalline (type)
power:10 watts
voltage: 12V
current:0.8amps
efficiency rate:~15%
Motor: DC Motor(direct current)
Speed:30rpm(high turn)
current:150mA
Components: Solenoid coil voltage (12 V)
Microcontroller:ATMEGA328 Controller type: self-programmable
Memory:32kbytes
power consumed:0.2mA

Multipurpose agricultural robot is definitely useful to all the farming community across globe as it would not only reduce the manpower needed to complete the tasks but also increases the efficiency of farmers. See *table-1 usage efficiencies for details.*

Table: 1 Comparison of usage efficiencies across factors

FACTORS	Manual	Tractor	Agricultural Robot
Man power	High	Moderate	Less
Time required	High	Moderate	Less
Ploughing/ tilling	Manual	Manual	Automatic
Seeding	Manual	Manual	Automatic
Watering	Manual	Manual	Automatic
Fertilizer/Pesticide	Manual	Manual	Automatic
Required energy	High	High	Less
Wastage	High	High	Less

UNIQUE/SALIENT FEATURES

While there are many agricultural implants that are manufactured and utilize Robotics and AI, our robot is innovative and unique in the following ways:

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- Its design is such that the entire operation can be carried by single individual and requires **less human intervention**. All four functionalities mentioned elsewhere such as digging, sowing, closing, and sprinkling of water & fertilizer are done simultaneously.

- Unhindered operation of this machine in **semi-arid and arid regions** is easier as the movement is not interrupted by wet and muddy soil.

- Our agricultural robot utilized **solar energy** and generates power that is stored in uniquely placed battery thereby can be used in any place without depending on electricity.

COST BENEFIT ANALYSIS OF USE OF THIS ROBOT:

For the purpose of analysis, let us see how the cost benefit works for farmer's favour by using our agricultural robot.

Assumptions: For working out costs following assumptions were in place.

- We are taking 1 acre (40 guntas; where 1 gunta= 1028 sft) arid or semi-arid land.
- Crops are either Red gram or Corn.
- Duration of crop 4 months
- Rates assumed are in INR prevalent in Karnataka- for Male-500/per day and Female-300/ per day.

Normally it takes 2 people (1 male and 1 female) for 2 days to till the land and plant the seeds. It takes additional 1 day to spay fertilizer and water the land. Let's assume that we might require 11 days of labour for maintenance of land throughout the crop time (ie. Roughly 4 months). Also, for weed removal and sprinkling water it might take additional 4 days. Thus, it's in all 18 days of labour for two people (Male and Female). Thus, cost for performing all the activities mentioned above for acre of land comes to INR 14,400/- for one crop.

On the contrary, using this machine- agricultural robot to complete each of the tasks for every acre of land, cost comes down significantly as it can be operated by one person alone- who is actually hired to not only do these tasks but also oversee its total responsibility for the crop. Thus, operational expenses for this machine can be said to be minimal. As the robot operates on solar power, electricity expenses too aren't required.

Additionally, weeding can be done intermittently in the land for maintenance of the crop. This too is easier as the robot can be operated by this same single individual without much effort. Weight of the robot too is roughly 6 kgs and can easily be transported and installed.

CONSPECTUS AND THE WAY FORWARD:

To sum it up, solar powered agricultural robot has been designed and prototype is developed for performing agricultural tasks. It is designed to multi-task and helps farmers in improving efficiencies, reduce utilization of manpower and costs. This small sized vehicle as mentioned above, weighs around 6-8 kgs and is easily moved around by single person.

To improve the efficiency in the agricultural sector there is a need of the mechanical control system. This can be achieved by the robots which can work faster with more productivity. This maneuverability and multi-tasking is the main advantage of our agricultural robot as it performs tilling, laying seeds, spraying fertilizers, sprinkling water all simultaneously that too utilizing solar energy. It can also help in removing weeds and do additional tasks, how we program with different tools.

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