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Design of Autonomous Seed Sowing Mechanism for Balcony Farming

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Abstract: ***In the agricultural field, seed planting is very time consuming in farming process and requires physical labour. The conventional seed sowing, machines requires more seed and quantity of seed per unit area increases and this affects the yield. We have designed an automatic seed sowing machine with minimum human interference, suitable for small scaled and balcony farming. We have designed seed planter mechanism for soyabean seed. For easy handling of the machine design is simplified. It is possible to vary the distance of planting between two seeds. We have used a nozzle to eject a seed and a power screw arrangement to enforce the seed into the soil and this assembly is allowed to slide on slotted bar, and further this slide in the direction perpendicular to the former in the same plane. The actuation of various mechanisms is done by Arduino programming. Thus, this method increases the efficiency of planting and improves the yield with reducing manual efforts.***
Keywords: Seed sowing, autonomous, mechanism, agriculture, seed metering.

I. INTRODUCTION

India is agricultural country more than 70% people depend on agriculture. To improve the economic condition growth in agricultural sector is important to achieve this goal efforts are necessary to reduce the cost of farming process by mechanizing the agricultural operations.[6]

Manual seed planting is one of the operations which is very time consuming and more labours are required for this operation. But this method has a drawback like low seed placement, variation in spacing and serious back ache for farmers. Conventional seed sowing method is available but is available but this has a lot of disadvantages like no control over the depth of seed placement, no uniformity in the distribution of seed placement.

Nowadays many industries are moving towards the automation in their working environment. This reduces the overall cycle time and cost of manufacturing of the product. Automation is the use of various control systems for operating equipment such as machinery processes in factories, and other applications with minimal or reduced human intervention.[3]

The seed planting machine comprises of various mechanisms to control X, Y & Z motions of the nozzle and power screw assembly. There are four servo motors to control the former motions and a DC motor to enforce the seed into the soil to a set depth. The coordination of various mechanisms is done using Arduino. The product is designed to be lightweight and portable.

II. LITERATURE SURVEY

Mechanical factors, which affect seed germination and emergence are:[2]

1) Uniformity of depth of placement of seeds
2) Uniformity of distribution of seed along rows
3) Transverse displacement of seed from the row
4) Prevention of loose soil getting under the seed.
5) Uniformity of soil cover the seed
6) Mixing of fertilizer with seed during placement in the furrow.

To achieve the best performance from a seed drill or planter, the above factors are to be optimized by proper design and selection of the components required on the machine to suit the needs of the crops. The seed drill or planter can play an important role in manipulating the physical environment. The metering system selected for the seed should not damage the seed while in operation.

As per the survey mechanisms that have been developed for seed planting have an issue of seed metering but we have designed the metering section such that only single seed is allowed to pass through the pipe at the ejection time. Previously developed mechanisms have the human interference and we have tried to completely automate the process. We have studied various mechanisms in order to minimize human effort. Power screw is used to insert the seed into the soil to a particular depth. The assembly has to be placed above the farming area, two frame sections are mounted on four on which the nozzle and plunger assembly slides in X and Y directions. Good level of accuracy is achieved as the assembly is electronically actuated.

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Typically, robots are used to perform jobs that are difficult, hazardous or monotonous for humans. They lift heavy objects, paint, weld, handle chemicals, and perform assembly work for days at a time without suffering from fatigue. Robots are defined by the nature of their movement. This section describes the following classifications of robots [1,4]:

a) Cartesian
b) Cylindrical
c) Polar
d) Articulated
e) SCARA

Cartesian Robot [6,1,4] Cartesian, or gantry, robots are defined by movement limited by three prismatic joints [1]

III. DESIGN METHODOLOGY

The product has been designed with following objectives:

1) To automate the process of seed sowing.
2) To put seeds at desired depth and at uniform spacing.
3) To minimize human efforts.
4) To design a durable and portable seed sowing machine.

The design of the mechanism is aimed to be simplified and efficient. The complete design consists of four mechanisms driven by servo and DC motors. The X and Y motion of the mechanism and seed metering section is controlled by servo motors to achieve accuracy whereas the seed enforcing mechanism is controlled using a simple DC motor. The whole actuation process is governed through electric circuit using Arduino.

A. Design of Nozzle & Seed Enforcing Mechanism

Concept of power screw is used for seed enforcing mechanism. The load on the screw is taken as 125psi for soyabean seed on the basis of literature survey. The torque on the screw is based on the specification of DC motor used i.e. 1.5 kgf.

The bolt size is calculated as M14 from the equation below:

$Mt = W * D * (\tan(Ø+ά)) /2$

Where, the value of W is taken to be 44 N. Square threaded power screw is used over other types due to better efficiency and no side bursting force on the threads of the screw. The design and motor assembly of the mechanism is depicted in Fig. 1.

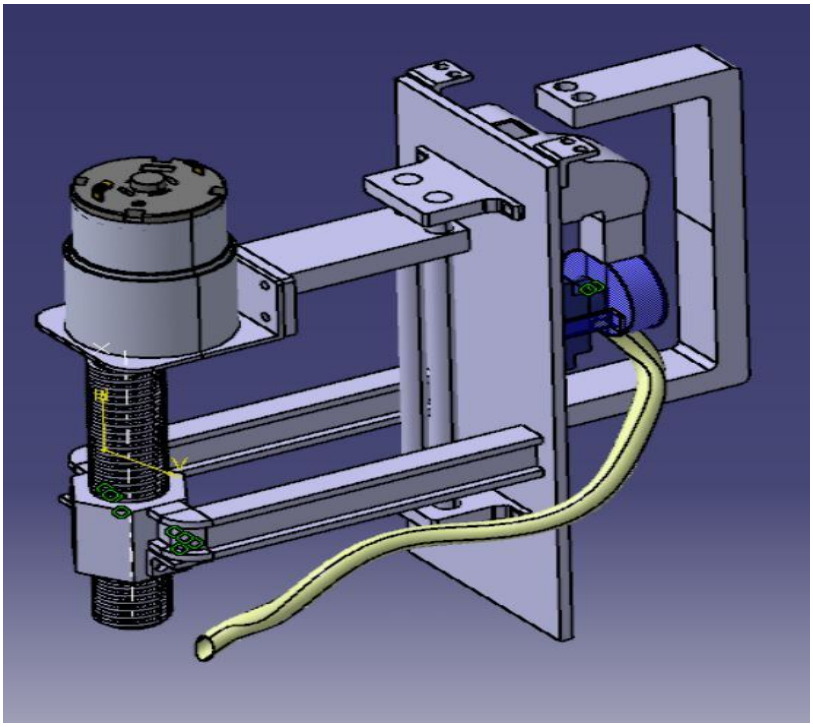


Fig.1 Design of motor assembly.

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B. Design of Frame

The frame structure for robot is designed as per the functioning of a typical Cartesian Robot mechanism. Typically, robots are used to perform jobs that are difficult, hazardous or monotonous for humans. They lift heavy objects, paint, and weld, handle chemicals, and perform assembly work for days at a time without suffering from fatigue. Material used for frame structure is aluminium for lighter weight and corrosion resistant. The frame is supported on four columns to get good stability. The design of frame structure is as shown in figure 5. The frame is slotted to allow sliding motion of the top frame and motor-nozzle assembly. Top frame member slides in Y direction with pulley and belt assembly mounted on the two fixed side frame members. Transmission is done using belt drive to avoid slippage despite compensating frictional loss. The various components of the frame like the C clamp, frame members and the supporting columns are shown in Fig. 2, Fig. 3 and Fig. 4 respectively. The assembly of the frame structure is observed in Fig. 5. The nozzle and seed enforcing mechanism are attached on the frame and the complete mechanism gives us the final product which is observed in Fig. 6.

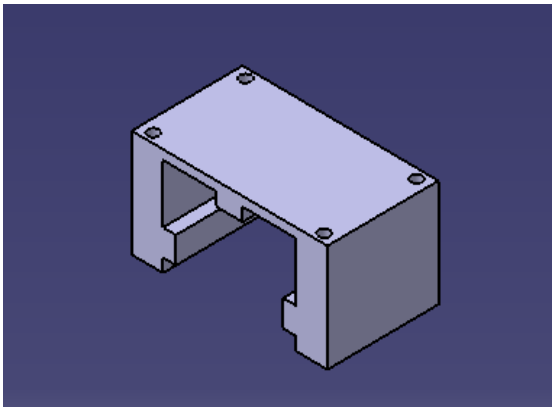


Fig.2 C clamp for guiding the top frame member.

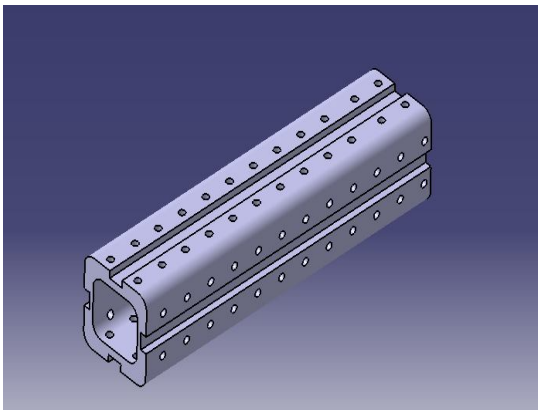


Fig.3 Member of Frame.

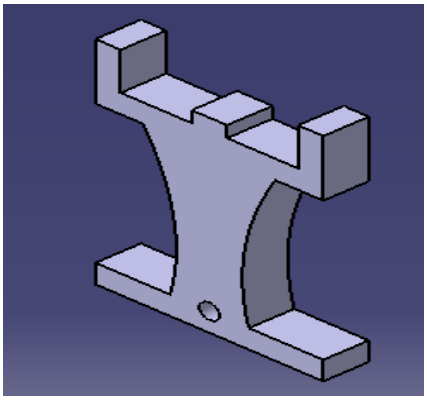


Fig.4 Supporting Columns in frame

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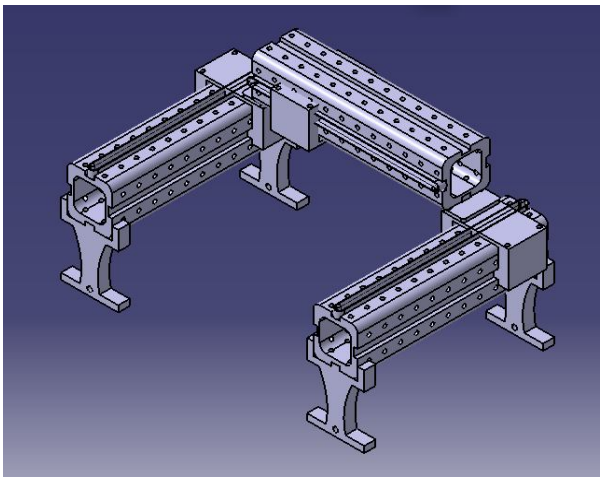


Fig.5 Assembly of Frame Structure.

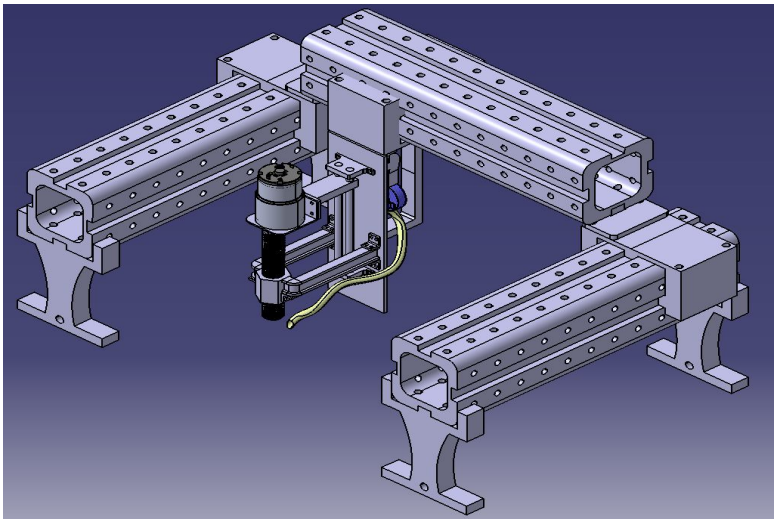


Fig.6 Assembly of complete seed sowing mechanism.

IV. DESIGN OF ELECTORNICS

The various mechanisms in the robot are governed using arduino and IC 298 though a program code as per the required operations at particular intervals,the circuit is shown in the below figure:

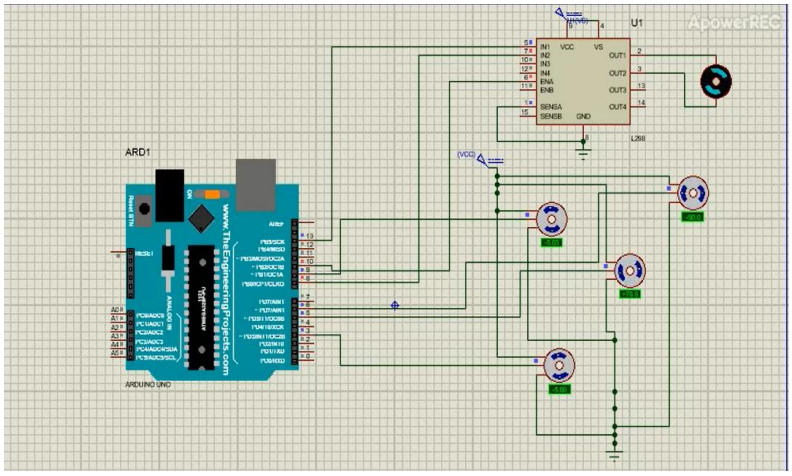


Fig.6:Electronic circuit

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The two motors initially move the platform of delivery to required position along the platform length followed by a single motor which moves the delivery mechanism along the perpendicular to length direction. This stations the delivery platform over the place intended and provided by the user. A metering motor then delivers required seed quantity which is then pressed into ground using a single motor powering the screw.

The motor configuration simulated in proteus represent working chronology of the automatic sowing mechanism. IC 298 has been incorporated to ensure user regulated depth control of seed sowing as it depends on seeds sowed. It allows motor rotation control for accurate seed delivery at provided depths.

V. STRESS ANALYSIS OF COMPONENTS:

Static structural analysis was carried out for the crucial components such as power screw, motor clamp and supporting columns, the following images depict deformation results as well as equivalent stress results. All the components were well inside the limit of stress and deformation for the selected material. Also, optimization for material reduction was carried out wherever possible to reduce cost as well as weight parameters and an optimized system was designed.

A. Analysis of Power Screw

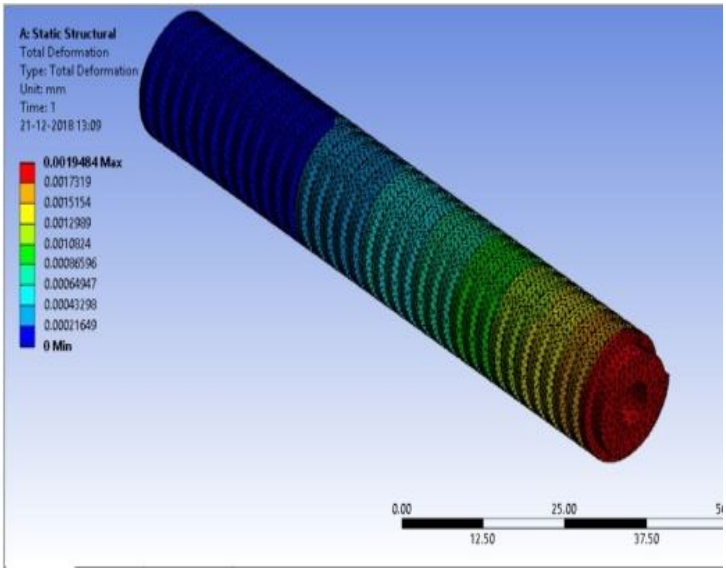


Fig.8 Deformation of thread

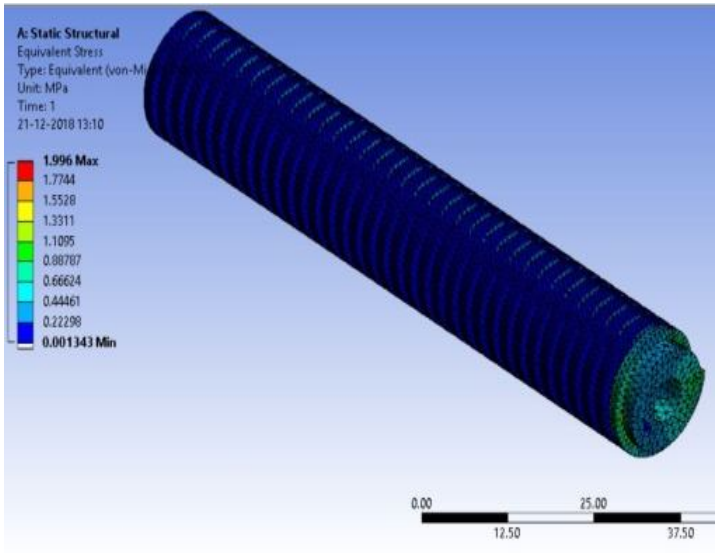


Fig.9 Equivalent Stress in Screw

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B. Analysis of Motor Clamp

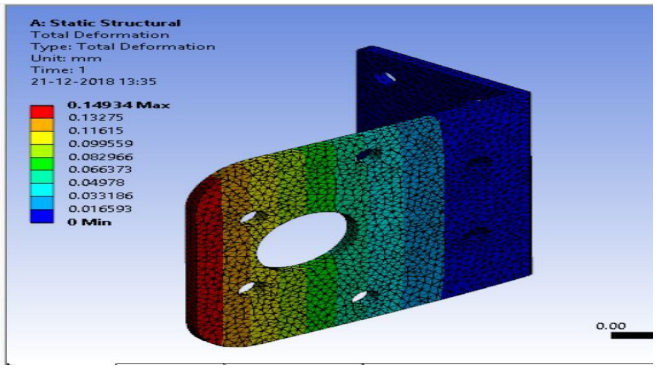


Fig.10 Deformation in motor clamp

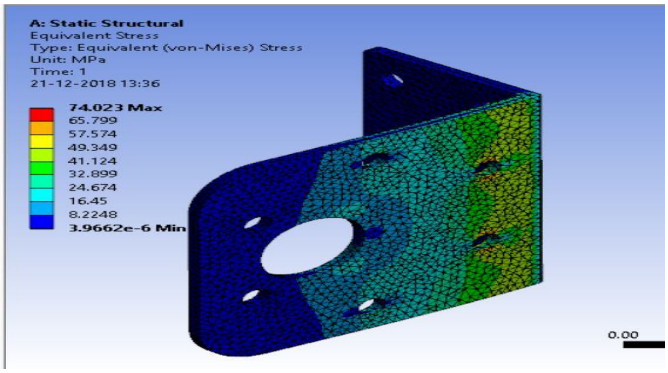


Fig.11 Equivalent Stress

VI. CONCLUSION

A. We have achieved accuracy in seed metering mechanism
B. Able to design a proper seed enforcing mechanism
C. Successful in minimizing the human efforts and decrease in duration of seed sowing
D. Designed a lightweight and durable mechanism
E. Fully automised mechanism with complete autonomy of mechanism
F. Able to enhance the yield of production

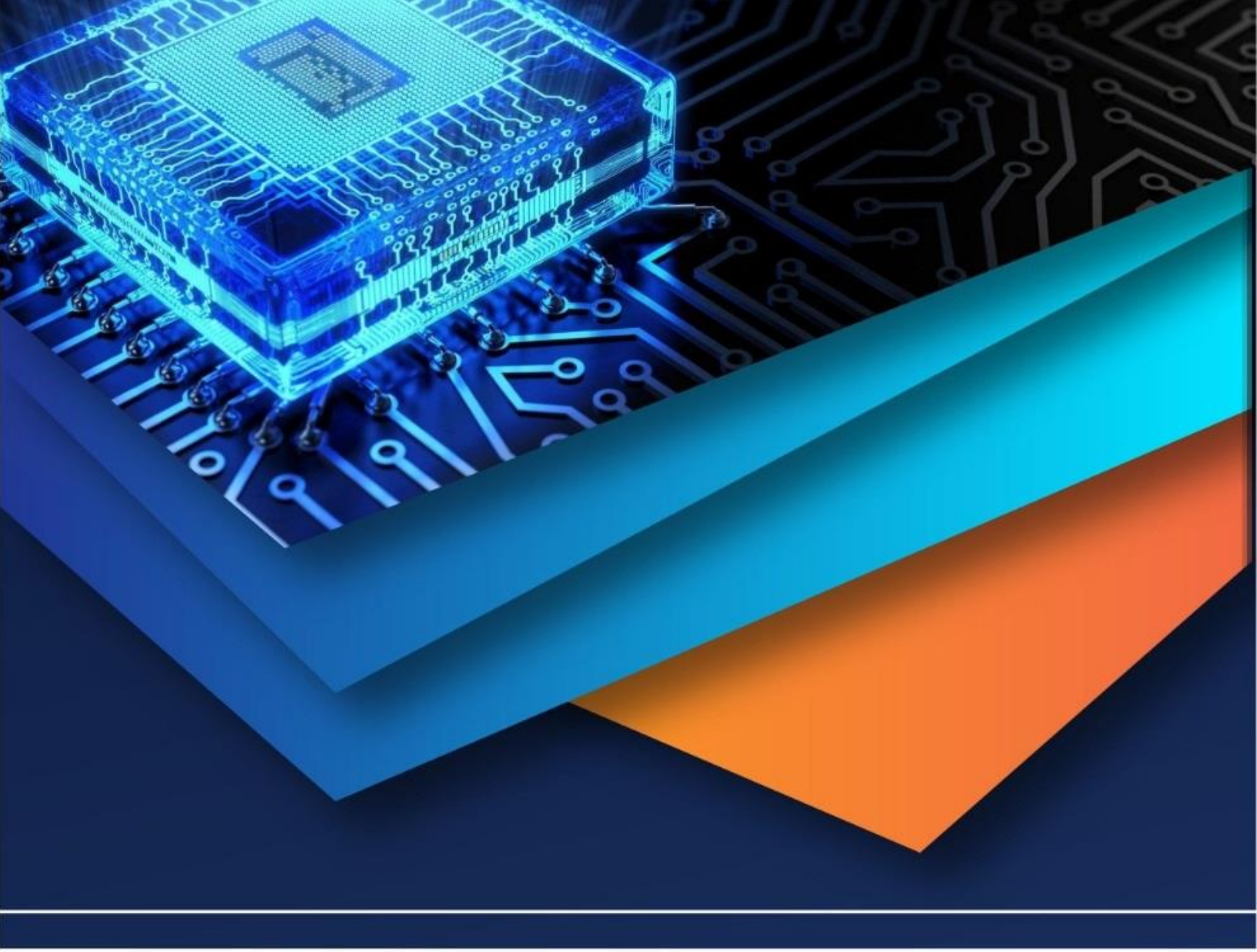
VII. FUTURE SCOPE

We can use camera for video interaction which will detect the obstacles during seed sowing. We can use various sensing technologies to advance the process of seed sowing. Various feedback sensors, motion sensors can be added for the excellent working of the robot. We are looking at both distributed and centralised farming models. These purpose-built environments will bring together a network of experts from different disciplines. Also aiming to design the robot which is universally mechanized for all types of seeds.

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