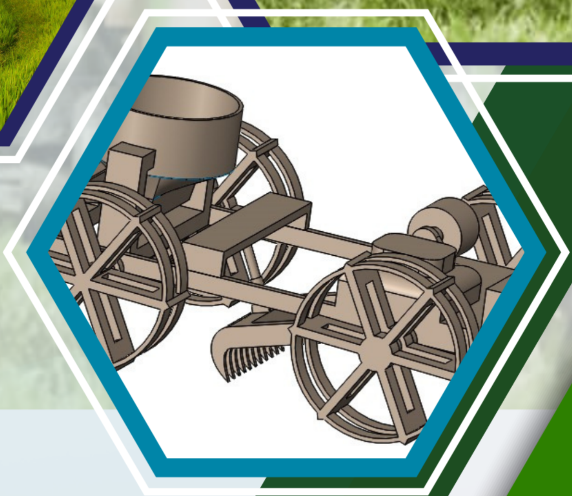
Automated Seeding Robot

The Autonomous Approach to Seeding

EE3204-Engineering Systems Design



Automated Seeding Robot

The Autonomous Approach to Seeding

by

Student Name	Index Number
SHK Lakshan	210334N
GNK Lakshitha	210337C
LMIA Lankanayake	210338F

Instructor:	A.G.B.P. Jayasekara
Teaching Assistant:	
Project Duration:	October, 2023 - December, 2023
Faculty:	Department of Electrical Engineering, University of Moratuwa

Contents

1
Introduction

The "Automatic Seeding System" is a revolutionary solution that can significantly improve the efficacy and efficiency of conventional seeding methods. It represents a significant advancement in the field of agricultural innovation. This project looks like a potential attempt to transform the fundamentals of crop growing at a time when agriculture is facing ever-changing difficulties like workforce shortages, climate uncertainty, and the need for sustainable resource management.

The needs of a growing worldwide population are gradually outstripping traditional seeding methods, which depend on physical labour and inaccurate methodologies. By automating and utilizing cutting-edge technologies in the crucial process of seed planting, the Automatic Seeding System aims to completely transform the agricultural industry.

This project report explores the complexities of the Automatic Seeding System, explaining its goals, underlying technology, and expected effects on farming methods. Through the integration of sustainability, efficiency, and precision, this novel method has the potential to maximize crop yields while simultaneously bolstering the resilience and sustainability of contemporary farming practices. We will discuss the specific objectives, technological underpinnings, and wider ramifications of this innovative seeding strategy in the sections that follow. We envision a time when agriculture and cutting-edge technologies coexist peacefully in the future, to the mutual benefit of farmers and the world food chain.

2

Literature review

Gupta et al. created and built a paddy seeder with a field capacity of roughly 0.5 ha/hr and a forward speed of 0.81 mls. No harm was resulting from the soaking seed metering method, albeit a 3%. There were reports of pre-germinated seed damage [1]. An okra planter that is manually controlled was created by Bamgboye et al. This planter's field capacity and efficiency were 0.36 ha/hr and 71.75%, respectively. According to reports, the seed rate was 0.36 kg/hr and the seed damage was 3.51% [2]. The various kinds of innovations that were accessible in the seed-sowing process have been discussed by Ramesh et al. The process of sowing is burying the seed in the ground to the required depth, covering it with earth, and then patting it down slightly. A variety of parameters, including row-to-row spacing, seed-to-seed spacing, seed rate, and depth of seed sowing, affect an optimal yield. These factors differ for different crops and agroclimatic conditions. Furthermore, planting devices are crucial in the realm of agriculture [3]. According to Atul et al., pneumatic equipment is easy to handle and may be used effectively in smaller spaces. Utilizing this equipment has also enhanced productivity [4]. The effectiveness of several Jab planter types was compared to the conventional method of seed planting by Ladeinde et al. There were minor differences between the standard planting method and the Jab planters in terms of human requirements and field capacity. The Agricultural Research Center of the University of Southern Mindanao has created single and double-row planters that can plant a hectare in 3-6 hours for single-row planting and 2-4 hours for double-row planting. A pleasant and easy-to-use corn seeder in the disc-style has been developed [5]. Two types of sowing machines—a pneumatic vacuum and a pneumatic pressure machine—have been compared by B. Mursec et al. In terms of seed sowing capacity, the two machines' performances have been determined to be comparable [6]. Navindgi et al. have discussed about robot-assisted sowing technique. The robot has an AT89S52 Microcontroller unit [7].

3
Solution

3.1. Design of seeding robot

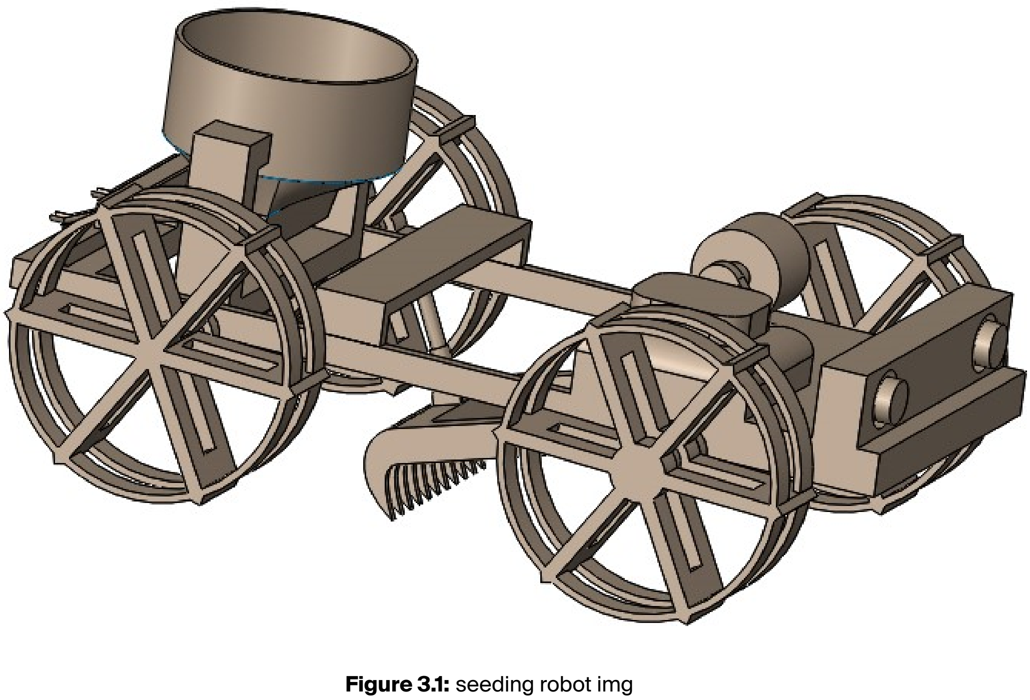
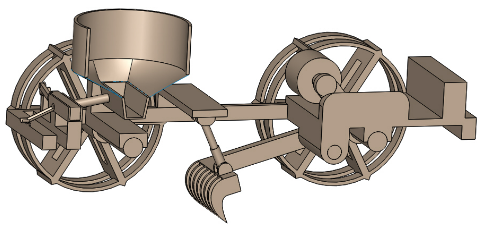


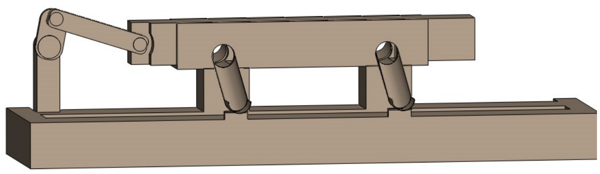
Figure 3.1: seeding robot img

The automated seeding system used in this study consists of three subsystems: the vehicle moving system, excavating system, and the seed sowing system. To address stability issues and adapt to the working environment, the robot is equipped with four wheels, with only the front wheel capable of rotation for steering purposes. These wheels are connected to four DC motors, all joined to an aluminum box bar base frame, ensuring the robot's load-bearing capacity while minimizing overall weight. A battery pack powers all electric components.

The seed sowing mechanism utilizes a tank equipped with a specially designed angular bottom to optimize seed distribution through a connected PVC pipe. Seeds are deposited onto the land at the pipe's open end. This robot is designed for line-by-line planting, and a sliding gate ensures consistent spacing between planting positions. The control unit regulates the rate of seed fall by controlling the speed of a motor connected to the slider crank mechanism, which opens and closes the gate as depicted in Figure 3.2 (b). This mechanism ensures precise seed placement while maintaining the desired spacing between planting positions. Also it not only minimizes seed wastage but also increases farm productivity.



(a) cross view of robot



(b) sliding gate mechanism

Figure 3.2: seeding robot view

Before seeding, it is necessary to prepare the agricultural land. To accomplish this task, the top layer of the agricultural land must be excavated. For this purpose, there is an excavating arm connected to the robot, as shown in the figure 3.3. The arm can rotate around the axis of the joint, and its rotation is controlled by a Hydraulic cylinder. It is expand or shrink according to user input. It controls the depth of excavation, aids in keeping the excavating arm above the ground when not in use, and ensures the stability of the excavating arm. The depth of excavation is a critical factor because it directly affects both the robot's efficiency and its power requirements. Consequently, we have limited the excavation depth in this design. This limitation ensures optimal performance and minimizes unnecessary energy consumption.

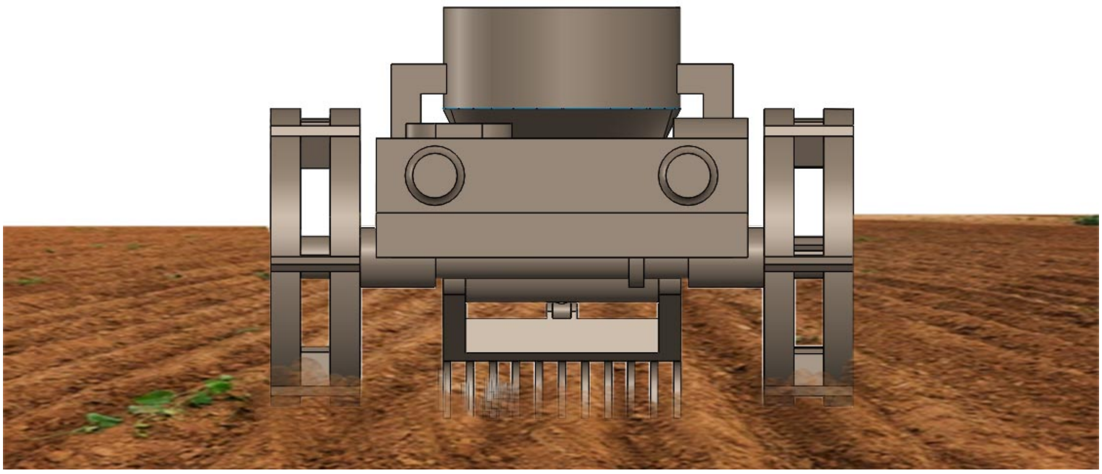


Figure 3.3: Front view

3.2. Automated control system.

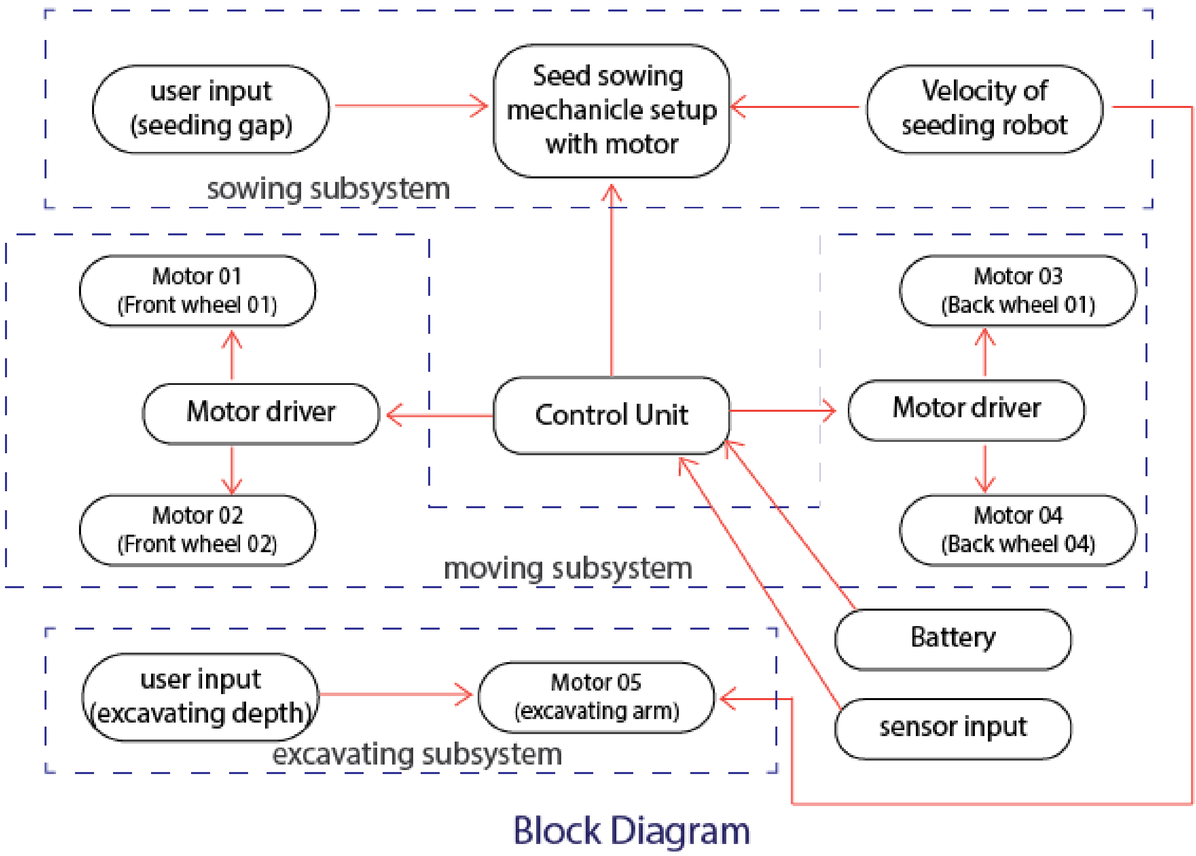


Figure 3.4: Block diagram

According to the block diagram, the seeding robot is divided into three main subsystems, all directly controlled by the control system. The pressure or force acting on the excavating arm and the velocity of the robot are the two primary state variables in the system. These parameters are measured using sensors. The rate of seeding and the power input to the motors, which are connected to the wheels, depend on the robot's velocity. Therefore, the accuracy of the velocity value is crucial for the robot to operate as expected.

In this study, we focus on the forces acting on the robot, aiming to obtain velocity variations with time through a MATLAB simulation model. Five types of forces act on the robot: inclined gravity force, thrust force, rolling friction force, force act on excavating arm, and the driven force provided by the wheel motors.

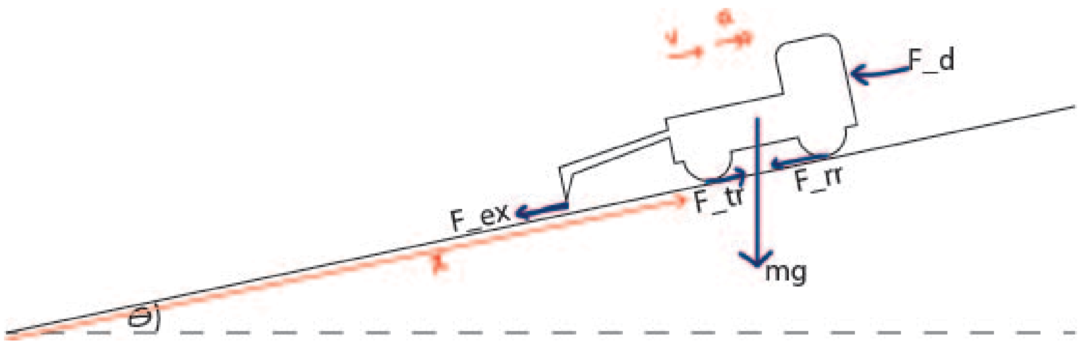


Figure 3.5: Force act on robot

The rolling resistance force (N)	- F_{rr}
The aerodynamic drag force (N)	- F_d
The gradient resistance force (N)	- $F_g = mgsin\theta$
Force act on excavating arm (N)	- F_{ex}
Force supply by wheel motors (N)	- F_{tr}

Table 3.1: Forces act on robot

The gradient resistance force is the force opposing the motion of an object on an inclined surface, as described by the equation: $F_g = mgsin\theta$ .In this equation, m represents the mass of the object, g is the acceleration due to gravity, and θ denotes the angle of inclination of the surface.

The rolling resistance force is mathematically represented by the equation μmg, where μ is the coefficient of rolling friction, m is the mass of the object, and g is the acceleration due to gravity. The rolling resistance force accounts for the opposing force that hinders the motion of an object as it rolls over a surface. It is important factor to reduce power consumption and increase efficiency.

$$F_{rr} = \mu mg$$

When robot structures move through an airstream, a resistive force acts on the system. This force is described by the following mathematical equation:

$$F_d = 0.5\rho ACv^2$$

The definition of parameters are,

The density of air (kg/m^3)	- ρ
The frontal area of the vehicle (m^2)	- A
The drag coefficient (dimensionless)	- C
The velocity of the vehicle (m/s)	- v

Table 3.2: symbol of parameter

To establish a relationship between the above mentioned forces and acceleration, Newton's laws are applied along the x-direction. $(F = ma)$,

$$F_{net} = ma$$

$$F_{tr} - F_{rr} - F_d - F_g – F_{ex} = ma$$

$$F_{tr} - mg - 0.5ACv^2 - mgsin\theta – F_{ex} = ma$$

4

Matlab simulation

4.1. Simulink model to analyze the variation of velocity and acceleration.

The state variables play a crucial role in controlling the operation of the seeding robot. The values of these state variables of seeding robot depend on specific conditions, such as the nature of the agricultural land, climate conditions, soil characteristics, and more. In our project, we aimed to develop a simulation model to analyze the variation of velocity with time, and for this purpose, we utilized a sample dataset. The values in this dataset represent general characteristics applicable to most agricultural lands. The relevant values are detailed in the table below.

parameter	**Value**
mass of the vehicle (m)	50 Kg
The angle of the incline (θ)	30 deg
density of air (ρ)	1.225 kg/m^3
Front area(A)	0.5 m^2
drag coefficient(c)	0.5
coefficient of rolling resistance(μ)	0.1
Force supply by wheel motors (F_{tr})–Average value	540 N
Force act on excavating arm (F_{ex}) – Average value	80 N

Table 4.1: parameter value of model system

The figure of relevent simulink model is given below.

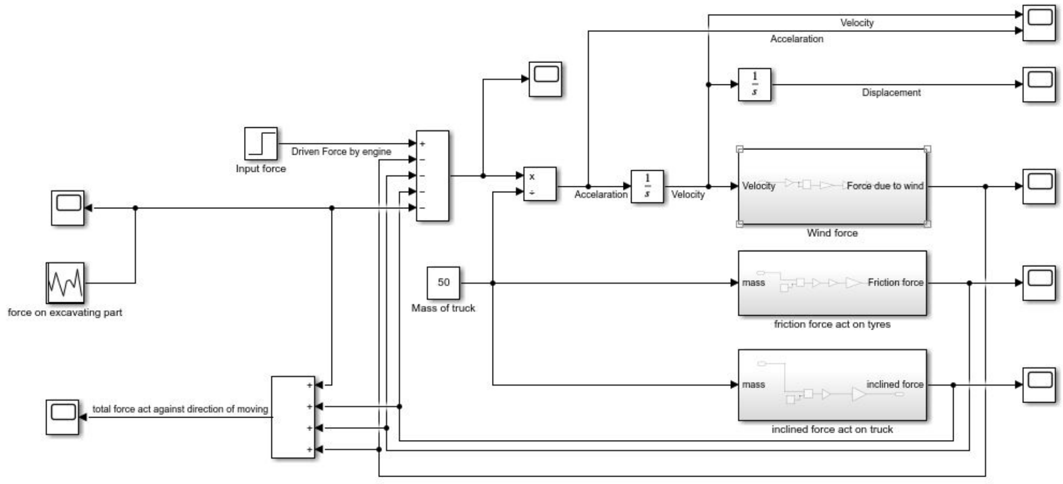


Figure 4.1: simulink model for analysis velocity and acceleration

4.2. Simulink model to automate robot

The below simulation model used to represent funtionality and motion of the automated seeding robot which we developed. It mainly simulate three part of motion. First one is the moving of the robot. The rotation of the wheel is represent it. The second one is the lifting up and down the excavating arm. It happen due to expand or shrink the telescopic leaver, which is connected to the arm. The third one is automation of open and close the sliding gate. It is controlled the rate of seed fall to ground from tank. The sliding mechanism is used to operate sliding gate. So this model represent main tasks (moving, excavating and seeding) of the automated seeding robot. The relevant model figure is given below.

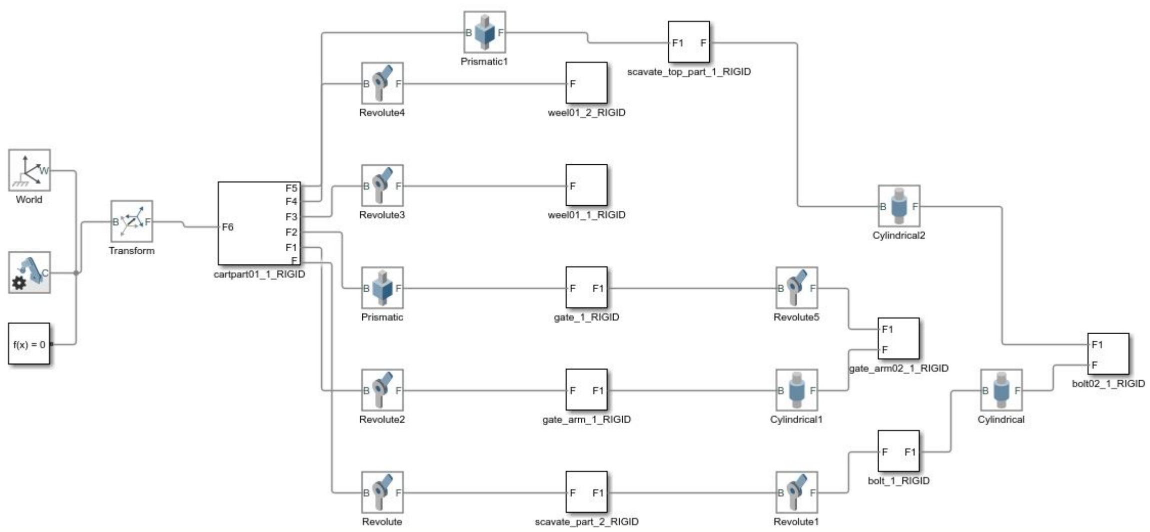


Figure 4.2: Simulink model of automated robot

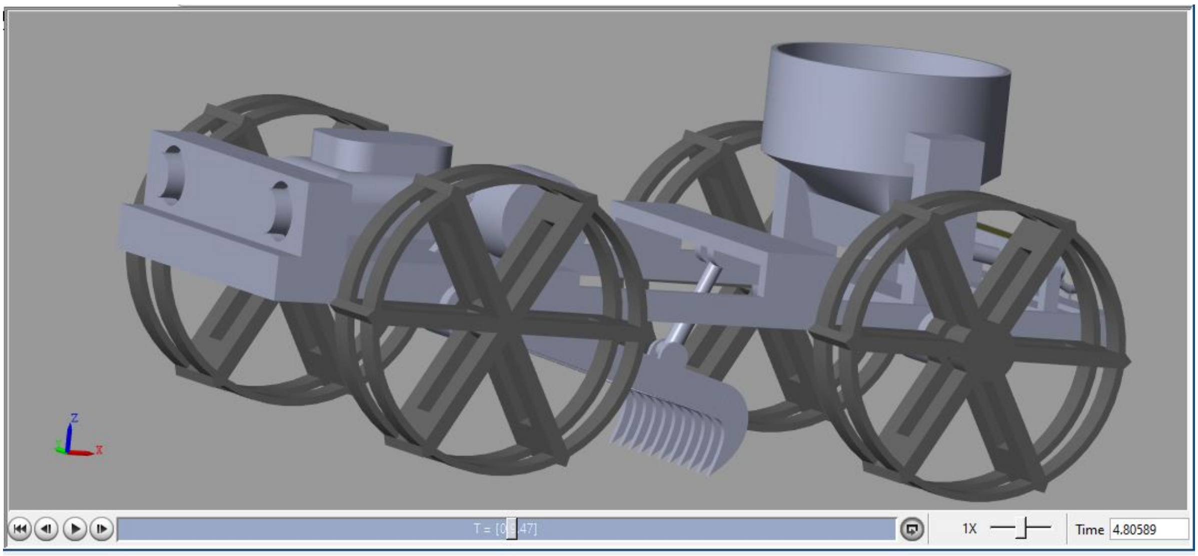


Figure 4.3: automated seeding robot

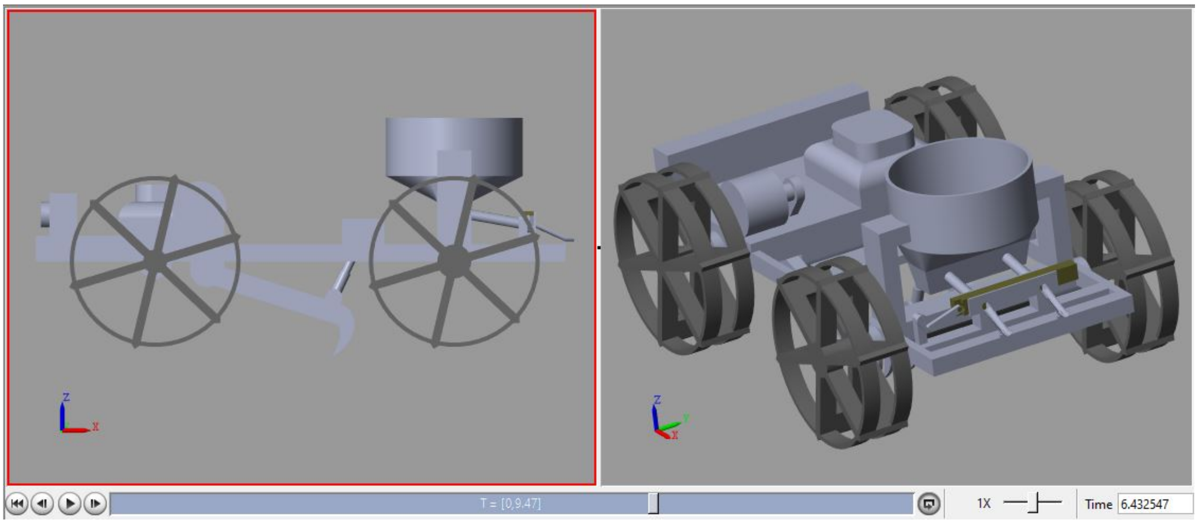


Figure 4.4: automated seeding robot

5 Results

5.1. Results from the Matlab simulation

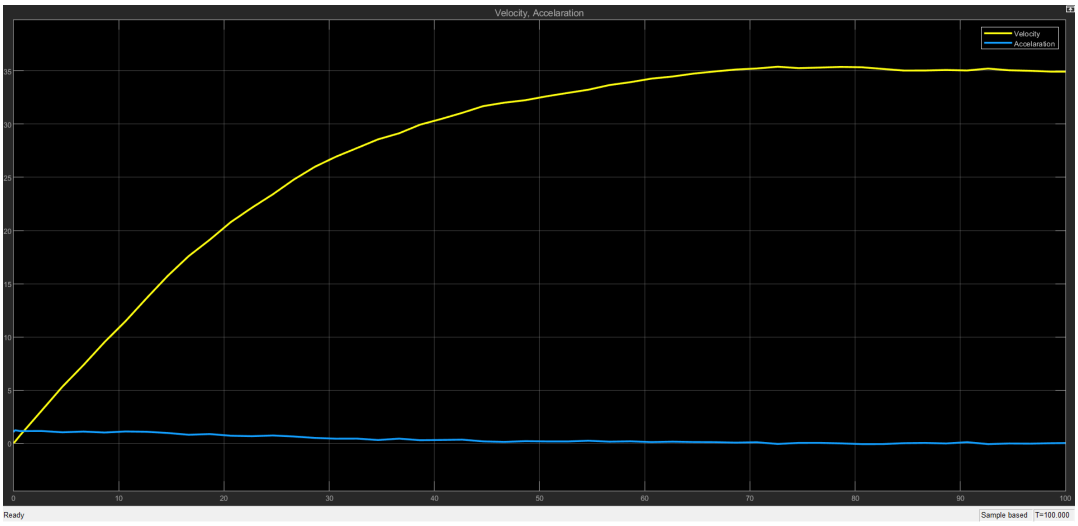


Figure 5.1: Velocity & Acceleration

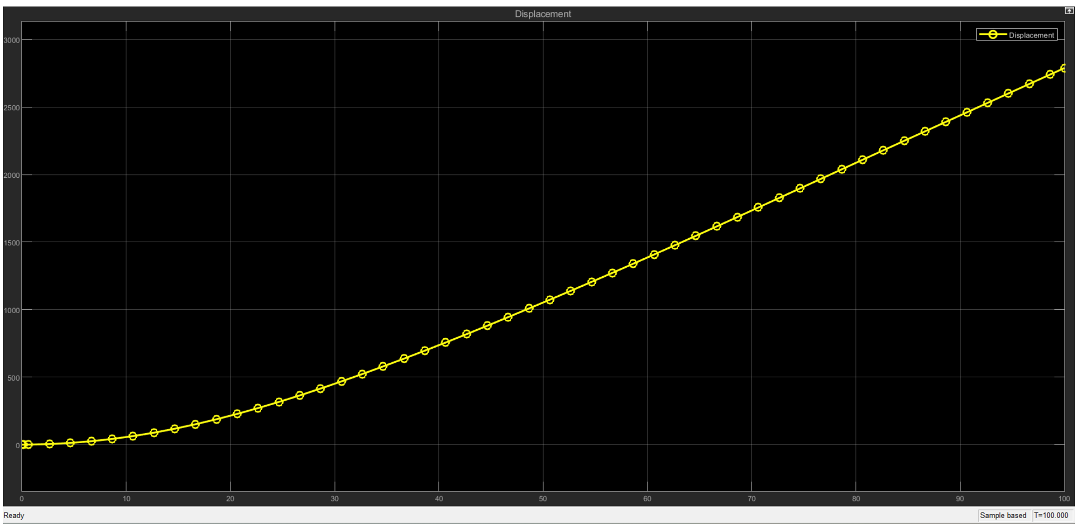


Figure 5.2: displacement

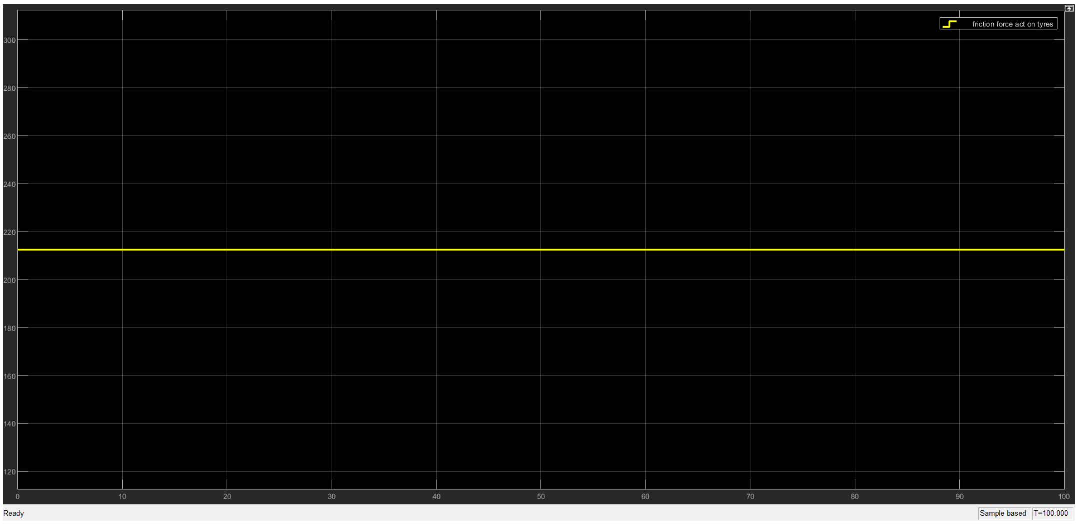


Figure 5.3: friction force

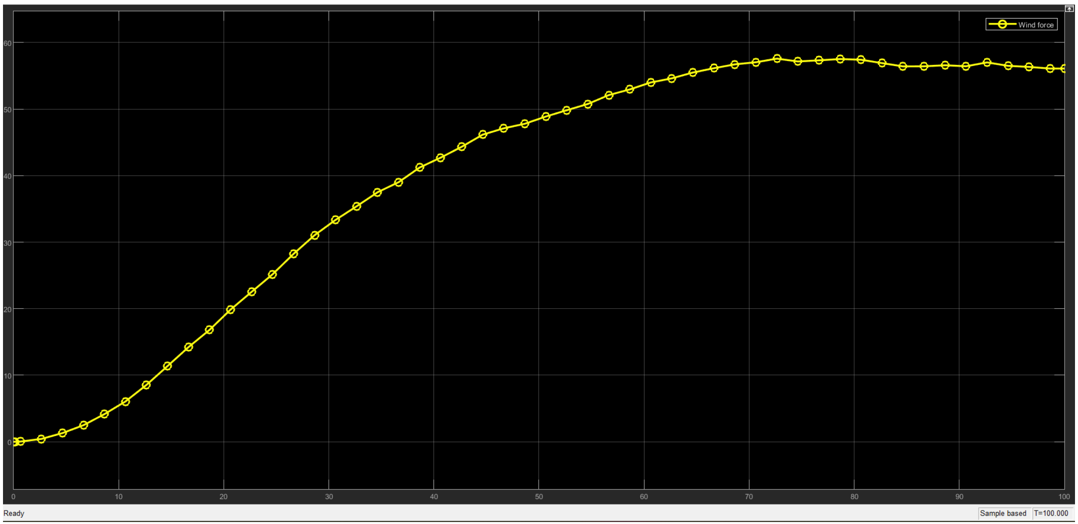


Figure 5.4: wind force

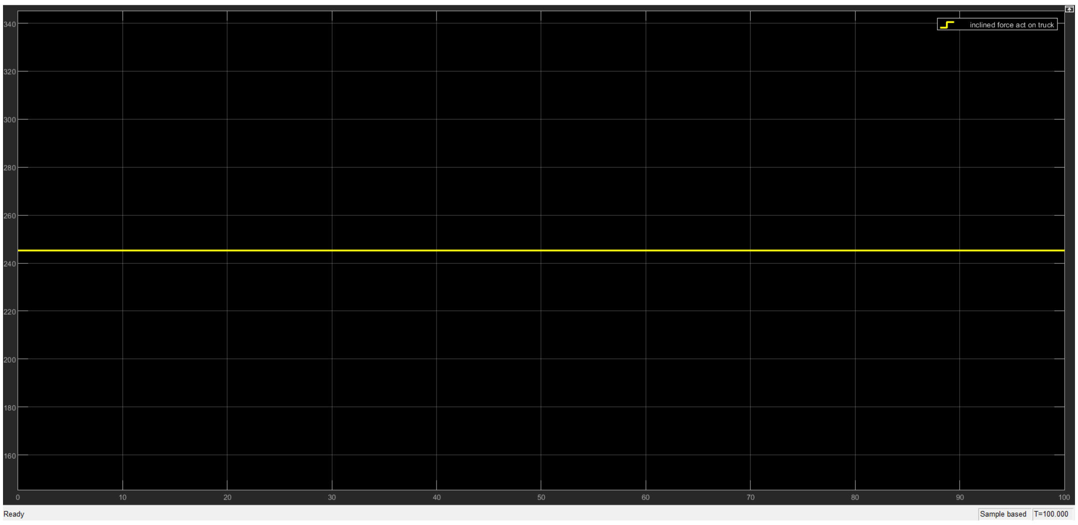


Figure 5.5: inclined force

6
Conclusion

The autonomous seeding robot consists of three essential subsystems: the vehicle moving system, the digging system, and the seed sowing system. Its objectives are to maximize farm productivity, reduce waste, and improve seed distribution for agricultural efficiency. The robot's stability is ensured by four wheels and a rotating steering wheel, while its autonomy is ensured by a battery pack.

The seed-sowing mechanism incorporates a specially designed tank for effective seed dispersion, with a slider-crank mechanism on a PVC pipe regulating seed release through a sliding door. This design allows the robot to function as a line-seeding robot, reducing seed waste and increasing agricultural output.

The seed sowing system uses a sliding door and tank for accurate seed dispersal, while the excavation system uses an arm for depth management. The automated control system modifies subsystems based on sensor data and optimizes performance using MATLAB simulation models.

The sowing robot focuses on sustainable agricultural methods and precision agriculture, maximizing output while reducing seed waste. The digging arm facilitates effective land preparation and precise seed dispersal, while real-time monitoring and MATLAB simulations allow the robot to adjust to changing environmental conditions.

The excavation system includes an excavating arm with a telescopic lever for controlled depth adjustment and rotation, improving overall seeding efficiency. The automated control system coordinates the subsystems using sensors to measure velocity and pressure/force applied to the digging arm.

In summary, the integration of these subsystems in the seeding robot provides a complete solution to stability, environment adaptability, and effective seed dispersal issues. This study contributes to the development of autonomous farming technology, which can increase crop output, reduce resource waste, and support environmentally friendly farming methods.

References

[1] C.P. Gupta, T. Herwanto, Design and development of a direct paddy seeder; Agricultural Mechanization in Asia, Africa and Latin, America 23 (1) (1992) 23– 27.

[2] A. Bamgboye, A. Mofolasayo, Performance Evaluation of a Two-Row Okra Planter, Agricultural Eng. Int.: CIGRE J. 06 (002) (July 2006).

[3] M.A. Ladeinde, S.R. Verma, V. Bakshev, Performance of semi-automatic tractor-mounted cassava planter 26 (1) (1995) 27–30.

[4] D. Ramesh, H.P. Girishkumar, Agriculture Seed Sowing Equipment: A Review, Int. J. Sci., Eng. Technol. Res. 3 (7) (2014) 1987–1992.

[5] A.F. Adisa, F.G. Braide, Design and Development of Template Row Planter, Transnational J. Sci. Technol. 2 (7) (2012) 27–33.

[6] Abdulrahman, Mangesh Koli, Umesh Kori, Ahmadakbar, Seed Sowing Robot, Int. J. Computer Sci. Trends Technol. (IJCST) 5 (2) (2017).

[7] A.B. Rohokale, P.D. Shewale, S.B. Pokharkar, K.K. Sanap, Multi-seed sowing machine, Int. J. Mech. Eng. Technol. 5 (2) (2014).

A

Task Division

Table A.1: Distribution of the workload

	Task	Student Name(s)
	Summary	
Chapter 1	Introduction	LMIA Lankanayake
Chapter 2	Literature review	LMIA Lankanayake
Chapter 3	Solution	GNK Lakshitha
Chapter 4	Solution-Matlab Codes	GNK Lakshitha
Chapter 5	Conclusion	LMIA Lankanayake
	Editors	SHK Lakshan
	CAD and Figures	GNK Lakshitha
	Document Design and Layout	SHK Lakshan