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INITIAL DESIGN OF AN AUTOMATED SYSTEM FOR PADDY SEEDLING PLACEMENT IN A GERMINATION TRAY

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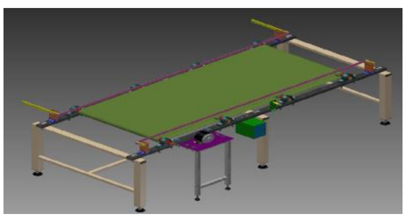
Graphical abstract



Abstract

Domestic demand for rice in Malaysia is more than the amount of local production; hence extra supplies are imported from neighbouring countries. For self-sustenance and food security, the government has targeted for a rise in the domestic rice production. Since conventional practice depends on labour, further mechanization is needed in order to achieve the goal. Inspired by the government policy, mechanization system based on System of Rice Intensification (SRI) has been developed and actively researched at the Universiti Putra Malaysia (UPM). One of the efforts is the design of a specialized seedling germination tray, which has been successfully patented. As part of further development program, an automated system for paddy seedling placement is currently developed. The system resembled a conveyor system with instrumentation for controlling the motion and placement of the seeding tray. Based on the result obtained, the conveyor was able to achieve start-stop distance at 16.98 mm if the time-delay variable was set at 100 ms. This paper presents the initial design development of the device. The machine was developed based the specification derived from the tray.

Keywords: SRI, paddy seedling, automation

1.0 INTRODUCTION

Domestic rice production in Malaysia is insufficient for local demands, thus imports from neighbouring countries are needed. In line with the Government policy to increase domestic production, new methods are required to meet the expectation. Currently, the cultivation of rice relies on huge labour power. Further mechanization is needed in order to increase production.

Application of cultivation method based on System of Rice Intensification (SRI) has been seen as a potential alternative and a number of literatures have shown the benefits of this technique [1]. Single seedling transplanting works by changing the management of the plants, soil, water and nutrients utilized in paddy rice production. Specifically, it involves transplanting single young seedlings with wider spacing, carefully and quickly into fields that are not kept continuously flooded, and whose soil has more organic matter and is actively aerated. These practices improve growth and functioning of rice plants root systems, and enhance the number and diversity of the soil biota that contribute to plant health and productivity [2], [3],[4], [5], and[6].

However, conventional SRI is also depending upon labour, which is less attractive for practical implementation, especially in Malaysia. At the Universiti

Putra Malaysia (UPM) efforts have been made to mechanize SRI. The initial step for this is the design of an innovative single seedling tray which has been successfully design and patented [7]. The tray has been optimized to accommodate 924 cavities, whereas each one is meant for a single seed. The overall size of the tray is 635 mm in length by 333 mm in width and 40 mm in height. The size for each cavity is 15 mm x 15 mm, while the centre to centre distance is 15.30 mm. The single seedling tray is a device for germinating paddy seeds, whereas initially the seeds are incapsulated in a media for growth, then the mixture of seed and media are placed into the cavities of the tray. The growth are monitored closely while they are in the nursery. Once the seedling growth have achieved the required limit, they will be transplanted on the field. Utilization of this tray is central to the mechanization of SRI because it is designed for both seeds germination and transplanting on the field.

This project limits its scope to support the preparation of seedling in the nursery tray. At the moment the seeds are manually placed into the cavities of the tray. This practice is laborious and time consuming. An automated system can improve the process significantly. This paper presents the initial development of an automated system for seed placement into the tray. The system resembles a conveyor with instrumentation for precise positioning of the tray.

2.0 MATERIALS AND METHODS

2.1 Development of a Design Concept

The basic shape of the tray is rectangular, with 635 mm in length and 333 mm in width. In order to define the specification of the conveyor belt, several factors were considered and summarized in Table 1. If the conveyor took the length of the tray as its width, then it would require a shorter runaway and eliminate sagging issue. If sagging is less, minimal idle rollers are needed to support the conveyor belt. In addition shorter conveyor runaway would reduce the cost of fabrication. In this design, a minimum of three trays were considered to be placed on the conveyor at any given period. The working length was 1200 mm with 200 mm space for placement of rollers at the front and rear end of the conveyor.

Table 1 Conveyor dimension consideration factors

Based on tray width dimension	Based on tray length dimension
Wide conveyor width	Narrow conveyor width
Shorter conveyor runway length	Longer conveyor runway length
Less potential for sagging	High potential for sagging

In general, the placement process would consist of three stages. At the initial stage, the tray would enter the conveyor. Next the first tray would go to the centre of the conveyor. A position sensor would sense the presence of the first tray as it entered the second stage, halted the movement of the tray at the correct position and prepared for seed placement. Once the placement was completed, the first tray would move forward to the third stage and ready for further works. The entire process would then be repeated. This movement concept is illustrated in Figure 1.

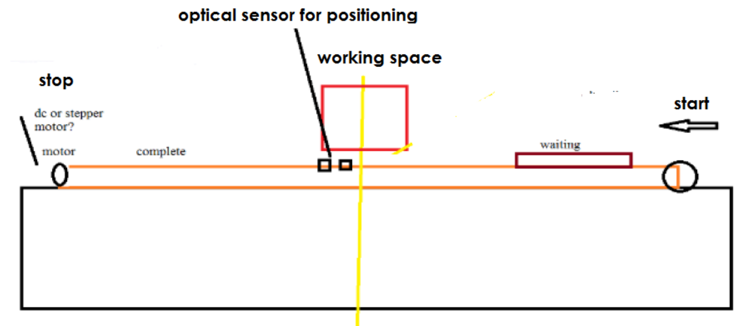


Figure 1 General Motion Concept

Several freehand sketches were prepared to interpret the general motion concept. Once a working idea had taken shape, a 3D model was prepared in Autodesk Inventor. The initial model is shown in Figure 2. The conveyor was placed on a table-type frame. A motor would drive a roller at one end, while a driven roller would be installed at the other end. Two idle rollers would be positioned in between the drive and driven rollers at equal distance in order to support the conveyor belt from sagging.

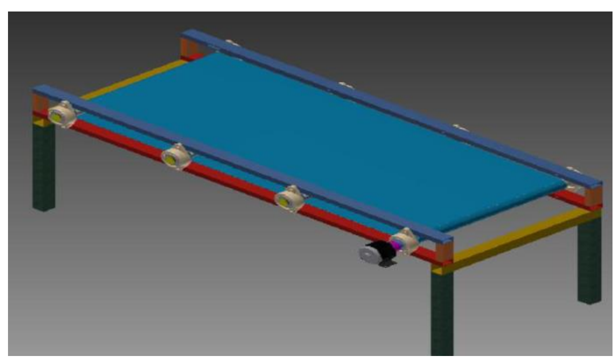


Figure 2 Initial 3D model

The design was further improved by allowing the driven roller to have adjustable position between 30 cm. This was added so that the tension of the conveyer belt could be maintained. An adjustable guide was built at one side of the conveyor to ensure that the tray stayed within the alignment. In addition, a screw type adjustable based was attached to the bottom part of the table. This would ensure that the conveyor surface was leveled (Figure 3).

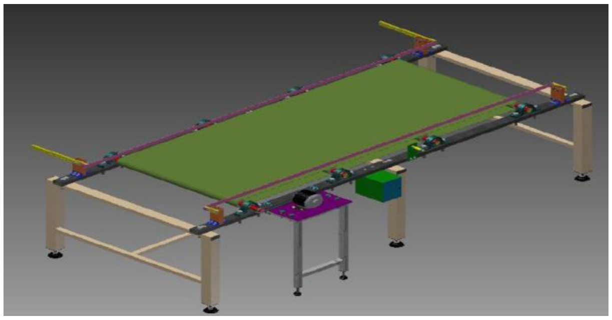


Figure 3 Complete 3D computer model

2.2 Motion Generation and Control

The conveyor was designed to be powered by a DC motor (24V, 250W, max load: 13.4A). This motor is typically used in motorized scooter. It was chosen for ease of interfacing and control. An infrared sensor was used to sense the presence of the tray for the filling stage (second stage). The signal from the sensor was fed to an Arduino Uno microcontroller. Motion control was achieved through a motor driver circuit, which acted as the interface between the microcontroller and the DC motor. The motor driver was essentially an external PWM generator. Figure 4 shows the instrumentation for controlling the motion of the conveyor. Figure 5 shows the flowchart of the algorithm developed for controlling the motion of the conveyor. The program starts by moving in the tray onto the conveyor. A sensor at stage 2 detects the tray and stops the motor for seed placement. The intermittent distance is kept at 15 mm. The seedling process is repeated until full and the tray will be sent to stage 3 for unloading.

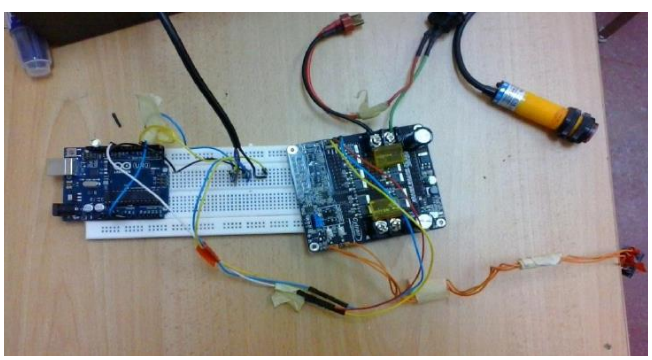


Figure 4 Instrumentation for controlling the motion of the conveyor

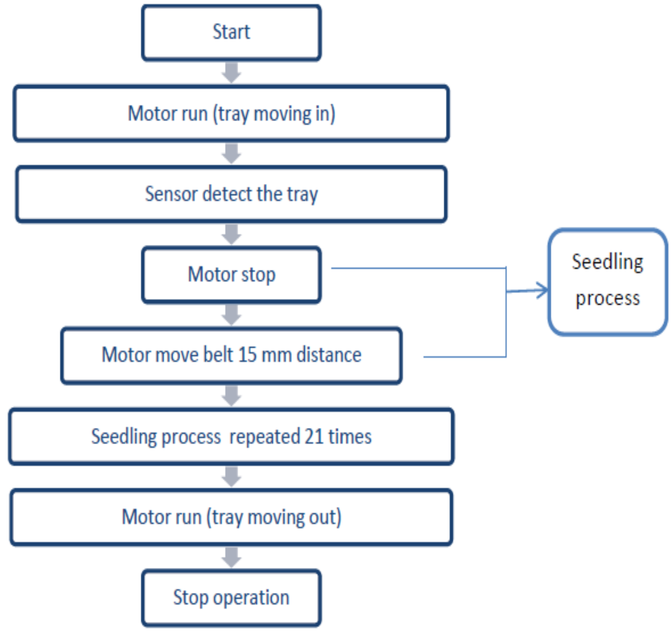


Figure 5 Flowchart of the algorithm for controlling the motion of the conveyor

3.0 RESULTS AND DISCUSSION

A proof of concept device was fabricated based on the model. The major parts are listed in the appendix. The conveyor system (Figure 6) was tested without trays placed on top of the conveyor belt and ran all the way from end to end. In this test, the motor was attached to two types of Li-Po batteries; (a) 7.5 V and (b) 12 V. The RPM was measured using a tachometer. The average at 7.5 V was 177, while the average RPM at 12V was 409. For a distance of 1.2 m, the average speed for 7.5 V was 22.2 m/s, while for the average for 12 V was 51.4 m/s. Even though the motor could run at 24 V maximum, the speed at 12 V seemed sufficient for this application.

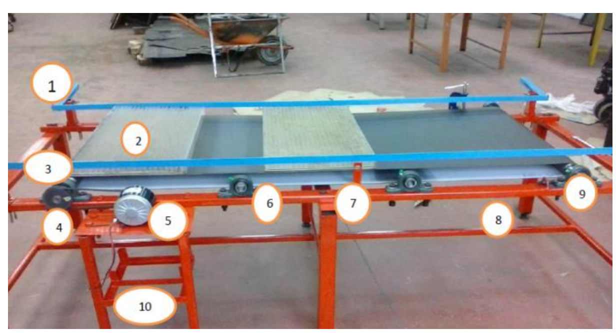


Figure 6 The fabricated conveyor system

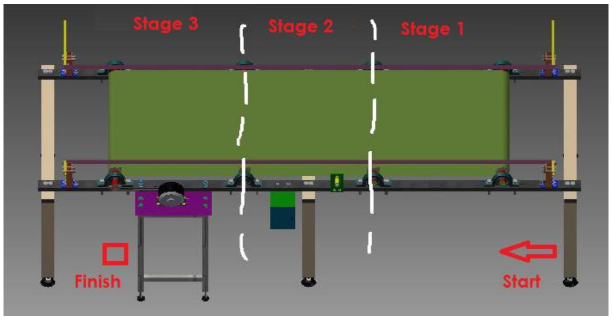


Figure 7 Test stages

Next, the conveyor was tested with speed control limited by software as programmed with PWM of the driver circuit and with three trays placed on top of the conveyor (Figure 7). The RPM was fixed at 190 and the equivalent linear speed was 23.9 m/s. The controller was programmed using *timer-delay* function to start and stop between rows of the tray. The data was recorded in Table 2. The average start-stop distance reduced linearly as the *timer-delay* variable varies from 300 ms to 70 ms, with the recorded distance were 73.3 mm and 11.63 mm. It was found that when the *timer-delay* variable was set at 100 ms, the recorded start stop distance was 16.98 mm, while the *timer-delay* variable of 90 ms recorded a start stop distance of 13.61 mm. This test topology was a feedforward type, in which start and stop occurred from one row to another. The system was not capable of performing a feedback control since both the motor and the sensors were not intended for precise placement. It was stipulated that for precise control both of these components must be replaced.

Table 2 Conveyor dimension consideration factors

***Timer-delay* variable (ms)**	**Average Start-Stop Distance Between Row (mm)**
300	73.43
200	42.24
150	28.72
100	16.98
90	13.61
70	11.63

Based on the results the set-up was able to achieved start and stop at 16.98 mm if the Timer-delay variable in the microcontroller was program at 100 ms. This was the nearest tolerance it could achieve although the optimum should be 15 mm. The drift between the target and the actual start-stop distance is 1.98 mm. Further improvement is needed to reduce the gap which could be done either by adding a more sensitive sensor or by changing into a higher resolution motor.

4.0 CONCLUSION

The initial stage of an automated seed placement system was proposed. The mechanical system designed for this machine was able to activate the conveyor without slippage. The algorithm written for controlling the motion was able to position the tray within the target limit. However the alignment between the drive roller and the driven roller was hard to maintain. Further improvement in this area is needed in order for the conveyor to work for long hours with minimal maintenance.

Acknowledgement

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Appendix

No	Component	Description
1	Adjustable guider	To adjust the position of tray and give the guide for tray moving
2	Tray	Single seedling tray was in row position at the starting point
3	Roller drive	To drive the belt for moving tray
4	Timing pulley	To rotate and drive the roller
5	DC Motor	To operate the rotation of belting
6	Roller support	To support the tray when at the middle and give the drive roller to rotate smoothly
7	Position of sensor	The sensor will detect the tray at the between to roller the seedling process is do at the stage
8	Leveling Feet	To adjust the level and stability of conveyor at the uninvent right surface
9	Tensional belt	To pull the baring in order to make sure the belt is tensioning
10	Box electronic placed	To store and placed electronic system of conveyor

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