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Integrating Automation in an Oil Palm Loose Fruits Collector

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ABSTRACT

Uncollected oil palm loose fruits contribute to losses for plantation operators. Up until now, various devices have been proposed, but none have dominated the market and planters are still looking for the best machine that could match manual collection. While manual collection is still economical, there are a number of disadvantages, such that it is not ergonomics and labor availability in plantation is decreasing. Therefore, a device that can best collect oil palm loose fruit is highly sought. In this project an attempt has been made in developing an automated machine to collect loose fruits. Initial design was a fully mechanical device with an elastic roller cage to collect the fruits. The second stage incorporated automation features, which was in the elastic cage auto feeding, and on a tracking system to track the motion of the device. This paper presents the development in integrating automation on the oil palm loose fruit collector.

KEYWORDS

Oil palm loose fruit, Loose fruit collection, Automation, Path tracking

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INTRODUCTION

Oil palm loose fruits are the ripest fruitlets in the matured bunch that naturally drop to the ground. There are two conditions for the loose fruits to fall; (1) over ripe fruit bunch – as the fruit over ripe, the fruit tends to come out from the bunch, (2) during harvesting, the fruit would fall and scatter as the fresh fruit bunch hit the ground. Usually, plantation workers would collect the loose fruits manually, either by picking or racking. There were machines built by various organizations (Nadzri et al., 2016), however until now, none could really satisfy the requirement needed. In some devices not just the loose fruits, but debris, dirt, and dried leaves were also collected. Hence, this required additional works to separate the loose fruits from the rubbish, that would also slow down the oil extraction process which comes later. As reported in Sime Darby Annual Report (2008), economically, loose fruits should not be neglected and abandoned because it would lead to losses up to RM30 million for a plantation operator per year. Deraman et al., (2009) also emphasized collection of oil palm loose fruits for profit maximization.

Collection of loose fruit causes several problems. Loose fruits are normally picked up by using hand and put together into buckets, plastic bags or gunny. Other than that, there also different options like using rake, planks and scoop (Motlagh, 2013), however the debris content can be up to 60% of the overall weight (Deraman et al., 2009). A worker has to bend his body to collect fruits on the ground and then move from tree to tree. Time taken to collect the fruits is usually 30% of the harvesting time. This method is time wasting and non-ergonomics, whereas the workers may experience back pain in the long run.

The objective of this paper is to describe the development of an oil palm loose fruit collector. The initial design was based on a mechanically operated machine. Then automation features were incorporated.

METHODOLOGY

The machine developed here was intended as a conceptual demonstrator. Hence the initial stage was a mechanically operated device. The focus was to find a method to collect and unload oil palm loose fruits on the ground. Next, the mechanically operated machine was tested to collect oil palm loose fruits on different surfaces. There were four types of surfaces, namely (1) Concrete, (2) Tarmac, (3) Grass, and (4) Oil palm ground. The areas for testing was 3 m x 3 m where a hundred of loose fruits were scattered evenly (Figure 1). There were two types of tests. The first test was following a path, and the second test was running over a random path until all fruits were collected. The test was repeated five times for averaging. The machine was pushed at walking speed. Finally, automation features were incorporated into the design that focus on the mechanism for collecting and loading the oil palm loose fruits.

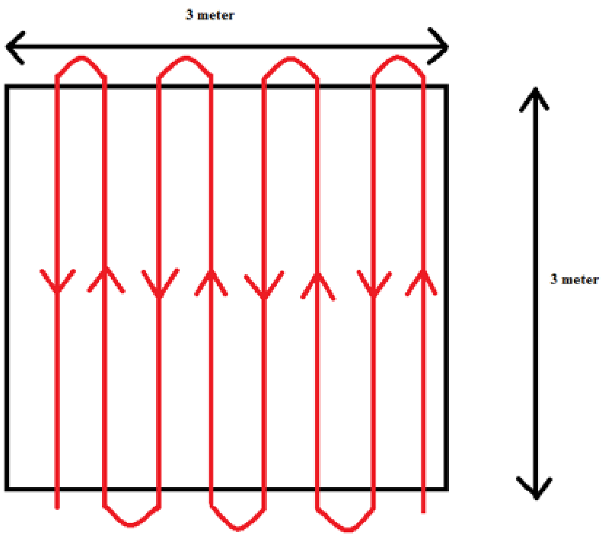

Figure 9: Planned path for surface test

RESULTS AND DISCUSSIONS

Initial Design Concept

The initial design concept was based on a non-motorized, mechanically operated machine. The machine was designed to have three operation steps, namely (1) loose fruit collection (2) loading into a basket (3) unloading the fruitlets. The CAD model and the fabricated model are shown in Figure 2.

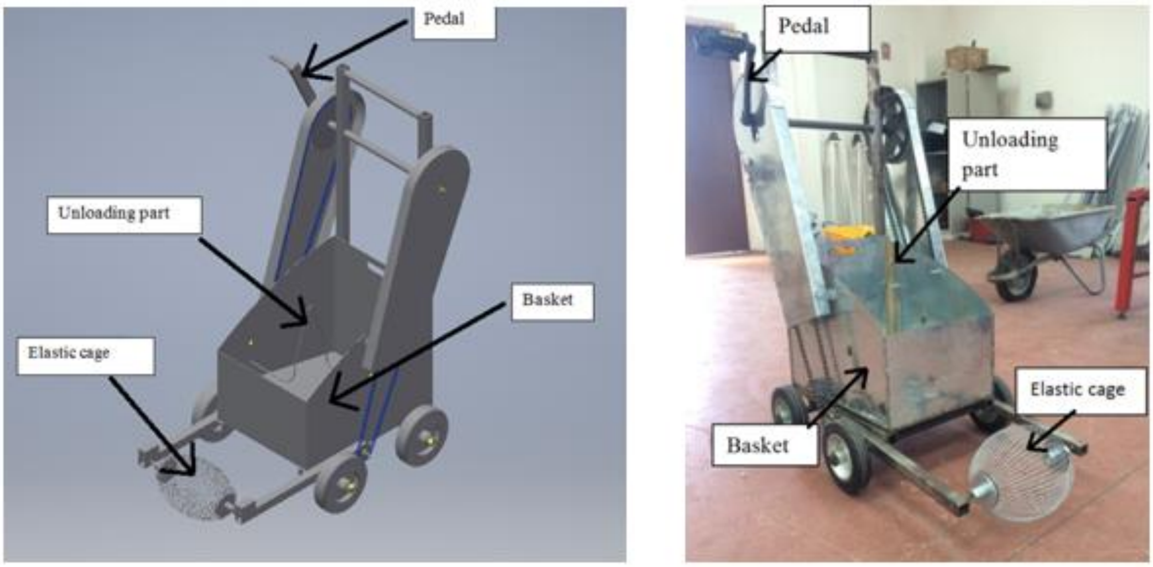

Figure 10: CAD model (left) and fabricated model (right)

On the first operation, the collection of loose fruits mechanism consisted of an elastic cage that collects the fruits into the cage. The cage was made from elastics wires that can accommodate different fruit sizes on an undulating ground, taken from a commercial golf ball collector. In a simple filling test, the cage could accommodate more than one kilogram of loose fruits. The cage rolled freely, independent of the carriage tires. Once the cage was full, the cage would be lifted to the center of a box to unload the fruits. Lifting and lowering of the cage was controlled by a sprocket chain mechanism power transmission. The rotations of the sprocket handler control the movement of the cage.

In order to unload the fruits from the cage, an opener that used a single side-pull caliper brake system would open the cage and the fruits fall through the opening space (second operation). The opening and closing of the cage was controlled by a lever positioned at the left side of the handle. The unloading of the fruits from the box was through the sliding opener behind the box. The box can accommodate more than 3 kg of fruits at a time. This operation was repeated until the box was full.

In the third operation, the basket would have to be full. Then, the machine would unload this to a bag by sliding up the back wall of the basket. The basket base was designed to be inclined so that a machine operator can easily unload all the fruits collected to the backside of the device. Figure 3 shows the collection operations based on the mechanically operated mechanism.

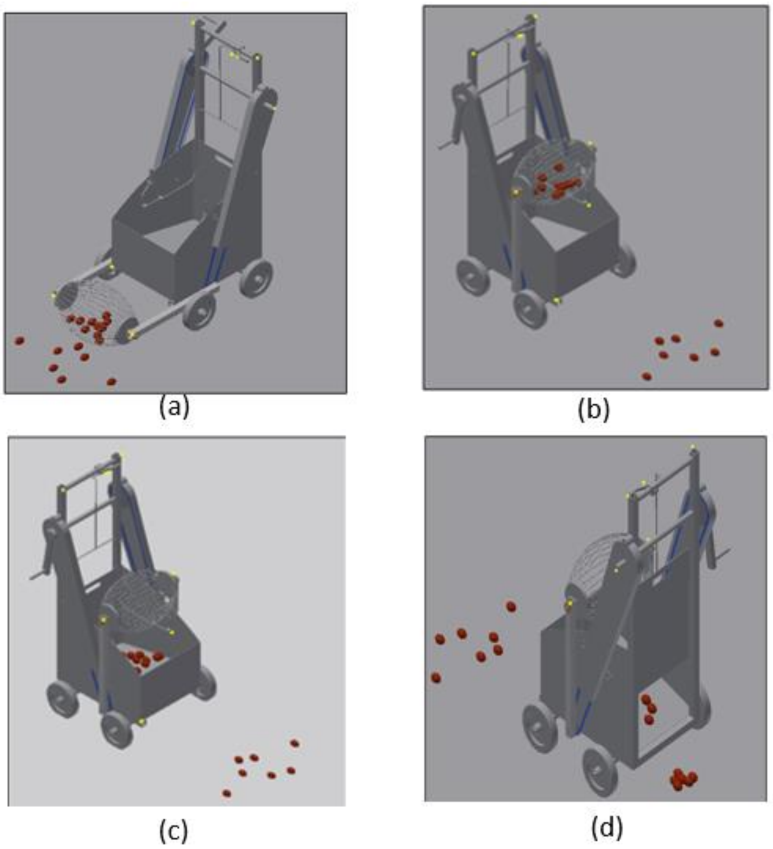

Figure 11: (a) collection of loose fruit, (b) lifting, (c) loading into a box, (d) unloading into a gunny

Analysis of the Initial Concept

The fabricated machine was tested in order to analyze its functionality. Table 1 shows the results of the test. On concrete, the average time taken was 2 min: 46 secs and the percent of collection was 60.2%. For random path collection, the time taken was 3 min: 8.6 sec. On tarmac, the average time taken was 2 min: 16 secs and the percent of collection was 63.4%, while it took 2min: 54.4 sec. On grass surface, the time taken was 2 min: 32 secs and the percent of collection was 64%, while for the random path was 2 min: 24 sec. Finally, on oil palm ground, the average time taken was 2 min: 50 sec and the percent of collection was 60.6%, whereas the random path was 2 min: 14.0 sec. It can be seen that using an elastic cage, the percent of successful collection was between 60 to 65%, therefore the collector may have to do several passes on the same route in order to fully collect the remaining balance. One of the problems observed during collection was the presence of stuck fruits between the cage that disturbed the rotation. Unless the rotation is smooth, the fruits cannot be collected efficiently.

Table 4: Results of collection on various surfaces

Surface type	Planned path		Random path
	Time	% collected	Time
(1) Concrete	2 min: 46.0 s	60.2	3 min: 8.6 s
(2) Tarmac	2 min: 16.6 s	63.4	2 min: 54.4 s
(3) Grass	2 min: 32.2 s	64.0	2 min: 24.0 s
(4) Oil palm ground	2 min: 15.0 s	60.6	2 min: 14.0 s

Integrating Automation

Automatic lifting. In order to automate the machine, firstly the collection operation has to be able to complete the task with minimal human intervention. Therefore, the subassembly for loose fruit collection was rebuilt. Instead of manual lifting through chain and sprocket mechanism, the actuator part was replaced with an automotive power window motor. An infrared sensor was placed at the elastic cage to sense the state of the unit, whether empty or full. A simple control algorithm was written and implemented on an Arduino prototyping board. Theoretically the cage could collect 542 loose fruits. Based on the current setting, the mechanism could lift the cage when it was 50% full. The modification on the part is shown in Figure 4.

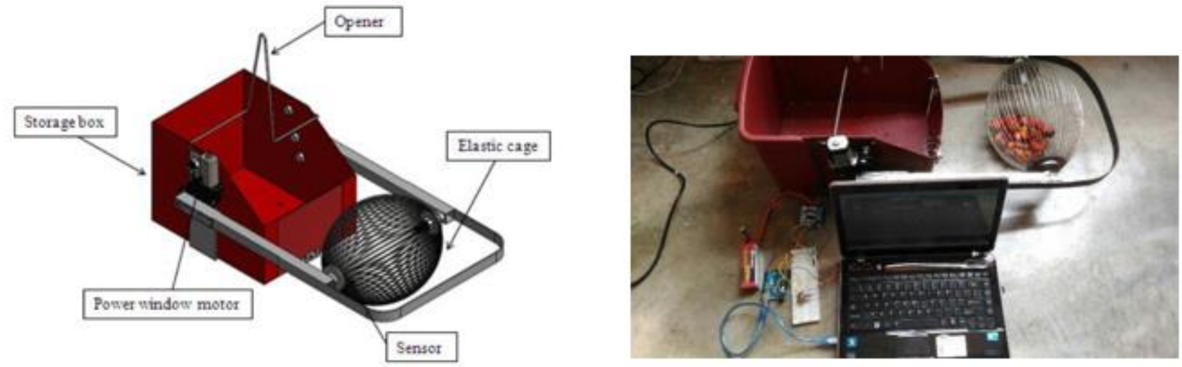

Figure 12: Automation modification for lifting and loading

Navigation. In automating the system, the machine platform had to have a navigation system so that it could run on its own in the plantation. The use of a GPS based system is not applicable in this case because the canopies of oil palm trees make it unreliable. Here initial attempt was made through dead reckoning. An MPU6050 chip was used. The chip consisted of 3-axes gyroscope sensor and 3-axes acceleration sensor, thus making it with 6 degrees of freedom capability. Figure 5 shows the apparatus for testing the algorithm. As of now, the current system has a 54% error in tracking the pathways. It was insufficient for application and requires more development on both the hardware and the software.

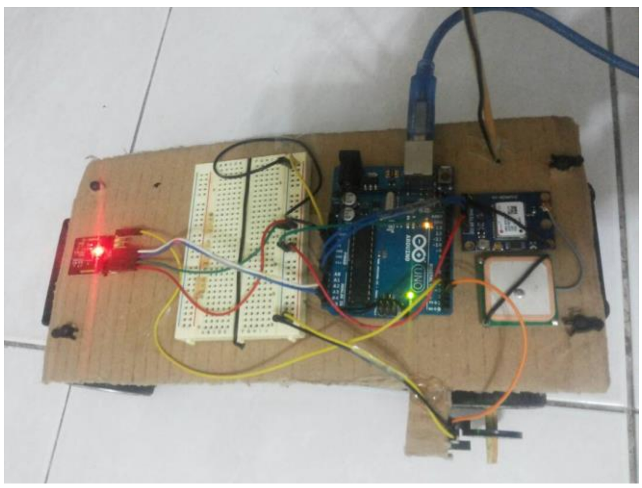

Figure 13: Apparatus for testing dead reckoning

Motorized powered platform: Lastly, the subassembly of the moving platform was made into another version with an electric motor, directly coupled to each of the rear wheel. All four wheels of the platform were fixed to the axle. Hence steering would be achieved with skid steering.

Figure 14: Motorized platform modification

CONCLUSION

This paper presents the work in progress at the Department of Biological and Agricultural Engineering to automate the mechanism for collecting oil palm loose fruits. Most of the works were exploratory, in order to search for various concepts that can be further developed into a working system. In order to incorporate automation capability into the system, three areas need to be strengthened; the capability of the machine to collect the fruits with minimal loses; navigation within the oil palm plantation; and locomotion of the platform.

REFERENCES

1. Deraman, Mohd Solah, Abd Rahim Shuib, and Mohd Salleh Jaafar. 2009. "Roller-Type Oil Palm Loose Fruit Picker". *Malaysian Palm Oil Board* 2009.
2. Motlagh, Jason. 2013. "Palm Oil for The West, Exploitation for Young Workers in Malaysia". Pulitzer Center.
3. Nadzri, M, Muhammad Muzakkir, M, and Afandi Ahmad, A. 2016 "ROLLER PICKER ROBOT (ROPICOT 1.0) FOR LOOSE FRUIT COLLECTION SYSTEM". *ARPN Journal of Engineering and Applied Sciences* 11.14: 8983-8986.
4. Sime Darby Annual Report. 2008