**Preliminary Design Review**

1. **Concept Design**

A diagram of a container

Description automatically generated

This concept is Cartesian Configuration, its base is a vehicle equipped with bands to enable movement across different terrains. On top of the vehicle, there are storage compartments and two robotic arms with three degrees of freedom. The first arm, Arm 1, is fixed on the vehicle and can rotate 360 degrees on a turntable above the vehicle. The second arm, Arm2, is fixed on the Arm 1 and contains a spring mechanism for extension and retraction, allowing it to move telescopically. At the end of the Arm2, there is a cutter device designed to sever the connection between durians and trees for harvesting. Below the cutter mechanism, there is a receptacle for collecting harvested durians, which can then be transported to the storage compartments.

A line drawing of a robot arm

Description automatically generated

The bottom part of the machine is a vehicle with bands instead of wheels, allowing it to move across different terrains. On top of the vehicle, there are storage compartments and two robotic arms, each with three degrees of freedom. The first arm, Arm 1, is fixed on the vehicle, and there is a rotating platform above the vehicle where Arm 1 is attached, enabling it to rotate 360 degrees. Additionally, Arm 1 is equipped with a hydraulic system that allows it to extend and retract, changing its length. Another arm, Arm 2, is fixed on Arm 1 and connected to Arm 1 via a hydraulic system, enabling adjustments to Arm 2's orientation. Arm 2 also has a hydraulic system to adjust its length, allowing for telescopic movement. At the end of Arm 2, there is an end effector—a cutter device designed to sever the connection between durians and trees for harvesting. Below the cutter mechanism, there is a receptacle for collecting harvested durians, which can then be transported to the storage compartments.

A sketch of a drone

Description automatically generated

The concept utilizes a drone with an end effector cutter, capable of severing the connection between durians and trees for harvesting. Below the harvesting mechanism, there is a large net to catch and collect the durians. The drone is controlled to reach the height of the durians, perform the cutting, and allow the durians to fall freely onto the collection net.

A drawing of a snake

Description automatically generated

The concept involves using a robotic snake with an end effector cutter, capable of severing the connection between durians and trees for harvesting. Below the harvesting mechanism, there is a large net to catch and collect the durians. The robotic snake is controlled to reach the height of the durians by wrapping around the tree and rotating its body to climb. Once it reaches the height of the durians, it performs the cutting, allowing the durians to fall freely onto the collection net.

1. **Concept Selection**

**Table 1.** Scores assigned to different concept selections.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Priority | Robot Snake | Drone | Cartesian Arm | Robot Arm |
| Safety | 5 | 3 | 3 | 4.5 | 4 |
| Production Cost\* | 4 | 4 | 2.5 | 3 | 2.5 |
| Efficiency | 4 | 1.5 | 3.5 | 5 | 5 |
| Ease of Operation | 3 | 1 | 2 | 4 | 3.5 |
| Adaptivity\* | 3 | 3.5 | 3.5 | 2.5 | 3.5 |
| Cost of Maintenance | 3 | 4 | 3.5 | 3.5 | 2.5 |
| Innovation\* | 1 | 5 | 4 | 2.5 | 3 |

**Notice:**

**I.** The maximum score of each factor is 5.

**II.** Production Cost\* - The higher of score is, the lower production cost of the concept needs, which is what we are desired.

**III.** Adaptivity\* -It describes the adaptivity harvesting capability of a machine working in a complex environment, such as intersecting branches of trees, different height of durian, etc.

**IV.** Innovation\* - It is rated by the frequency of a kind of machine appearing in our daily life. The more situation where it appears, the lower score will be assigned, i.e., relatively less innovative.

**Table 2.** Final concept selection.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Robot Snake | Drone | Cartesian Arm | Robot Arm | Maximum |
| Weighted Sum | 67.5 | 70 | 87 | 81.5 | 115 |
| Percentile | 0.586956522 | 0.608695652 | 0.756521739 | 0.708695652 | 1 |

Since our motivations of designing a durian picker machine are mainly keeping people safe and lowering the labor price, two factors, Safety and Production Cost, are assigned with a high weight (**Table 1**). Innovation is relatively less important comparing with the other capabilities which really dominated this problem. We observe that Robot Snake attributes advantages in production cost and maintenance cost, which indicate a low labor price, but it is bad at the views of efficiency and ease of operation. Based on the assigned scores, features and performance of Drone do not distinctly stand out as superior or inferior. Cartesian Arm and Robot Arm perform better than the previous two concepts (**Table 2**), however, Cartesian Arm is supposed to better a little bit than Robot Arm in the perspectives of safety and production cost. Therefore, considering all the factors above, Cartesian Arm wins for its robustness and cost-effectiveness.

1. **Technical Specification:**

Geometry and Physical Properties:

A drawing of a machine

Description automatically generated

1. L 5m and W = 2m: The length and width of a normal car, convenient for normal driving during picking. According to the figure, each point represents a durian tree, so the spacing of rows and spacing between rows are smaller than 5m, So, we set the row displacement is smaller than 5m, then the car displacement must smaller than 5m and width equal to 2m.

A white paper with black writing

Description automatically generated

1. H = 10-20m: In the durian planting area, the height of the durian tree is generally between 10-20m, and in order to be successful in picking, the height must be in this interval.
2. A = 1.5m: This is the length of the arm and the picker, and in order for it to be successful, the length must be more than half the width. To get it to touch the durian.

Functional Requirements:

Loads = Weight of durian + Weight of robot arm = + Weight of robot arm = 24.525N + Weight of robot arm

Torques = Weight of durian Length of robot arm = + Torque of robot arm = 36.7875N + Torque of robot arm

Speed of the car = 0-30 km/h

Speed of the arm = 2m/min

Interfaces:

The whole system will be controlled by a worker sitting inside the robot car. The movement of the robot arm is manually operated, using a simple handle.