Oil Palm Sorting System of Fresh Fruit Bunch (FFB) Using Forward Chaining Algorithm

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Abstract. Oil palm is the producer of oil and fuel. To get a good quality, it is necessary to sort the fresh oil palm fruit based on the characteristics and criteria of the type of fresh fruit bunches (FFB). This paper aims to carry out the process of sorting the oil palm fruits using the Forward Chaining algorithm to obtain superior quality oil palm fruit based on the characteristics and criteria of fresh oil palm fruit bunches. The sorting phase purpose is to shorten industrial process phase and reduce cost. This sorting mechanism will be developed as a system that can educate oil palm farmers to do sorting before the oil palm goes through the industrial process. The research method uses a forward chaining algorithm by determining 5 criteria and 39 characteristics of fresh oil palm fruit bunches with percentage value determined by using the classical probability calculation. The accuracy of this research is 100%.

1. Introduction
Oil palm is an oil and fuel-producing plant. Indonesia is the largest oil palm producing country in the world. Some of the oil palm producing islands are Sumatera and Borneo, so many of the residents in both islands work as oil palm farmers. To get good quality oil, oil palm needs to be processed with structured stages and processes, one of which is the sorting process. The sorting process is carried out to obtain oil palm fruit with good and viable quality for industrial processing [1]. This sorting mechanism will be developed into a system that can educate oil palm farmers to do sorting fresh oil palm fruits before putting it into the industrial process. The sorting process is based on the characteristics and criteria of fresh fruit bunches. Forward chaining methods is a method that has been widely used, one of which detects diseases in cocoa plants. In this study, an accuracy of 84% was obtained [2]. Furthermore, the forward chaining algorithm is also used to diagnose human eye disease with an accuracy of 83% [3]; then, the forward chaining method is used to detect rachitis based on the symptoms encountered by the patient and the result is a recommendation for the patient to have a further doctor examination [4]. This paper aims to carry out the process of sorting oil palm fruits using the Forward Chaining Method to obtain superior quality oil palm fruit based on the characteristics and criteria of fresh oil palm fruit bunches.

2. Methodology

2.1. Determining the Criteria
There are 5 criteria for sorting palm oil fruit including in this research, which are (1) Normal bunches (2) Excessive stem bunches, (3) Long bunches (4) Dwarf bunches (5) Single Fruits [5]. All criteria are shown in Figure 1.
The oil palm fruit bunches criteria

The sorting criteria are determined by the fruit ripeness standard, which is < 2 bumpy/kilogram. It means that if the weight of the fruit is 10 kilograms, at least 20 single fruits will naturally fall. The fruit maturity limit is set >75% - 90%, it assures that all fruits will be detached. Fruits received by the factory are fruits in fractions 1, 2, 3, and 4. The following table shows the fruit fraction and the degree of ripeness.

| No | Fraction | The amount of fruit falls before harvest | Colour of oil palm fruit | Level of Ripeness |
|----|----------|----------------------------------------|-------------------------|-------------------|
| 1  | Oo       | 0 % Loosen                             | Green/Black             | Unripe            |
| 2  | O        | 1–12.5 % The outer layer detached      | Black                   | Underripe         |
| 3  | 1        | 12.6–25 % The outer layer detached     | Orange                  | Ripe             |
| 4  | 2        | 25.1–50 % The outer layer detached     | Orange                  | Ripe I           |
| 5  | 3        | 50.1–75 % The outer layer detached     | Orange                  | Ripe II          |
| 6  | 4        | 75.1–100 % The outer layer detached    | Maroon                  | Overripe I        |
| 7  | 5        | 100 % The outer layer detached         | Maroon                  | Overripe II       |

Table 1 describes 7 criteria for the degree of oil palm fruit ripeness. The degree of ripeness, which can be observed from the outer layer that is loosen from the fruit, is scaled from raw to overripe.

2.2. Weighing the Accuracy

Weighing is conducted using classical probability approach. The classic probability formula is defined as the probability of an event A, denoted P(A) in which n is the number of events and n(A) is the number of results obtained A [6]. The weighing is shown in formula 1.

\[
A = \frac{n(A)}{n}
\]

\[
Probability(A) = \frac{Number \ of \ outcomes \ in \ A}{Total \ number \ of \ outcomes \ in \ the \ sample \ space}
\]

Then

\[
Probability(A) = \frac{Number \ of \ symptoms}{Total \ number \ of \ symptoms}
\]

Formula (1) is used to calculate relative frequency value by dividing the number of events with the total number of events. Formula (2) explains the process of calculating the probability of the oil palm fruits fit in the sorting category, while formula (3) is used to compute the probability value.

2.3. Developing Decision Tree

Before constructing a decision tree, the forward chaining inference rules, shown in Figure 2, must be determined. In addition, the decision tree results are built based on rules that have been set by the expert by looking at the characteristics and criteria of the oil palm degree of ripeness [7]. The decision tree is shown in Figure 3.
Figure 2. Inference rule on forward chaining.

Figure 3. The decision tree was taken from criteria and characteristics list

Figure 2. shows a decision tree that is built based on IF-THEN rules between a list of criteria and characteristics [8].

2.4. Decision Making

Decision making is based on IF-THEN rules from a list of criteria with characteristics [8] [9], shown in Figure 4.

Figure 4. IF-THEN rule
3. Result and Discussion

Based on the testing, the Forward chaining algorithm is considered capable of helping the process of sorting the list of criteria with characteristics. Based on the calculations, the result percentage is 100% which fits the company standard. It means that this algorithm can later be developed into a better sorting system. Let us think about an example of sorting. If 5 characteristics are identified as (1) Grey/black stalk (C017), (2) Bunch weightless or more than 2 kilograms (C018), (3) Shrink/dry fruit skin (C019), (4) Bunches containing sand/soil (C021), and (5) Bunches containing fertilizer/midrib (C022), with the possibilities of sorting (1) Bunches remnant I (S015), (2) Bunches remnant II (S016), (3) Sorted bunches (S017) and, (4) Rotten Bunches (S018), the following result will be obtained by knowing several data as listed in Table 2.

Based on the testing, the Forward chaining algorithm is considered capable of helping the process of sorting the list of criteria with characteristics. Based on the results of the calculations obtained a percentage of 100% results following company standards. This means that this algorithm can later be developed into a better sorting system. An example of sorting is done as follows below. If 5 characteristics are identified, including (1) Grey/black stalk (C017), (2) Bunch weightless or more than 2 Kilograms (C018), (3) Shrink/dry fruit skin (C019), (4) Bunches containing sand/soil (C021) and, (5) Bunches containing fertilizer/midrib (C022), with the possibility of sorting are (1) Remnant bunches I (S015), (2) Remnant bunches II (S016), (3) Sorted bunches (S017) and, (4) Rotten Bunches (S018), if several answers are known as listed in Table 2, the following results will be obtained.

\[
S(A) = \sum \text{characteristics selected from sorting of categories} \times 100\%
\]

From the calculations, the results of the sorting percentage of each category are: bunch remnant I (S015) at 60%, bunch remnant II (S016) at 60%, past sorted bunch (S017) at 100%, and rotten bunch (S018) at 50%. Therefore, based on the probability value which include 6 characteristics and criteria, the largest value obtained is S(S17), which is 100%. Based on the characteristics selected, the result of the sorting of oil palm fruit is considered as Past Sorted Bunches type.

Table 2. Example of Decision Making

| The characteristic detected | Answer | The next characteristic | Detection of sorting | Details |
|-----------------------------|--------|------------------------|----------------------|---------|
| C017                        | 1      | C018                   | S15, S16, S17, S18  | Continuous Examination |
| C018                        | 1      | C019                   | S15, S16, S17, S18  | Continuous Examination |
| C019                        | 1      | C021                   | S15, S16, S17, S18  | Continuous Examination |
| C021                        | 1      | C022                   | S17                  | Continuous Examination |
| C022                        | 1      | Finished               | S17                  | Detected Sorting |

Table 2 explains examples of decision making in determining the results of sorting oil palm fruit based on the detected characteristics, in which C17 has 4 sorting detections namely S15, S16, S17, and S18, which are listed in Table 4. The table of characteristics listed in Table 3.

Table 3. The list of palm oil characteristics.

| CID  | Characteristics                     |
|------|-------------------------------------|
| C001 | Stem length <2 centimetres          |
| C002 | Bunch weight>2 kilograms with white stem |
| C003 | Yellow/orange fruit                 |
Table 3. It is a list of characteristics of oil palm fruit-based on expert standards from a company. Table 4 is a table listing the criteria for sorting oil palm fruits based on the stems in the bunch.

**Table 4. List of criteria for sorting oil palm fruits based on bunches**

| SID  | Bunches Criteria                     | Statement     |
|------|--------------------------------------|---------------|
| S01  | Empty bunches                        | Normal bunches|
| S02  | Ripe bunches                         | Normal bunches|
| S03  | Overripe bunches                     | Normal bunches|
| S04  | Overripe bunches                     | Normal bunches|
| S05  | Underripe bunches                    | Normal bunches|
| S06  | fungi/termites infected bunches      | Normal bunches|
| S07  | Raw bunches                          | Normal bunches|
Table 4. shows the number of sorting criteria for each oil palm fruit that has peeled off.

4. Conclusion
The conclusion of this study is the Forward Chaining Algorithm can be applied to help the process of sorting oil palm fruits based on fruit bunches criteria, with a validity level of calculation of 100%. The sorting is done in step by step based on the rules in forward chaining.

5. References
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