# Performance Evaluation of Fuzzy Logic Approach for Orchid Identification (*Orchidaceae*) in Liwa Botanical Garden Lampung Based on Leaf Morphology

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## Abstract

*Orchidaceae is the Latin name of orchids that have various types of flowers. The flowers usually have different characteristics between one and another, starting from the characteristics of shape and size. To differentiate the types of orchid plants, you can look at the shape, length, width and tips of the leaves. However, due to the similarity of characteristics, identification of orchid plant types tends to be subjective, resulting in potential errors in identification. Mistakes in determining the type of orchid will result in errors in culture development, grouping and care that can result in losses due to death. This research aims to develop a fuzzy based approach for identifying the type of orchid plant based on leaf characteristics such as shape, length, width and tip of the leaf.. In this research, we focus on the types of orchid plants (Dendrobium) taken from the Liwa Botanical Garden, West Lampung. The stages carried out in the research were to create a knowledge base based on expert abilities, while for identification using fuzzy logic calculations. This research used 20 orchid criteria data from an expert. We have done several numerical experiments by using real data. The results were compared with those given by the expert. It is shown that the approach would be very accurate with an accuracy of 100%.*

**Keywords:** *Fuzzy Logic, Orchids, Dendrobium, Leaf, Morphology, Liwa Botanical Garden*

## 1. INTRODUCTION

The Liwa Botanical Garden located in West Lampung Regency(Lampung, Sumatra island) is an institution that performs ex situ conservation of plants including orchids. Orchids have been given high priority in conservation because many orchids are threatened in the wild because of exploitation and overcollection for economic reasons that lead to the population decline and disappearance of many orchid species. Another threatening factor is deforestation causing the loss and damage of orchids, a natural habitat that will lead to the extinction of orchids. Liwa Botanical Garden has an important role in the preservation and conservation of plants including orchids. Many orchid species have been collected from the natural habitats for conservation purposes in the Liwa Botanical Gardens. However, many orchid species have not yet been identified in these gardens[1]

Identification of orchid species is important in orchid conservation. The present study focussed on the identification of some specimens of Dendrobium (one of the largest orchid genera) that will be based on the morphological characters as one of the important tools in the plant's taxonomic and systemic basis. The morphological characters that will be used in the present study are leaf morphology. Given the urgency of identification and the limitations of specimens in the field, especially flower organs, this study is important. This study aims to determine variations in morphological characters and phenetic relationships for the identification of Dendrobium in the Liwa Botanical Garden. The results of this study are expected to serve as basic information in the identification of natural orchids to support conservation in the Liwa Botanical Garden[1].

Orchidaceae (orchids) is one of the biggest plant families that consist of approximately 25,000 species belongs to over 900 genera across the world. Orchids have high variations in the morphology of the flowers, leaves, and stems (pseudobulbs). Dendrobium is one of the orchid genera containing a large number of species (approximately 1500 species) widely spread across the world, from Japan, China, India, the Malacca Peninsula, Indonesia, the island of Papua, to Australia[1]. Orchid plants have the Latin name orchidaceae, which have various variations ranging from shape, length, width and size of leaves and flowers with various unique characteristics.[2]. Orchid plants have special characteristics such as different shapes, sizes and leaf tips, making them different from other plants in Indonesia. It is estimated that there are 5000-6000 orchid species spread throughout regions such as Kalimantan, Java, Papua and Sumatra.[3]. On the island of Sumatra, precisely in Lampung Province, West Lampung Regency has many kinds of orchids[4]

One type of orchid flower can have characteristics in the form of different leaf shapes and sizes, which can make it difficult for people to know the type of orchid flower. Based on leaf morphology, orchids have six types, namely (1) Moon Orchid (2) Dendrobium (3) Vanda Orchid (4) Cattleya Orchid (5) Oncidium Orchid, and (6) Cymbidium Orchid. The Dendrobium type has ten names with different characteristics. The characteristics of orchid flowers that have similarities can be a problem because it relates to determining the type, especially for the public or related officers who sometimes provide subjective identification. To differentiate the types of orchids, you can look at the leaves, such as the shape of the leaves, the length and width of the leaves[5]. In general, orchids have many similarities, especially when looking at the shape and size of the leaves, this can cause

errors in identification. Mistakes in determining the type of orchid will result in care errors which can result in losses due to death. Therefore, the identification process can utilize information technology to assist identification using fuzzy logic.

Fuzzy logic has the function of providing problem solving modeling as humans do with the help of computer technology. The use of fuzzy logic allows a problem formulation to be solved easily with an accurate solution[6]. Fuzzy logic aims as a step to see the input space in processing until it becomes the output space. The basis for applying fuzzy logic is fuzzy sets. Fuzzy logic also has the ability to solve problem formulations that contain uncertainty. The application of fuzzy logic is influenced by expert knowledge of the rules contained in it[7].

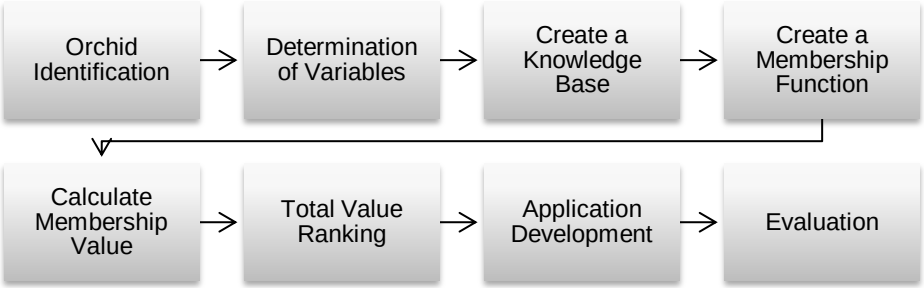
Several studies on the application of fuzzy logic have been carried out in the agricultural sector. Research conducted[8]applying fuzzy logic to IoT Smart Farming. The results of this research can help farmers in optimizing the growth of Phalaenopsis orchids.[9]conducted research by applying IoT-based mamdani fuzzy logic to a Smart Garden for cultivating Oyster Mushrooms. Applying the Fuzzy Mamdani method, the tool can control temperature automatically in the range of 25°C to 28°C and is able to support humidity in the range of 87% to 90%. Apart from that, other research uses fuzzy C-Means for flower image segmentation. The application of fuzzy different colors as features in object segmentation in digital images can influence the results. In segmenting similar flower objects that vary in number and have a green background, the use of the LAB color model component achieves the highest performance among other models such as RGB, HSV and YcbCr[10].

Based on research, the application of fuzzy logic has been proven to help farmers in various problems. The aim of this research is to create a knowledge base based on expert abilities, while identifying Dendrobium orchid types using fuzzy logic. Input is in the form of orchid criteria such as leaf shape, length, width and leaf tip. The output of the proposed system is a value that is close to the orchid type. This research needs to be carried out to help related parties such as farmers, experts, and agricultural and plantation officers in the process of identifying orchid plant types more easily and accurately..

## 2. Methods

### 2.1 Research Methodologies

These are research steps carried out starting from the orchid identification stage to the evaluation stage. This research stage is shown in Figure 1.




**Picture1. Research stages**

### 2.2 Orchids (Orchidaceae)

Orchids or Orchidaceae are plants that easily adapt to their growing environment so that orchid plants can be found in almost all parts of the world. Orchids as a type of ornamental plant with all their stunning uniqueness have attracted the attention of ornamental plant fans.[11]. The diversity of orchids in Indonesia is very large, there are around 3,000 species and have high economic value. This great potential is an advantage for our country, but at the same time it is also a challenge to maintain, manage and preserve it. This genetic wealth asset is capable of providing high economic value if managed well. To optimize the use of orchids, various efforts are needed, one of which is inventorying orchid types as a first step[4]. Based on leaf morphology, orchids have six types, namely (1) Moon Orchid (2) Dendrobium (3) Vanda Orchid (4) Cattleya Orchid (5) Oncidium Orchid, and (6) Cymbidium Orchid. In the research, the object used was the Dendrobium orchid. This type has very identical leaves[12]. The type of Dendrobium orchid can be seen in Figure 2.

**Picture2. Dendrobium orchid type**

### 2.3 Variable

This is a criterion that will be used as a consideration to determine the type of natural Dendrobium orchid. The four leaf variables used are (a) Shape, (b) Length, (c) Width, and (d) Leaf Tip.

## 2.4 Knowledge Base (Knowledgebase)

A knowledge base is a type of database used for knowledge management. These databases provide functions for the collection, organization, and retrieval of computerized knowledge. The most important thing about a knowledge base is the quality of the information it contains. The best knowledge bases have articles that are well written and maintained for accurate results, as well as a carefully designed content format and classification structure.[13]. This knowledge base is built on expert expertise. An expert on this research, Dr. Mahfut, S.Sc., M.Sc. a researcher in the field of orchid plant biology from the University of Lampung. The knowledge base for identifying Dendrobium orchid species is shown in Table 1.

**Table1. Knowledge base of Dendrobium orchid leaf morphology based on experts**

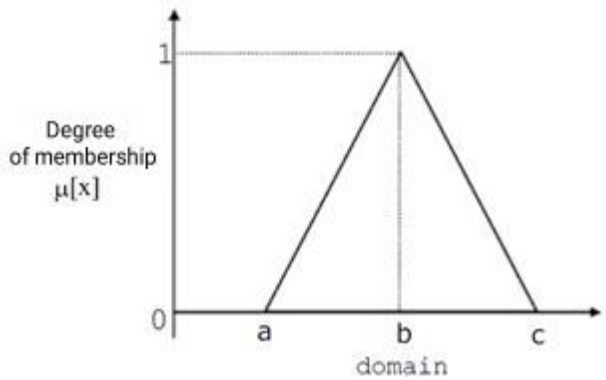
| Type | Form | Length (cm) | Width (cm) | End |
|---|---|---|---|---|
| *D. Cetifolium* | Ovals | 10.6 | 7.5 | Tapered |
| *D. Anae* | Shield | 12.7 | 10.2 | Tapered |
| *D. Crumenatum* | Ovals | 5 | 6.5 | Blunt |
| *D. Montanum* | Ovals | 15.2 | 10.5 | Tapered |
| *D. Babience* | Ovals | 14 | 9 | Tapered |
| *D. Nobile* | Heart | 19.5 | 12.6 | Pointed |
| *D. Phalaenopsis* | Heart | 15.6 | 6,8 | Tapered |
| *D. Taurium* | Ovals | 18 | 7.6 | Tapered |
| *D. Cucumerium* | Ovals | 12.5 | 18 | Tapered |
| *D. Spectacular* | Ovals | 9.2 | 11.1 | Pointed |

## 2.5 Fuzzy Logic

Fuzzy logic is a logic that has a value of fuzziness or fuzziness between true or false[14]. Fuzzy logic can be used in the fields of control theory, decision theory, and some parts of science management. The advantage of fuzzy logic is that it is capable of linguistic reasoning, so that in its design there is no longer a need for mathematical equations for the objects being controlled.[7]

## 2.6 Membership Functions

The membership function is a curve that shows the mapping of input data points into their membership values or degrees of membership which have an interval between 0 and 1[15]. One way that can be used to obtain membership values from fuzzy sets is through a function approach[14]. The curve used is a triangular curve. This curve is basically a combination of 2 lines (linear). This model curve is appropriate to use because of the suitability of the knowledge base for finding the middle value. The shape of the triangular curve is shown in Figure 3.




$$\mu[x]=\begin{cases} 0 & x\leq a \text{ or } x\geq c \\ (a-b)/(b-a) & a\leq x\leq b \\ (b-x)/(c-b) & b\leq x\leq c \end{cases} \quad (1)$$

**Picture3. Membership curve of triangular representation**

### 2.7 Degree of Membership

In fuzzy set theory, the role of membership degree as a determinant of the existence of elements in a set is very important[16]. Membership value or degree of membership or membership function is the main characteristic in reasoning with fuzzy logic[15]

## 3. Results and Discussion

### 3.1 Source Data

The data used in this research is data on the morphology of natural Dendrobium orchid leaves taken from the Liwa Botanical Gardens, West Lampung Regency, Lampung Province, Indonesia in 2018. This data does not yet contain the orchid types shown in Table 2:

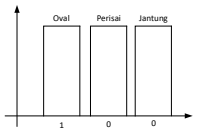
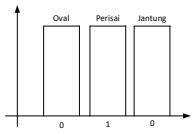
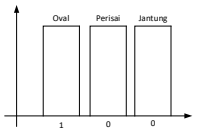
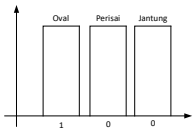
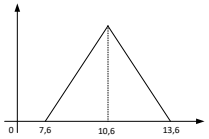
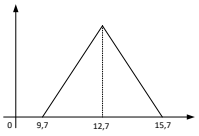
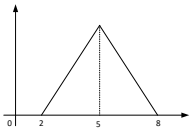
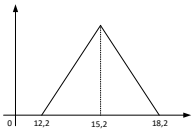
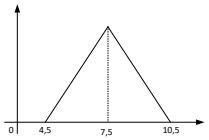
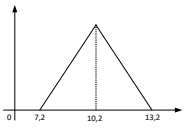
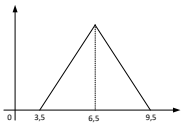
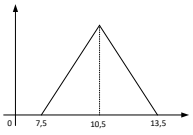
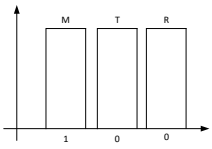
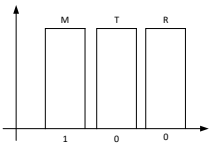
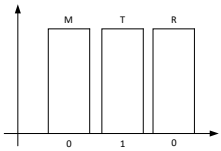
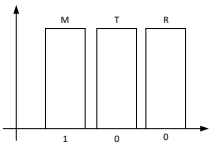
**Table2. Sample data on the criteria for the Dendrobium type orchid**

| No | Form | Long | Wide | End |
|---|---|---|---|---|
| 1 | Ovals | 17.3 | 10 | Tapered |
| 2 | Shield | 11 | 20 | Tapered |
| 3 | Heart | 9.5 | 9.4 | Pointed |
| 4 | Heart | 13 | 11 | Tapered |
| 5 | Ovals | 12 | 7.6 | Blunt |
| 6 | Shield | 10.6 | 9 | Tapered |
| 7 | Ovals | 15 | 8 | Blunt |
| 8 | Ovals | 16.3 | 12.4 | Tapered |
| 9 | Heart | 17 | 6.9 | Blunt |
| 10 | Shield | 12.4 | 7.2 | Pointed |
| 11 | Ovals | 10 | 9 | Tapered |
| 12 | Shield | 9.6 | 13 | Tapered |
| 13 | Ovals | 18 | 14 | Blunt |
| 14 | Heart | 14 | 10.8 | Pointed |
| 15 | Shield | 13.7 | 12 | Pointed |
| 16 | Heart | 5 | 6,8 | Tapered |
| 17 | Ovals | 7 | 8 | Pointed |
| 18 | Ovals | 8.2 | 10.5 | Tapered |
| 19 | Heart | 9 | 11.1 | Blunt |
| 20 | Ovals | 15 | 18 | Tapered |

### 3.2 Membership Function for Orchid Types

The membership function is created based on variables formed from the criteria for each type of orchid. Table 3 displays a sample of membership functions for the Dendrobium Cetifolium orchid criteria

**Table3. Membership function for each type of orchid**

| Variable | *Cetifolium* | *Anae* | *Crumenatum* | *Montanum* |
|---|---|---|---|---|
| Form |  |  |  |  |
| Length (cm) |  |  |  |  |
| Width (cm) |  |  |  |  |
| End |  |  |  |  |

| Variable | *Babience* | *Noble* | *Phalaenopsis* | *Taurium* |
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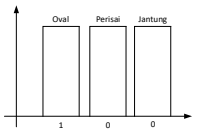
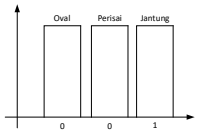
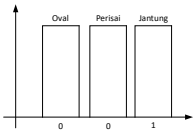
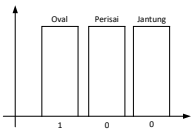
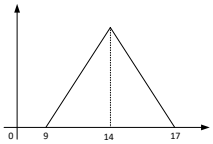
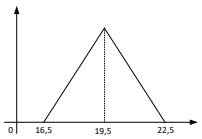
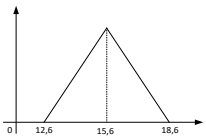
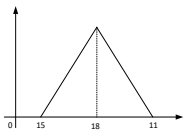
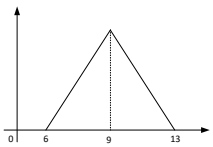
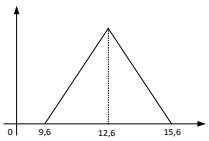
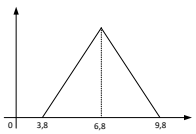
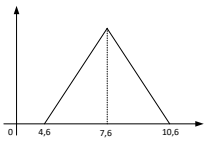
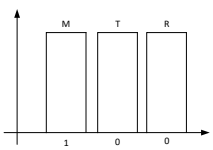
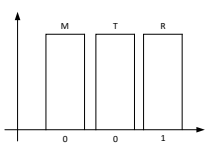
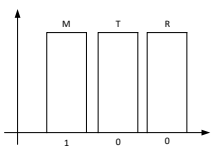
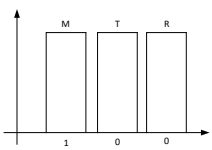
| Form |  |  |  |  |
| Length (cm) |  |  |  |  |
| Width (cm) |  |  |  |  |
| End |  |  |  |  |

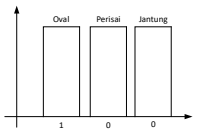
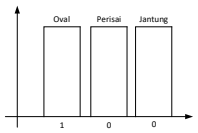
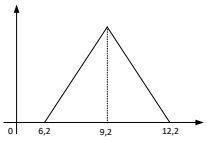
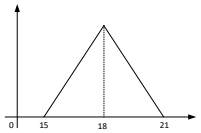
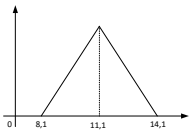
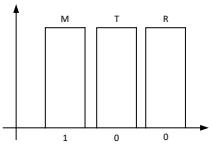
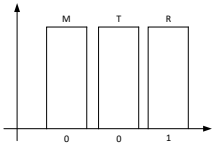
| Variable | *Cucumerium* | *Spectacular* |
|---|---|---|
| Form |  |  |
| Length (cm) |  |  |
| Width (cm) |  |  |
| End |  |  |

**Table 2.** Comparison Metrics

Based on the membership function in Table 3, then calculate the membership value for each variable. Membership values are shown in Table 4.

**Table4. Sample membership value for the Dendrobium Cetifolium type**

| No | Variable | Data | Membership value |
|---|---|---|---|
| 1 | Form | Ovals | μ=”Oval”, then 1 |
| 2 | Long | 17.3 | μ=0 |
| 3 | Wide | 10 | μ=0.16 |
| 4 | End | Tapered | μ=”Tapered”, then 1 |

Next, calculate the total value for each type of orchid using the following equation:
$TotalType = Leaf\ Shape\ Value + Length\ Value + Width\ Value + Tip\ Value$ (2)

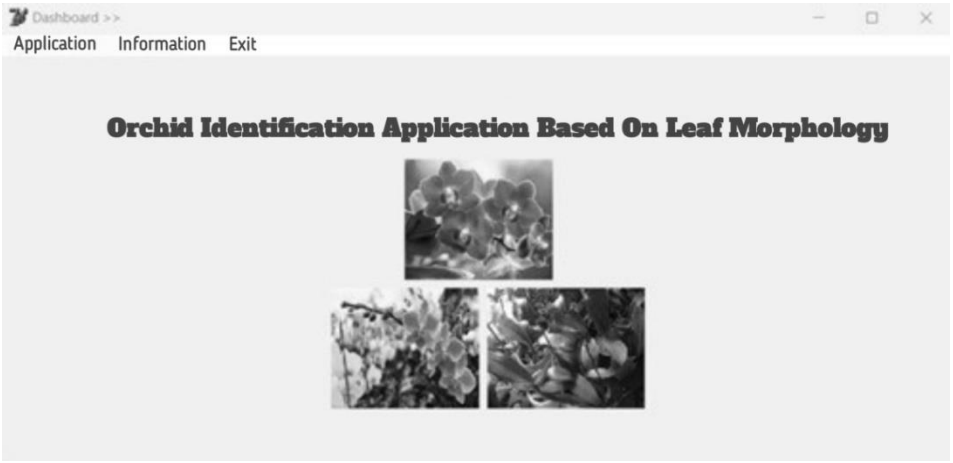
The calculation results for each type of orchid are shown in Table 5. The highest total value shows the results of identifying the orchid type. Based on the criteria of shape = "Oval", length = 17.3 cm, width = 10 cm, and tip shape = "Tapered", then from the total calculation results the largest can be identified as an orchid type*Taurium.*

**Table5. Total value of each type of orchid**

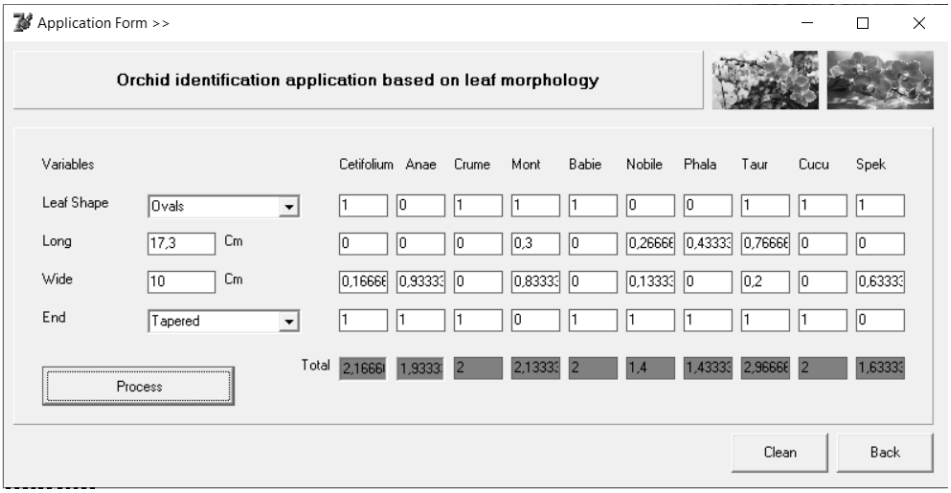
| No | Types of Orchids | Total |
|---|---|---|
| 1 | *D. Cetifolium* | 2.16 |
| 2 | *D. Anae* | 1.93 |
| 3 | *D. Crumenatum* | 2.00 |
| 4 | *D. Montanum* | 2.13 |
| 5 | *D. Babience* | 2.0 |
| 6 | *D. Nobile* | 1.44 |
| 7 | *D. Phalaenopsis* | 1.43 |
| 8 | ***D. Taurium*** | ***2.96*** |
| 9 | *D. Cucumerium* | 2.00 |
| 10 | *D. Spectacular* | 1,633 |

### 3.3 Application

The application was developed using the Pascal programming language with the Delphi GUI. Users can fill in orchid criteria data in the form of leaf shape, leaf length, leaf width and leaf tip shape. Press the process button to display the calculation results. The highest value was identified as an orchid type. The application display can be seen in Figure 4-5.




**Picture4. Application dashboard page**




**Picture5. Orchid identification page based on leaf morphology**

### 3.4 Evaluation

Evaluation is carried out to calculate the accuracy between the proposed system and recommendations from an expert. Table 6 displays the results of orchid identification from the proposed and expert systems

**Table6. Comparison of orchid identification based on proposed and expert systems**

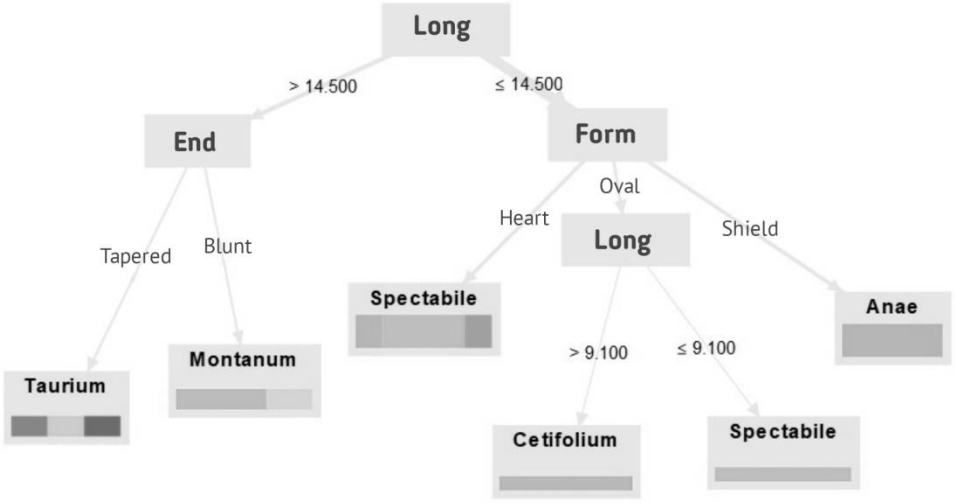
| No | Form | Long | Wide | End | Identify Experts | System Identification | Information |
|---|---|---|---|---|---|---|---|
| 1 | Ovals | 17.3 | 10 | Tapered | *Taurium* | *Taurium* | **In accordance** |
| 2 | Shield | 11 | 20 | Tapered | *Anae* | *Anae* | **In accordance** |
| 3 | Heart | 9.5 | 9.4 | Pointed | *Spectacular* | *Spectacular* | **In accordance** |
| 4 | Heart | 13 | 11 | Tapered | *Anae* | *Anae* | **In accordance** |
| 5 | Ovals | 12 | 7.6 | Blunt | *Cetifolium* | *Cetifolium* | **In accordance** |
| 6 | Shield | 10.6 | 9 | Tapered | *Anae* | *Anae* | **In accordance** |
| 7 | Ovals | 15 | 8 | Blunt | *Montanum* | *Montanum* | **In accordance** |
| 8 | Ovals | 16.3 | 12.4 | Tapered | *Noble* | *Noble* | **In accordance** |
| 9 | Heart | 17 | 6.9 | Blunt | *Phalaenopsis* | *Phalaenopsis* | **In accordance** |
| 10 | Shield | 12.4 | 7.2 | Pointed | *Anae* | *Anae* | **In accordance** |
| 11 | Ovals | 10 | 9 | Tapered | *Cetifolium* | *Cetifolium* | **In accordance** |
| 12 | Shield | 9.6 | 13 | Tapered | *Anae* | *Anae* | **In accordance** |
| 13 | Ovals | 18 | 14 | Blunt | *Montanum* | *Montanum* | **In accordance** |
| 14 | Heart | 14 | 10.8 | Pointed | *Spectacular* | *Spectacular* | **In accordance** |
| 15 | Shield | 13.7 | 12 | Pointed | *Anae* | *Anae* | **In accordance** |
| 16 | Heart | 5 | 6,8 | Tapered | *Phala* | *Phala* | **In accordance** |
| 17 | Ovals | 7 | 8 | Pointed | *Spectacular* | *Spectacular* | **In accordance** |
| 18 | Ovals | 8.2 | 10.5 | Tapered | *Spectacular* | *Spectacular* | **In accordance** |
| 19 | Heart | 9 | 11.1 | Blunt | *Spectacular* | *Spectacular* | **In accordance** |
| 20 | Ovals | 15 | 18 | Tapered | *Cucumerium* | *Cucumerium* | **In accordance** |

Evaluation uses accuracy calculations by calculating the correct class of the proposed system calculation using the equation:

$$Accuracy = \frac{Appropriate\ Amount}{Total\ Data} \quad (3)$$

$$Accuracy = \frac{20}{20} = 100\%$$

The data in Table 6 can be displayed using a Tree Diagram as in Figure 3. In the Tree Diagram it can be seen that if the Length is> 14.5 and the Tip = "Blunt" then the type can be predicted as "Montanum", but if the Edge = "Tapered" then the type is "Taurium" . The Tree Diagram is shown in Figure 6.




**Picture6. Tree diagram based on leaf morphology identification**

## 4 Conclusion

This research produced a proposed system for identifying Dendrobium orchid species which was built using an expert's knowledge base. The data used was taken from the Liwa Botanical Gardens, West Lampung Regency, Lampung Province, Indonesia. Orchid leaf criteria data such as shape, length, width and tip of the leaf are used as variables. Next, a membership curve model is created using fuzzy logic. The results of fuzzy logic calculations are membership values. The membership value is calculated to obtain the orchid type that best suits the orchid profile. Evaluation of the proposed system is carried out by calculating the correct number of orchid types by comparing the system recommendations with expert recommendations. The evaluation results showed that the proposed system was able to identify orchid types with an accuracy value of 100%. These results indicate that the proposed system is suitable to be used to help determine orchid types quickly and accurately. This research still has shortcomings in terms of the data and variables used. The sample data used is 20 data, while the variables use four leaf criteria so it is necessary to add them to suit the type of orchid from each location.


## Acknowledgement

We would like to thank Universitas Mitra Indonesia for providing assistance in the form of funding. Thank you also to the management of the Liwa Botanical Gardens, West

Lampung Regency who have assisted in data collection and all parties who have assisted in the process of completing the research so that this article can be completed.

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