Species identification of specimens from *Primula* genus using fuzzy logic

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RESUMEN

Plant recognition is an opening research area because of its difficulty, an innovative instrument of recognition is to use fuzzy sets and approximate reasoning. This research uses that instrument in an implementation using approximate reasoning. Every attributes of various species are represented by fuzzy sets. These attributes are the inputs of an intelligent inference engine.

***Keywords*:**
Fuzzy logic, plant recognition, fuzzy logic

1. INTRODUCTION

One of the main tasks for the day-to-day of a botanist is plant recognition, but also environmental jobs like environmental impact assessment need to make an effective identification of species in the affected area. Nowadays dichotomic keys are used as a part of the process of identifying species, but this technique is useful only if botanic specialists are using it, but even if specialists change their usual environment it will be too much complicated.

Species determination is based on morphologic characteristics which can be various and from different types, some of them will be precise and others will have high degree of uncertainty, this latter group of attributes can be easily modelled with fuzzy sets.

Dichotomic keys ask a series of questions, but it is possible that you don't know the answer of one of them, so you can not continue with the identification. This problem is known as incomplete acknowledge and Fuzzy logic works well with it.

This paper proposes a mechanism to solve these problems using fuzzy logic, the system described below is based on the information representation using fuzzy sets and apply inference rules to do approximate reasoning.

2. COLLECTING START INFORMATION

First of all, it was necessary recollected information about each Spanish specie member of *Primula* genus: *P. elatior, P. veris, P. acaulis, P. farinosa, P. integrifolia, P. latifolia, P. pedemontana, P. hirsuta*. Every characteristic found and their values are included in a table, for instance mealy (yes/no), leaf length and width, petiole length, limb shape, etc...

Then each attribute is classified as Boolean, measurable or fuzzy. The objective is that when the user introduces values for some of these attributes watching the plant, the system inferences its specie.

Linguistic labels that are relative to measurable attributes have been modeled with fuzzy sets of trapezium shape. Various fuzzy sets have been separately designed for immeasurable attributes watching the different values that they can take.

Collected attributes has been classified as inputs of the application and using a set of inference rules the system is able to obtain the membership degree of each one of species. Conjunctions of rule premises have been developed through two fuzzy logics which have had good results, Zadeh Logic and the product logic.

Preview study

A table is filled reading technical description of every species. It is necessary to reflect on these attributes and eliminate those not contributing to find differences among species. Furthermore, for a non expert on botanic, it is difficult to find a correct classification because vocabulary is unknown as well as its correct interpretation. An example of these descriptions, is in "Description of the specie Primula elatior", from "Flora Ibérica "[1].

Reading description of each of the species, attributes and values are exposed in the Table 1.

Table 1. *Primulas* Classification.

Name		***Elatior***	***Veris***	***Acaulis***	***Farinosa***	***Integrifolia***	***Latifolia***	***Pedemontana***	***Hirsuta***
Mealy			no		si		Mealy only in the	no	no
Leaf	**measurements (cm) Length xWidth**	3-3,5× 2-8,5	4-25×1,7-7	5-20 (35)× 1,5-7	1,5-6 (12)×0,4-1,2 (2)	0,8-3,5(6)×0,4-1,4 Length of (2) 3-8 times its width	5,5-17×2-5,5	2 - 4 (10)	1,5-9
Petiole	**Length**	0,5-2 times limb length	0,5-3 times limb length	Shorter or equal to limb length		0,3-2,4 cm	2,5-8 cm		
	Shape	winged	± winged						
Limb	**Maximum Width**		in the middle	in the apical middle		central third	central third	near to the center	near to the center
	Base	± attenuate	contract sharply or attenuate	attenuate	attenuate	attenuate	contract sharply or attenuate		contract sharply
	Dentate	dentate irregularly or nearly entire or crenate subtly	crenate subtly and irregularly	of irregular and subtly dentate to crenate	dentate or nearly entire	entire	Entire or ± dentate		rough irregular
	Rough	of rough to not rough	yes	yes	lightly rough				
Inflorescence		multi-flowered	multi-flowered	insulated flowers		1-2 (3) flowers	multi-flowered	1-25 flowers	Multi-flowered

Representation of the information

After the preview study, we obtained a set of attributes and their linguistic labels. Those attributes are considered as linguistic variables which are modeled by fuzzy sets. After having studied the variety of values for every variable, their membership functions are designed taking into account their characteristics. The design is made using XFuzzy.

Some of these representations of the attributes are detailed below.

Mealy Attribute, it is Boolean.

Note that Boolean variable means that the characteristic is absolutely clear, since the membership degrees are 0 or 1, a plant can be mealy or non-mealy. System goes on even if this attribute is unknown, what improves the classic dichotomy method.

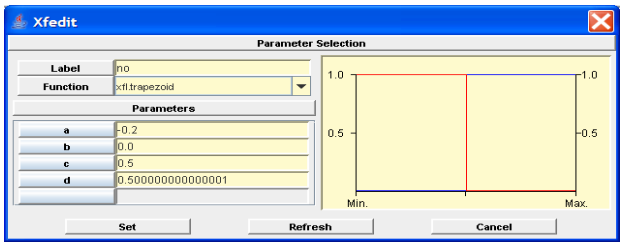

Figure 1. Mealy Attribute

Length and width of the leaf Attributes, they are numeric.

For every species we have an interval of values for width and length. These variables are modeled by a trapezoidal fuzzy set, because we don't want to exclude a specific specie if the leafs measures are a little less. In this way, we are decreasing the membership degree of this premise, therefore the inference rule also decreases its membership degree. We obtain an effect of soft computing

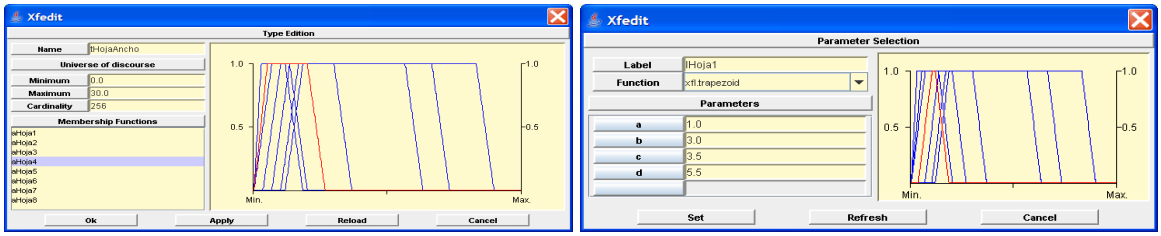

Figure 2. Length and width of the leaf Attributes.

Petiole measure attribute, it is numeric.

One variable can have more than one representation, for instance the petiole measure sometimes is described as a numeric value and others as a rate. Both are modeled by a trapezoid fuzzy set.

Maximum Width, it is non-measurable.

The representation of this attribute has tree fuzzy sets for each one of linguistic labels, “the lower part of the leaf” “the medium part” or “the upper part”. This is the classic example of linguistic labels found in numerous applications of fuzzy logic, inference and fuzzy control.

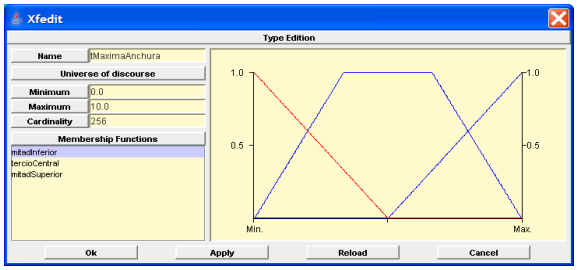

Figure 3. Maximum width Attribute.

- The limb can be dentate or crenate, both attributes are non-measurable.

The limb shape has almost two characteristics, we separate them into dentate and crenate. Dentate/crenate attribute has values from entire (non-dentate/crenate) to dentate/crenate. Each species has a different value, and then a specific function has been designed for various characterizations.

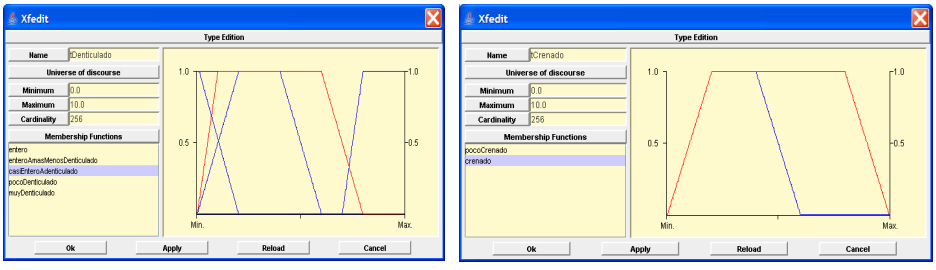

Figure 4. Limb shape, dentate and crenate attributes.

3. FUZZY INFERENCE

For a specific specimen the program calculates its membership degree of "I am of the specie A", based in imprecise premises which have been obtained from the attributes previously modeled, the program uses rules as: "If 'x is A' then 'y is B'" with a certain membership degree, and calculates the membership value of the specimen for each species.

3.1 Rules

There is one instance of each variable that characterizes one species, those instances are the premises for the rule of this species. Premises are connected with a conjunction AND -&-. Two triangular norms have been developed: minimum and product. For instance, a rule in XFuzzy is shown in (1).

if(inFarinosa == no & inHojaLargo == lHoja1 & inHojaAncho == aHoja1 & inPecioloLongProporcion == peciolo1 & inAlado == alada & inLimboBase == masMenosAtenuado & inInflorescencia == muchas & inLimboDenticulado == casiEnteroAdenticulado & inLimboCrenado == pocoCrenado & inRugosa == noRugosaArugosa) $\Rightarrow$ outPlanta = eliator (1)

A specialist chooses values for some attributes that can be observed. The system uses minimum and product norm and calculates the membership values between 0 and 1. These values will be updated if the specialist introduces another value for any attribute. Although the output is an imprecise conclusion, it is also necessary to make a decision and to choose the species with a higher membership value. It is the specialist who must make this choice.

Salidas del Sistema								
Nombre	Elatior	Veris	Acaulis	Farinosa	Integrifolia	Latifolia	Pedemontana	Hirsuta
Mínimo	0,50	0,00	0,20	0,00	0,75	0,00	1,00	1,00
Producto	0,38	0,00	0,05	0,00	0,75	0,00	1,00	1,00

Figure 5. Example system output.

The developed software in java for the determination of the 'Primulas' family of plants is available at

http://www.fdi.ucm.es/profesor/lgarmend/SC/Programas/primulas.jar

4. CONCLUSIONS

This paper tries to show the usefulness of fuzzy logic in plants recognition, although it is worth mentioning that this is only the beginning and it would be necessary to continue this project with every genera and families. This big project would require a working group consisted of a specialist in fuzzy logic and inference and a botanic specialist.

In future researches an improvement would be to generalize membership functions into easier fuzzy sets as "little, medium, much", and to find patterns for different types of attributes. Additionally, an expert system would be included to ask questions and to guide the identification.

5. REFERENCES

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