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FUZZY LOGIC MODELING IN PREDICTIVE ECOLOGY

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Abstract

In terms of ecology forecast effects of climate change, the purpose of our study is to develop a predictive model of growth and adaptation of species in environmental and bioclimatic conditions. The impact of climate change on forests is the result of combined effects in magnitude and frequency of these phenomena. Like the data involved in the growth process of the species occur in an uncertain environment due to their complexity, it becomes necessary to have a suitable methodology for the analysis of these variables. The basic principles of fuzzy logic those are perfectly suited to this process. As input variables, we consider the temperature, rainfall, humidity, soil type, plant species concerned. The result output variable is the adaptability of the species expressed by the growth rate or extinction. As a conclusion, we prevent the possible strategies for adaptation, with or without shifting areas of cultivation and forestry.

Keywords: *Climate changes; Ecology, Predictive model, Fuzzy logic*

Introduction

Most atmospheric scientists agree that climate changes are going to increase the mean temperature with increased frequency of climatic extremes, such as drought, floods, and storms. Under such conditions, there is high probability that forests will be subject to increased frequency and intensity of stress due to climatic extremes (La Porta et al., 2008)

Most scientific studies of climate change use models to generate projections at the global and regional levels. Scientific studies on climate change typically provide discipline-specific results, based for example on climatic variables (temperature, precipitation, etc.)

In general, Ecosystems are nested systems and typically show variation in spatial and temporal scales, making them extremely difficult to predict and control. In a local knowledge the fuzzy cognitive maps are qualitative models of a system consisting of variables and the causal relationships between those variables (Ozesmi & Ozesmi, 2004).

It is therefore essential to understand the impacts of climate change on forests to be able to develop strategies and adaptations necessary to maximize the potential for mitigation. Since these data are characterized by their bioclimatic uncertainty and imprecision, a fuzzy system is proposed for remedying them. The forecasting model takes into account the impact of different parameters that often interfere.

The proposed system is extensible to other factors that are not supported in this study. As several factors affect each measured value, and the term climatic changes are also relative, it becomes necessary to analyze such data with the tools of artificial intelligence especially fuzzy logic inference. The nonlinear systems difficult to model mathematically are usually monitored by fuzzy logic. It is a system of logic and based on set theory and continuous variables. Fuzzy logic is a methodology for problem solving or in other words "problem solving control system methodology”. Its implementation can be performed in hardware or software or by combining both. Conclusions that are based on vague, imprecise, missing input information are simply provided by fuzzy logic (Faran Baig et al., 2011). .

The proposed system utilizes fuzzy logic. Fuzzy logic is an extension of classical logic. In our situation it is very difficult to use classical logic to model a system with the available knowledge. Classical logic does not allow working with uncertainty in the information when knowledge about the behavior of the systems is imprecise (Alayón et al., 2008).

Presentation of the study area

Boutaleb forest is located in the district of Setif in Algeria on its southern border with the province making M'sila southwest of Batna.

Statement of vegetation

The statement phytoecological is a floristic inventory which corresponds to the list of species present in the area is minimal or optimal in our case 200m in the dense forest of *Cedrus atlantica Manneti* and *Pinus halepensis*

Different dominant species in the massive Boutaleb are studied:

Cedrus atlantica, *Artemisia herba alba*, *Retama retam*, *oxycedrus Juniperus*, *Quercus ilex*, *Pinus halepensis, Echinops spinosus.ec.*

Materials and methods

Presentation of spices

The Atlas cedar (*Cedrus atlantica or*).

This is a tree species of the family *Pinaceae*. Although often with a peak tabular adulthood durability is important. This species is adapted to the Mediterranean climate tolerant to water stress, IL can withstand summer drought as atmospheric drought. Some sources are more susceptible to spring frosts (early bud. From the perspective of global warming, the area of introduction could extend northward.

(1 to 2 meters, sometimes less requires the following exhibitions: light, sun, perfectly adapted to drought, tolerates all well drained soils same limestone. The plant dies from of -10 °C. The aerial parts are damaged from.

***Cade juniper (Juniperus oxycedrus*)**

Is an evergreen shrub in warm climates, upright rather conical. It is a tree that can reach 14 meters, but the dimensions are usually much smaller -10 ° C.

Holm oak (Quercus ilex)

It is a tree of 5-20 meters high. It is mesophanérophyte microphone. The foliage is evergreen. It has a life span of 200-500 years. It is a monoecious species.

Quercus ilex tolerate many extreme weather and grows well, albeit slowly, with little or no summer irrigation once established. It supports up to -12 ° C. Holm like aridity, drought and sun. The plant supports winds, which allows him to enjoy the sea edge.

Aleppo pine (Pinus halepensis)

Is a conifer family *Pinaceae*. Tree about 20-30m and often leaning slightly right, the branches are quite spread out. The Aleppo pine is yet the only large tree to grow easily and naturally in the limestone to poor soil and dry. Highly resistant to the Mediterranean coast, it appears even in semi-arid regions.

It is an essence of light that supports strong illumination and long periods of drought.

Aleppo pine present in the arid, semi arid and sub-humid in the wet. Penetrates widely throughout the Mediterranean and supra locally reach much higher altitudes.

Table 1. Number of newborns according areas with anatomic parameters

Species	temperature		pluviometry		soil		Moisture	
	ideal	*reel*	*ideal*	*Boutaleb*	*Nature*	*Boutaleb*	*species*	*Boutaleb*
Junipersus oxycedrus	10°C	2.8-23.5	300-400 mm	427mm/ year	Limestone acid	Mineral-stony limestone	Not support	Wet 8.5 months, 3.5 months dry
Cedrus atlantica	-1°-+10°C	2.8-23.5	500-2000mm	427mm/ year	Brown stony forest-	Mineral-stony limestone	strong	Wet 8.5 months, 3.5 months dry
Pinus halepensis	Resistant to high temperature	2.8-23.5	350-700mm	427mm/ year	limestone	Mineral-stony limestone	strong	Wet 8.5 months, 3.5 months dry
Quercus ilex	12°C	2.8-23.5	low	427mm/ year	stony	Mineral-stony limestone	strong	Wet 8.5 months, 3.5 months dry

Fuzzy logic inference

The fuzzy logic approaches, a sub-field of intelligent systems, are being widely used to solve a wide variety of problems in medical, biological and environmental applications. One of the most important areas of application of fuzzy set theory as developed by Zadeh (1965) Fuzzy sets. Information and Control 1; 8:338–353.is Fuzzy Rule-Based System. These fuzzy logic systems constitute an extension of the classical rule-based systems, because they deal with "if-then" rules whose antecedents and consequences are composed of fuzzy logic statements, instead of classical logic ones. In a broad sense, a fuzzy rule-based system is a rule-based system where fuzzy logic is used as a tool for representing different forms of knowledge about a problem, as well as for modeling the interactions and relationships that exist between its variables. Due to this property, fuzzy logic principles have been successfully applied to a wide range of problems in different domains for which uncertainty and vagueness emerge in varying ways. Fuzzy modeling (Pedrycz, 1996), fuzzy control (Driankov, 1993).and fuzzy classification (Chi et al., 1996) are the most common applications.

Fuzzy logic deals with reasoning on a higher level, using linguistic information acquired from domain experts. The above-mentioned capabilities make fuzzy logic a very powerful tool to solve many ecological problems, where data may be complex or in an insufficient amount. The fuzzy logic concept provides a natural way of dealing with problems where the source of imprecision is an absence of sharply defined criteria rather than the presence of random variables (Bouharati et al., 2008).The fuzzy approach considers cases where linguistic uncertainties play some role in the control mechanism of the phenomena concerned (Demir & Korkmaz, 2008). Fuzzy inference systems (FIS) are powerful tools for the simulation of nonlinear behaviors with the help of fuzzy logic and linguistic fuzzy rules (Mamdani, 1977).

Fuzzification

In order to make fuzzification the linguistic expressions below are used. The proposed fuzzy logic factors impact control system consists of five input variables.

Fuzzy variable "Rainfall" has the linguistic values height, medium, and height.

Fuzzy variable "Temperature" has the linguistic values low; medium; height

The variable "Wind-speed" has (low, medium, and height).

The variable “Frost” has (little and big)

The variable “Wind-speed” has (low, medium, and height).

The mapping values of input variable through the membership function are the linguistic values. Fig.1. The linguistic values of inputs are shown as a result:

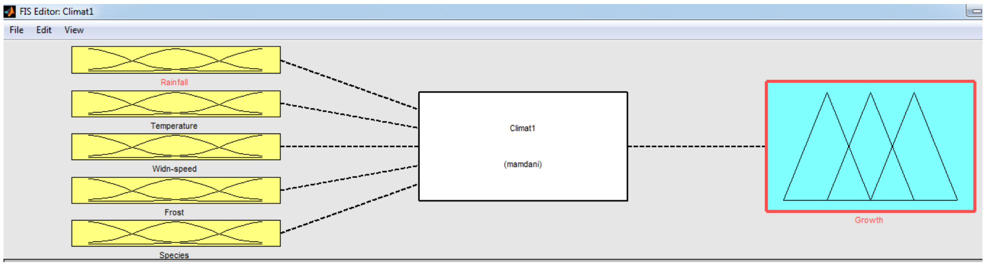

Figure 1. Plot of inputs-output fuzzy system

Fuzzyfication the input variable "Temperature"

The entry that represents the temperature is composed of three fuzzy intervals and membership functions defining the cold, warm and hot temperature. Fig.2

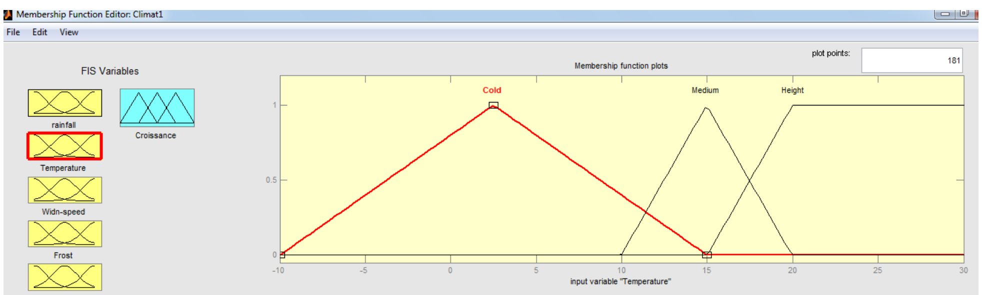

Figure 2. Plot of membership functions for fuzzy input variable “Temperature”

Representation of the input variable "Species"

The entry that represents the species is composed of five non intervals and fuzzy membership functions defining the nature of species. Fig.3.

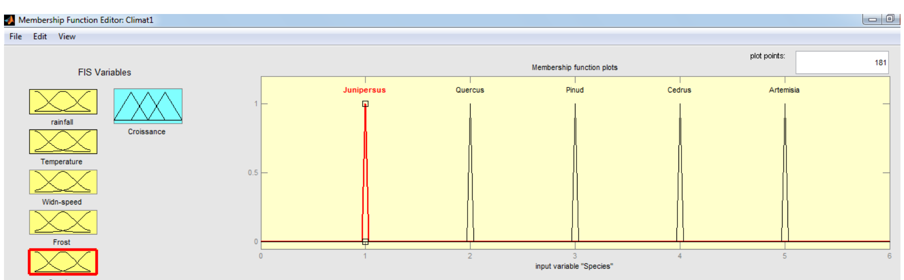

Figure 3. Plot of membership functions for fuzzy input variable “Spices”

Fuzzyfication of the output variable

As output variable we define three variables representing the expected growth rate of the species. We represent each membership function defining the three rate "low growth" corresponding to a value between 0 and 2 "growth medium" between 1 and 3 as a "great growth" number between 2 and 4. Fig.4

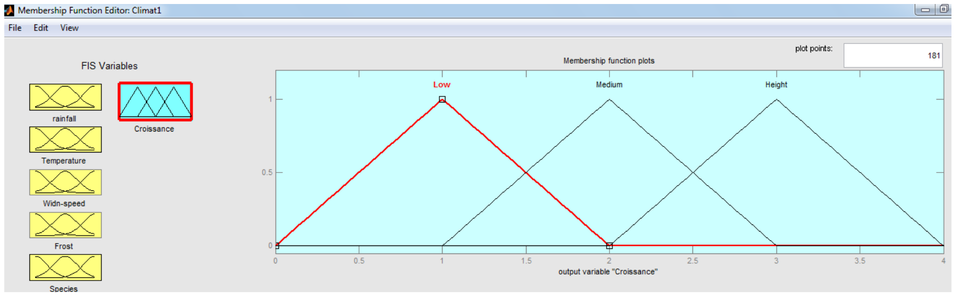

Figure 4. Plot of membership functions for output fuzzy variable

Inference engine

The inference engine consists of AND operator, in fact this operator select minimum input value for the output and also this is not the logical AND. This inference engine takes five inputs from the fuzzifier to produce the output Result value according to the min-max composition. This method uses min-max operation between the five inputs. According to Table 1, fuzzy rules are established. According the results of the fuzzification of input and output variables, the rules must include all possible combinations. As all the variables are independent of each other, therefore all the variables may lie in any of the regions. Therefore all combinations rules are required because input variables do not depend upon each other. Each input variable behaves an individual effect on output. Fig. 5

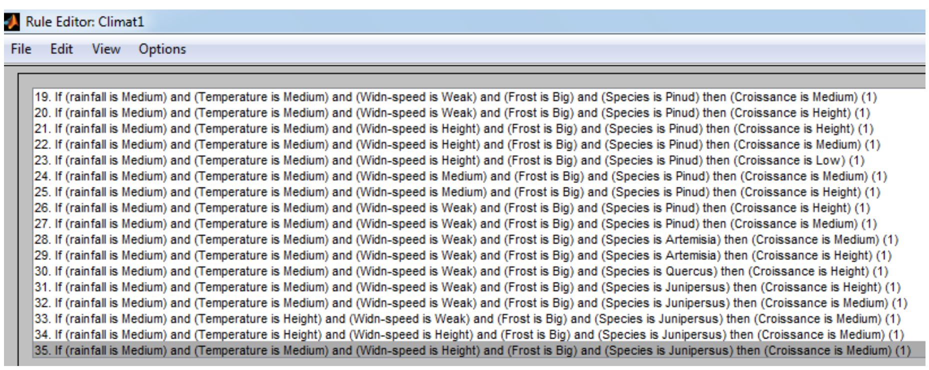

Figure 5. Plot of inference rules

Defuzzifier

This system has one output that describes the function of growth rate, in fact explains the effect of climate parameters on rate growth of any spices. The crisp value output is given by the defuzzification process after estimating its input value.

In this system we have center of average (C.O.A) method which has the mathematical expression that is. In the defuzzification the exact expression is obtained with “centroid” method according to validity degree. The output value according to the input values obtained from the designed fuzzy engine system. Fig. 6.

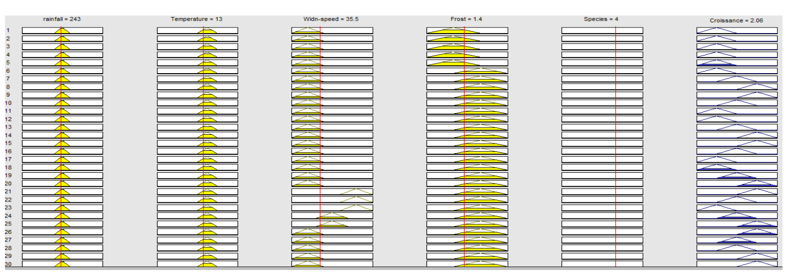

Figure 6- Plot of defuzzyfication rusult

Conclusion

One plot at a time shows the relation between any five inputs with one output. The output rate growth shows the dependences on inputs.

The designed system can be extended for any number of inputs. We can define this system for any number of inputs. The design work is being carried out to design state of the art fuzzy logic climate changes effect control system in future using hybrid neuro-fuzzy system.

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