Climate Changes Effect On The Agents Involved In Epidemic Diseases: Intelligent Technique Modeling

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Abstract: Various reasons are considered as causes of decrease or extinction of virus or bacterial species. Some causes are due to changes in climatic conditions, others are due to human intervention such as habitat change or the introduction of other species in competition. All these parameters are characterized by their uncertainty and imprecision. Also, each species reacts in a different way than the other. To analyze the evolution taking place on a given species, we propose an analysis using an intelligent system based on the principles of fuzzy logic. As fuzzy logic deals with uncertainty, its application in this area proves to be adequate. A fuzzy system is constructed with three input variables (climatic conditions, habitat change, and introduction of other species) and an output variable that expresses the nature of the species involved epidemic diseases and there evolution. A rule base is established, which will allow to randomly enter values at the input of the system to instantly read the result at the output.

Keywords: Virus, Bacteria, Epidemic diseases, climatic change, intelligent systems, fuzzy logic.

1. Introduction

Climate changes produce a total disruption of factors epidemic diseases ecosystems. The extinction and behavior change of some species is a consequence of environmental change. Some others have the possibility of rehabilitation. These changes leave no doubt as to their effect on ecosystems [1]. Several modeling strategies are used to predict the impact of climate change on the spatial distribution of species. However, the system is more complex than it seems. Other factors are involved in this problem. The dynamics of the species and their capacity for dispersal are to be taken into account [2]. The problem posed to the modeling of such phenomena is its complexity or a set of factors that intervene. Some factors are related to the very nature of the species. Some are more mobile than others, some adapt better than others. As a result, some species are extinct, and some other migrates to other environments more suitable. During the migration of certain species, the latter may also undergo a conquest of conquest with other species. Also, the effect of climate change does not affect all species to the same degree. Several studies attempt to model such phenomena. However, given the complexity, uncertainty and inaccuracy of the data, it is very difficult. In our study, we propose a model based on artificial intelligence techniques. Among these techniques, fuzzy logic is perfectly adapted to such problems. The advantage of fuzzy logic lies in the fact that it deals with uncertainty and imprecision. A fuzzy inference system is established with three factors (climatic conditions, environmental change) that constitute the input variables. The species causing epidemical diseases are considered as the output variable of the system. A basis of rules is established. The system completed, will make it possible to predict the degree of profiling or extinction of the species under study. As the input variables are expressed in linguistic terms, the output at the output of the system will be as accurate as possible in linguistic and numerical terms.

2. Factors that influence species

2.1 Climate change

The effects of climate change can affect viruses and bacteria species at different scales. That concerns the scale from the individual, population, community, and ecosystem to the biome. The study of this impact allows the warning and establishes global and sub-continental approaches [3]. Various projects are being studied to identify species vulnerable to climate change. Studies on spatial and temporal analysis and modeling methods are established. This will allow the choice of the most appropriate approaches [4].

2.2 Environmental change

Environmental change has a direct impact on the evolution of diseases agent's species. Environment loss is generally a consequence of climate change. This threatens microorganism's biodiversity. Knowledge of the phenomena that govern this process is still poorly understood given its complexity. Strategies used in species evolution and management must take into account the relationship between environment changes and the effects of each threat individually. For this, it is necessary to quantify the magnitude of each parameter [5]. Non-native species introduced into a given environment significantly affect the ecosystem. It becomes necessary to identify them and to list and prioritize them in order to better manage their impact. This is the most effective way to reduce the effect of non-native species on native species [6].

2.3 Proliferation of other species

Some viruses and bacteria communities are considered typical of a particular conditions or locality. However, under the effect of certain influences either natural or under human intervention, the environmental of these is modified. While some species appear and disappear rapidly, others settle and adapt, while others become a real threat to native species. The local species is then strongly disturbed as the ecosystem in general [7].

3. Fuzzy modeling

Fuzzy logic finds application in different domains. In environmental matters, it makes it possible to manipulate subjectivity in the image of human reasoning. This involves a decision-making process that manages the dependencies between environmental factors [8]. Complex ecosystem management, including ecological expertise and site-specific data, can only be integrated through unclear reasoning. The introduction of logical and reliable information implies the use of fuzzy logic by setting rules [9]. In our case, the input variables (climate change, habitat change, and other species effect) are considered imprecise variables, hence fuzzy variables. They will be expressed in linguistic terms. The output variable that expresses the profiling or extinction of the species studied is also considered uncertain and fuzzy. The degree of its effect is represented numerically and symbolically. Where uncertainties related to linguistic inaccuracy, blurred inference compensates for this lack [10]. Fuzzy inference systems (FIS) are powerful tools for the simulation of nonlinear behaviors with the help of fuzzy logic and linguistic fuzzy rules [11] ; [12].

3.1 Fuzzy modeling

The proposed system using Matlab R2010b, consists of three input variables (climatic conditions, environment changes, and other species effect) and one output variable that expresses the nature of the morbid species and its evolution. (Figure 1).

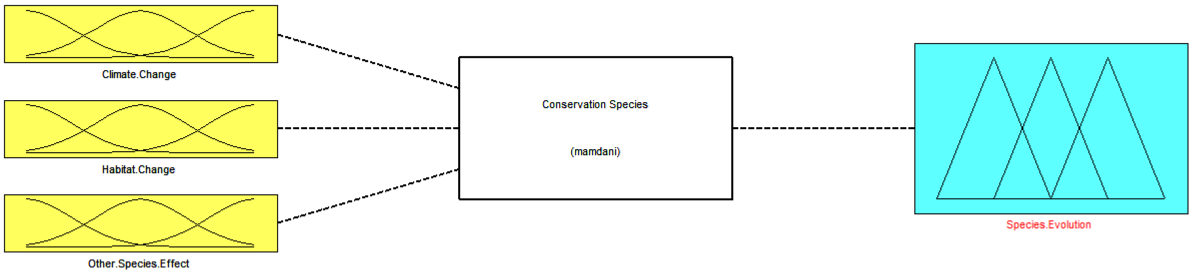

Fig. 1. *System bloc*

3.2 Fuzzyfication of variables

This step consists to convert numerical values to linguistic expressions. The inputs and output are classified into three membership triangular functions. The values of each variable are expressed using linguistic terms:
The variable "climate change" is fuzzyfied on [Low, Average and high effect]
The variable "environment changes" is fuzzyfied on [Low, Average and high effect]
The variable "other species effect" is fuzzyfied on [Low, Average and high effect]
The output variable is also fuzzyfied on [safe, risky, morbid]

```
[System]
Name='Morbid Species'
Type='mamdani'
Version=2.0
NumInputs=3
NumOutputs=1
NumRules=19
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'

[Input1]
Name='Climate.Change'
Range=[0 4]
NumMFs=3
MF1='Low':'trimf',[0 1 2]
MF2='Average':'trimf',[1 2 3]
MF3='High':'trimf',[2 3 4]
[Input2]
Name='Environment.Changes'
Range=[0 4]
NumMFs=3
MF1='Low':'trimf',[0 1 2]
MF2='Average':'trimf',[1 2 3]
MF3='High':'trimf',[2 3 4]

[Input3]
Name='Other.Species.Effect'
Range=[0 4]
NumMFs=3
MF1='Low':'trimf',[0 1 2]
MF2='Average':'trimf',[1 2 3]
MF3='High':'trimf',[2 3 4]

[Output1]
Name='Species.Evolution'
Range=[0 4]
NumMFs=3
MF1='Safe':'trimf',[0 1 2]
MF2='Risky':'trimf',[1 2 3]
MF3='Morbid':'trimf',[2 3 4]
```

A basis of the rules is established of the form (Si ... Then) example:

IF climate change has a high effect AND habitat change has an average effect AND the effect of other species introduced has and high effect THAN the evolution of this specie is decay. The basis of the rules must contain all possible combinations. This allows the connection between the input variables and the output variable.

4. Result and discussion

As the factors involved in the occurrence and development of morbid species evolution are multiple and complex, the fuzzy logic proposed system overcomes this uncertainty. Based on effect of each input variable, the analysis allows for a species evolution prediction. By fuzzyfication of the input variables, uncertainties related to the limits are considered. The variable "climate change effect" for example is fuzzyfied. Indeed, there is no sharp distinction between low and average effect on the all species. The variable "environment changes effect" also is fuzzyfied. Indeed, there is no sharp distinction between average and high effect on the all species. By the same way, the variable "other species effect" is fuzzyfied. Indeed, there is no sharp distinction between two neighbor membership functions on the all species. The value of the specie evolution is also expressed in linguistic term as stable, decay or increase and also expressed in numeric term as a degree of belonging to the function. When the basis of the rules is established to encompass all possible combinations, this will allow the introduction of the random values at the input to instantly read the resultant value at the output and thus predict the evolution of one or the other species. This tool will also able to predict the nature of epidemic disease (Figure 2).

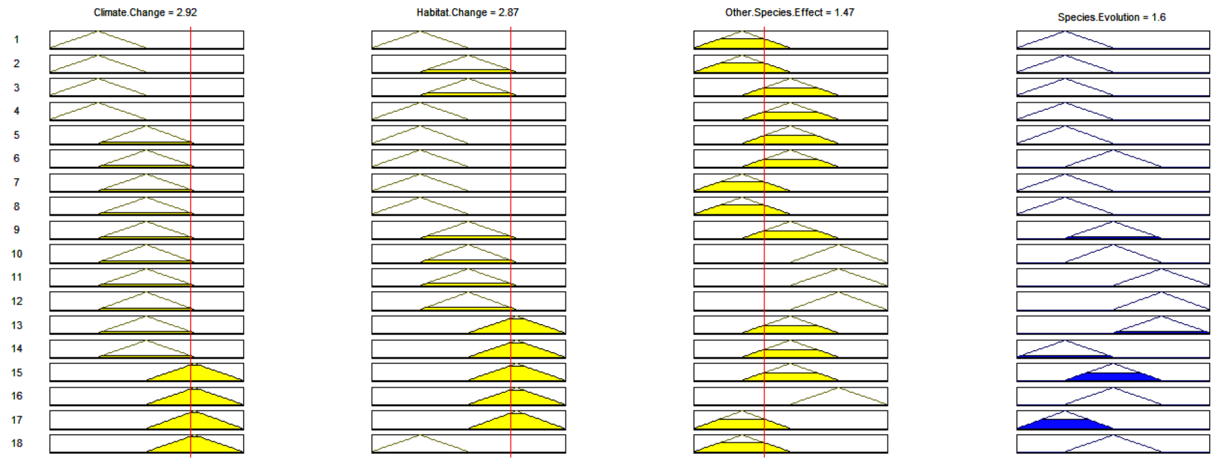

Fig. 2. *Application example*

5. Conclusion

The agents involved in the occurrence of epidemic diseases are multiple. Viewing their complexity and especially the conditions of their proliferation, it is very difficult to model them mathematically using the classical tools. The use of this intelligent tool makes it possible to take care of these uncertainties and this inaccuracy. Climate change, changes in their environment, and competition between agents such as viruses or bacteria are treated as fuzzy variables and therefore uncertain. The degree of proliferation of such or such a species is a consequence of the input factors of the system. The proposed tool makes it possible to fix these variables randomly at the input to read the result at the output and thus to predict the appearance of epidemic diseases with the maximum accuracy.

Note

The author declares that no conflict of interest and no competing financial interest

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