Chapter 13
Fuzzy-Based Approach for Reducing the Impacts of Climate Changes on Agricultural Crops

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ABSTRACT

Climate changes play a significant role in the crops plantation process. Such changes affect the suitability of planting of many crops in their traditional plantation dates in a given place. In contrary, many of such crops become more suitable for planting at other new dates in their traditional places or in other new places regarding the climate changes. This chapter presents a fuzzy-based approach for optimizing crops planting dates with the ongoing changes in climate at a given place. The proposed approach incorporates four phases. The first phase is concerned with climate data preparation. And the second phase is concerned with Defining suitability membership functions. While in third phase is responsible for automatic fuzzy clustering. Finally, the fourth phase is responsible for fuzzy selection and optimization for the more suitable plantation dates for each crop. This chapter consists of an introduction, related works, the proposed approach, a first case study, a second case study, results discussion, future research directions and finally the chapter conclusion.

INTRODUCTION

Generally, a spatial database can be defined as a set of objects located in some reference space that attempts to model some enterprise aspects in the real world. Spatial agro-climatic database is a spatial database that contains the data of the climate variables for some places during specific periods of time. Almost, the data stored in such databases are needed to be searched in a more flexible human-like manner.

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For example, there is a need for a query approach that allows queries such as "select the more suitable dates for planting specific crop in Giza with a matching degree around 88%".

Commonly, the structured query language SQL is the widest used language for querying relational databases. It was initially presented by Chamberlin and Boyce for data retrieval and manipulation. Traditional SQL uses the two-valued logic (crisp logic) in generating and processing a query statement. Most real-world problems abound in uncertainty and any attempt to model aspects of the world should include some mechanisms for handling uncertainty as illustrated in Zhang et al. (2002) and Theresa Beaubouef and Frederick E. Petry1 (2010). Mohammed et al. (2014), Sabour(2014), Kumar and Pradheep (2016) and Werro and Nicolas (2015) show how to avoid the limitation of SQL when dealing with uncertainty by using the flexibility of fuzzy logic. Initially, Fuzzy set theory was proposed by Zadeh (1965). Since then, many researches in many fields have been achieved using the ideas of fuzzy logic. In consequence, fuzzy queries have appeared in the last 30 years to cope with the necessity to soften the sharpness of Boolean logic in database queries. Commonly, a fuzzy query system can be defined as an interface for users to retrieve information from a database using human linguistic words which are qualitative by nature as presented in Branco et al. (2005). This area of research is still interesting as there are needs for more improvements of existing approaches. This chapter proposes a fuzzy-based query approach for querying a spatial agro-climatic database depending on human like query. Such query approach helps in determining the more suitable planting date of crops in specific place.

Nowadays, climate change represents the most affecting phenomena in almost all aspects of our life. Climate change is a change in the statistical distribution of the patterns of the weather conditions when that change lasts for an extended period of time (millions of years). It is caused by factors such as variations in the radiation of the solar received by Earth, plate tectonics, and volcanic eruptions America's as shown in Climate Choices (2010). Also, it has significant impacts on conditions affecting agriculture. For any crop, there exist optimal climate conditions for its growth. So, the effect of an increase in temperature depends on how it is far from the optimal temperature for the crop growth and production. Accordingly, Karl et al. (2009) Showed that the ongoing changes in climate variables such as humidity and temperatures degrees affect the suitability of traditional plantation dates of some crops in a given place.

RELATED WORK

Many approaches have been proposed for the problem of the affection of climate changes on agriculture. Some approaches aimed mainly to show the impact of cli-mate change on crop production like Defang et al. (2014), Bizikova et al. (2015) and Hamid et al. (2013). They proved that the agricultural productivity had been affected reflecting the climate changes. They also advise to make some adaptation on planting dates or by planting crops that are less sensitive to climate changes to get over such effects. Also, climate changes greatly affect the water resources in regions in which agriculture depends on rain. As water resources are one of the most important parameter in plantation process, a new approach has been developed to make adaptation to crop planting dates with climate changes like in Moussa et al. (2014) and S.A. Mohaddes and Mohd. Ghazali Mohayidin (2008). Another approach for crop yield forecasting was presented in Pankaj Kumar (2011) to map the relations between climate data and crop yield. This technique based on time series data of 27 years for yield and weather data. Other approaches have been developed such as Fuzzy-based Decision Support Systems for evaluating land suitability and selecting the most suitable crops to be planted is provided as in Sri Hartati and Imas S. Sitanggang (2010) and

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