Technique and Decision Algorithm for Meteorological Factors Reduction in Agriculture Using Discernibility Function

Ms. Parul Saini

#Research Scholar, Department of Statistics, M.D.University, Rohtak

Abstract

Meteorology is a branch of Atmospheric Science, which mainly focuses on predicting weather and climate, and studying the forces that bring about change in our environment. Climate is a long term pattern of weather conditions for a given area. Climate change refers to a statistically significant variation in either the mean state of the climate or its variability, persisting for an extended period. As the issue of Global warming is heating up and natural disasters have become frequent, environmental challenges have become more and more popular with implications for agriculture and health. There is need to develop some technique for screening meteorological factors, so that the agricultural output should be increase. To achieve this motive, technique and decision algorithm for factor reduction using Rough Set Theory (RST) is studied, which is used to reduce the dimensionality of the dataset without loss of generality.

Key words: Discernibility Matrix, Factor Reduction, Indiscernibility Relations, etc.

1. Introduction

Observations of the physical and biological variables in the environment are essential in agricultural meteorology. Meteorological considerations enter into assessing the performance of plants and animals because their growth is a result of the combined effect of genetic characteristics and their response to the environment. Without quantitative data, agro-meteorological planning, forecasting, research and services by agro-meteorologists cannot properly assist agricultural producers to survive and to meet the ever-increasing demands for food and agricultural by-products.

The observations required depend on the purpose for which they will be used. For the characterization of agro-climate, for climate monitoring and prediction, and for the management of natural resources, national coverage over periods of many years is required. These data also provide the background for the shorter-term decision-making involved in activities such as response farming, monitoring of, and preparedness and early warning for, natural disasters, along with forecasts for pests and diseases.

Agricultural meteorology is concerned with every aspect of local and regional climates and the causes of their variations, which makes standard observation of climatic variables a fundamental necessity. It is also concerned with any climatic modifications, which may be introduced by human management of agriculture. Physical variables of climate are observed to assist the management of agricultural activities. Such management includes determining the time, extent and manner of cultivation and other agricultural operations (sowing, harvesting etc.). Besides scientific observation of the physical environment, the simultaneous evaluation of its effect on the objects of agriculture, namely, plants, animals and trees, both individually and as communities, is also a prerequisite of agricultural meteorology. Biological observations generally are phenological or phenometric in nature or both. Phenological observations are made to evaluate possible relations between the physical environment and the development of plants and animals, while the phenometric types are made to relate the physical environment with biomass changes. The observing programme at agricultural meteorological stations should include observations of some or all of the following variables characterizing the physical environment: solar radiation, sunshine and cloudiness, air and soil temperature, air pressure, wind speed and direction, air humidity and soil moisture, evaporation and precipitation (including observations of hail, dew and fog). The water balance, evapotranspiration and other fluxes may be deduced from these and other measurements. Minimum accuracy for the different variables is recommended in World Meteorology Organization (WMO).

Table 1: Minimum accuracy for variables by WMO

Variable	Accuracy required in daily values	Variable	Accuracy required in daily values	Variable	Accuracy required in daily values
Temperature, (including max/ min, wet and dry bulb, soil)	< ±0.5ºC	Evaporation	±1 mm	Wind Speed	±0.5 m/s
Rainfall	±1 mm	Relative Humidity	±5%	Air Pressure	±0.1 hPa
Solar radiation (including sunshine)	10% (±1h)	Photoperiod	10% (±1h)		

Pawlak (1982) introduce the concept of RST to deal with uncertain, incomplete or vague information. RST is an extension of set theory and has the implicit feature of compressing the dataset. Such compression is due to definition of equivalence classes based on indiscernibility relations. The classic approach is to obtain the discernibility matrix, to determine its corresponding discernibility function and to simplify it, in order to get the set of reducts. For given information system S with n elements has a symmetric discernibility matrix with dimension$n \times n$. The entries of the matrix are denoted by c_{ij} for $i \neq j$. Each entry contains the subset of attributes that distinguishes element x_i and x_j, being the diagonal entries null, according to the definition

$$c_{ij} = \{a \in A | a(x_i) \neq a(x_j)\} \qquad \text{for } i = 1,2, \ldots\ldots, n; i \neq j$$

The corresponding discernibility function f_A is a Boolean function of m attributes $(a_1, a_2, \ldots.., a_n)$ given by

$$f_A(a_1^*, a_2^*, \ldots.., a_n^*) = \wedge\{\vee c_{ij} | 1 \le j \le i \le n, c_{ij} \ne \emptyset\}$$

This classical approach is used to reduce the dimensionality of data set contain the information.

2. Methodology

Consider the situation where the agro-meteorologists are interesting to study the effect of four parameters: wind speed (P_1), sunshine (P_2), rainfall (P_3) and soil temperature (P_4) on the agricultural productivity. The Table 2 gives the information regarding the desired level of above parameters. An information system or information table can be viewed as a table, consisting of objects (rows) and attributes (columns). It is used in the representation of data that will be utilized by Rough Set, where each object has a given amount of attributes

Table 2: Information System

Observation Day	Wind Speed (P_1)	Sunshine (P_2)	Rainfall (P_3)	Soil Temperature (P_4)
D_1	No	Yes	High	Yes
D_2	Yes	No	High	Yes
D_3	Yes	Yes	Very High	Yes
D_4	No	Yes	Normal	No
D_5	Yes	No	High	No
D_6	No	Yes	Very High	Yes

The discernibility matrix for the concern situation is given by

	D_1	D_2	D_3	D_4	D_5	D_6
D_1	–					
D_2	P_1, P_2	–				
D_3	P_1, P_3	P_2, P_3	–			
D_4	P_3, P_4	P_1, P_2, P_3, P_4	P_1, P_3, P_4	–		
D_5	P_1, P_2, P_4	P_4	P_2, P_3, P_4	P_1, P_2, P_3	–	
D_6	P_3	P_1, P_2, P_3	P_1	P_3, P_4	P_1, P_2, P_3, P_4	–

The Boolean simplification of f_A yields the set of reducts of A is given by

$$f(P_1, P_2, P_3, P_4) = [(P_1 \vee P_2) \wedge (P_1 \vee P_3) \wedge \ldots \ldots \ldots . \wedge (P_3)] \wedge \ldots \ldots ..$$

$$\ldots \wedge [(P_1, P_2, P_3, P_4)]$$

The Boolean simplifications of this function yields then a single reduct

$$f(x) = P_1 \wedge P_3 \wedge P_4$$

Thus by theory, this reduct is composed of three parameters P_1, P_3 and P_4.

Decision tables and decision algorithms

A decision table contains two types of designated attributes one is the condition attribute and other is decision attribute. In Table 2, the attributes of wind speed, sunshine and rainfall can all be considered as condition attributes, whereas the soil temperature attribute is considered a decision attribute. Table 2 shows that observation day; Day 2 and Day 5 effecting from the same parameters since the condition attributes of wind speed, sunshine and rainfall possess identical values, however, the values of decision attribute differ. These set of rules are known as either inconsistency, non-determinant or conflicting.
The number of consistency rules, contained in the decision table are known as a factor of consistence, which can be denoted by $\gamma(\mathcal{C},\mathcal{D})$, where $\mathcal{C}$ is the condition and $\mathcal{D}$ the decision. If $\gamma(\mathcal{C},\mathcal{D}) = 1$, the decision table is consistent, but if $\gamma(\mathcal{C},\mathcal{D}) \neq 1$ the table of decision is inconsistent. In given information Table 2, $\gamma(\mathcal{C},\mathcal{D}) = {}^{4}/_{6}$, that is, the Table 1 possesses two inconsistent rules (Day 2, Day 5) and four consistent rules (Day 1, Day 3, Day 4, Day 6). The decision rules are frequently shown as implications in the form of "if…then..." . To proceed is shown one rule for the implication soil temperature:

If
Wind Speed = No and
Sunshine = Yes and
Rainfall = High
Then
Soil Temperature = Yes

A set of decision rules is designated as decision algorithms, because for each decision table it can be associated with the decision algorithm.

3. Discussion and Conclusion

Different problems can be addressed though Rough Set Theory, however during the last few years this formalism has been approached as a tool used with different areas of meteorological research. Climate change refers to a statistically significant variation in either the mean state of the climate or its variability, persisting for an extended period. As variation in the climate is the most important global environmental challenge facing humanity with implications for agriculture and health. There is need to develop some technique for screening meteorological factors, so that the agricultural output should be increase. In the present study, technique for factor reduction and its algorithm using Rough Set Theory (RST) is studied, which is used to reduce the dimensionality of the dataset without loss of generality.

In general, the Rough set theory, as an approach to knowledge discovery from incomplete, vagueness and uncertain data. The rough set approach to processing of incomplete data is based on the lower and the upper approximation, and the theory is defined as a pair of two crisp sets corresponding to approximations. The main advantage rough set theory has also provided the necessary formalism and ideas for the development of some propositional machine learning systems.

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