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Agro Meteorological Weather Forecasting system using Soft Computing

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Abstract: Our aim is to identify, characterize different agro meteorological parameters. To propose a new approach for agrometeorological weather forecasting process, optimizing agricultural production. To assess the feasibility of Soft Computing for agrometeorological weather forecast and compare it with existing methods (curve fitting, crisp function, probabilistic functions etc.).

Keywords: Weather Forecasting, agro meteorological, agricultural production, soft computing

I. INTRODUCTION AND PROBLEM DEFINITION

Agricultural meteorology or Agrometeorology is a branch of meteorology that examines the effects of weather and climate on crops, animal and other agricultural operations. Agricultural meteorologists collect and interpret weather and climate data needed to understand the interactions between vegetation and their atmospheric environments. The meteorological observation made by agricultural meteorologists is valuable in making proper decisions for managing resources consumed by agriculture, to optimize agricultural production and to help farmers to minimize any adverse effects on agriculture of the environment. Such information is vital to ensure the economic and environmental sustainability of agriculture now and in the future. Agricultural meteorologists also quantify, evaluate, and provide information on the impact and consequences of climate variability and change on agriculture. Moreover, agricultural meteorologists develop strategies to deal with climatic events such as floods, hail, or droughts and climatic changes such as global warming.

Agricultural meteorologists are involved in many aspects of agriculture, ranging from the production of agronomic and horticultural crops and trees to the final delivery of agricultural products to market.

II. WEATHER FORECASTING AND PREDICTION

Processes for formulating and analyze the information about future weather conditions based upon the collection of meteorological observations is called weather forecasting. Weather forecasts may be classified according to the space and time scale of the predicted phenomena. Atmospheric fluctuations with a length of less than 100 m (330 ft) and a period of less than 100 s are considered to be turbulent. The study of atmospheric turbulence is called micrometeorology; it is of importance for understanding the diffusion of air pollutants and other aspects of the climate near the ground. Standard meteorological observations are made with sampling techniques that filter out the influence of turbulence. Common terminology distinguishes among three classes of phenomena with a scale that is larger than the turbulent microscale: the mesoscale, synoptic scale, and planetary scale.

The mesoscale includes all moist convection phenomena, ranging from individual cloud cells up to the convective cloud complexes associated with prefrontal squall lines, tropical storms, and the intertropical convergence zone. Also included among mesoscale phenomena are the sea breeze, mountain valley circulations, and the detailed structure of frontal inversions. Most mesoscale phenomena have time periods less than 12 h. **The prediction of mesoscale phenomena is an area of our research.** Most forecasting methods depend upon empirical rules or the short-range extrapolation of current observations, particularly those provided by radar and geostationary satellites. Many mesoscale phenomena pose serious threats to life and property, it is the practice to issue advisories of potential occurrence significantly in advance. These "watch" advisories encourage the public to attain a degree of readiness appropriate to the potential hazard. Once the phenomenon is considered to be imminent, the advisory is changed to a "warning," with the expectation that the public will take immediate action to prevent the loss of life.

The next-largest scale of weather events is called the synoptic scale, because the network of meteorological stations making simultaneous, or synoptic, observations serves to define the phenomena. The migratory storm systems of the extratropics are synoptic-scale events, as are the undulating wind currents of the upper-air circulation which accompany the storms. The storms are associated with barometric minima, variously called lows, depressions, or cyclones. The synoptic method of forecasting consists of the simultaneous collection of weather observations, and the plotting and analysis of these data on geographical maps. An experienced analyst, having studied several of these maps in chronological succession, can follow the movement and intensification of weather systems and forecast their positions. This forecasting technique requires the regular and frequent use of large networks of data.

Planetary-scale phenomena are persistent, quasistationary perturbations of the global circulation of the air with horizontal dimensions comparable to the radius of the Earth. These dominant features of the general circulation appear to be correlated with the major geographic features of the globe.

III. NOW AND THEN

Numerical weather prediction is the prediction of weather phenomena by the numerical solution of the equations governing the motion and changes of condition of the atmosphere. Numerical weather prediction techniques, in addition to being applied to short-range weather prediction, are used in such research studies as air-pollutant transport and the effects of greenhouse gases on global climate change.

The first operational numerical weather prediction model consisted of only one layer, and therefore it could model only the temporal variation of the mean vertical structure of the atmosphere. Computers now permit the development of multilevel (usually about 10–20) models that could resolve the vertical variation of the wind, temperature, and moisture. These multilevel models predict the fundamental meteorological variables for large scales of motion

Over the last decade, weather predictions have improved greatly in accuracy because of the availability of satellite data, numerical models, and real-time computer processing power. These forecast tools are highly impressive, but have some important limitations.

1. Commonly available public forecasts are issued for relatively large "zones" covering perhaps a dozen countries and half-dozen major cities. Local weather can vary considerably within a forecast zone. Our local area is very flat, which reduces wind disturbance and soak rainwater deeply into the soil.
   Depending on wind direction and season, our local atmosphere may have been hydrated and moderated. During winter daylight hours, the sun shines less than 40% of the time. Local winds tend to be from the west southwest or southwest, except during April, when they are easterly.
   Because every region is exceptional to some degree, we believe that computer-assisted forecasting could be improved if, as a last step, the process were refined by an expert system that could take better account of local climatic modifiers. For this purpose we will use soft computing to discard such type of problems.
2. Public forecasts are based on observations that may be eight hours old and base data for some of the widely-used atmospheric models can twelve hours old. Given this lag time, we conclude that data obsolescence will continue to be a compromising factor for the foreseeable future, and that this lag will continue to limit the validity of forecasts, especially toward the end of the forecast window.

IV. DISCUSSION

Given this situation, we believe that commonly available public forecasts could become more reliable if, they were adjusted by an intelligent system that could take better account of current and changing local conditions.

Discovering and understanding the dynamic phenomena of weather, to accurately predict different weather events, has been an integral component of our study. The weather data, being inherently fuzzy in nature, requires highly complex processing based on human observations, satellite photography, followed by computer simulations. This is further combined with an understanding of the principles of global and local weather dynamics.

Weather forecasting has been a very important issue through last two decades. As we know due to global warming and human interference in nature has made the predication of climate, a totally unpredictable. We need to have a new approach which can predicate about the trend of weather- rain, Min temperature, Max temperature, Bright Sun Shine Hours, Humidity etc.

So long, the techniques used for weather forecasting is probability distribution, curve fitting, normalization. Still our predications are unpredictable. We propose a new approach that use concept of fuzzy logic in meteorology system.

V. WHAT IS FUZZY THEORY

‘Fuzzy logic’ was introduced by Sir Lofti Zadeh (1965) as an extension of classical set theory and is built around the central concept of a fuzzy set or membership function. Fuzzy set theory, the proper name for this theory, enables the processing of imprecise information by means of membership functions, in contrast to Boolean characteristic mappings. The conventional characteristic mapping ϕ of a classical set A (called crisp set) takes only two values: one, when an element belongs to the set; and zero, when it does not.

$$\phi_A(x) = \begin{cases} 1, x \in A \\ 0, x \notin A \end{cases}$$

Where $\phi_A(x)$ is characteristic function and A is classical set.

Here, $\phi_A(x) \in \{0,1\} \qquad \forall x \in A$

While, in fuzzy set theory, an element can belong to a fuzzy set with its membership degree μ ranging from zero to one. Fuzzy sets $\widehat{A}$ are usually identified with these membership functions. For an environmental variable X, we can consider the fuzzy set $\widehat{A}$ of acceptable values.

If x is a possible value of X, then $\mu_{\widehat{A}}(x)$ denotes its membership degree in the fuzzy set $\widehat{A}$.

Where,

$$\mu_{\widehat{A}}(x) \in [0,1] \qquad \forall x \in \widehat{A}$$

$\widehat{A}$ is the fuzzy set of that environmental variable X. As fuzzy set theory have a basic concept in mathematics, it is not misunderstood that it has a tremendous impact on various mathematical disciplines, such as logic, algebra, data analysis, statistics, etc. But more importantly, fuzzy set theory has a vast numbers of applications that make use of these mathematical disciplines. This has crystallized into tools such as fuzzy arithmetic, approximate reasoning, control paradigms and modeling paradigms, which are at our disposition for application in the new fields of interest.

In fuzzy rule-based systems, knowledge is represented by if–then rules P => Q. Fuzzy rules consist of two parts: an antecedent part P stating conditions on the input variable(s); and a consequent part Q describing the corresponding values of the output variable(s). Usually, the case of a single output variable is considered. In Mamdani type models, both antecedent and consequent parts consist of fuzzy statements concerning the value of the variables, whereas in Sugeno type models, the consequent part expresses a (non) linear relationship between the input variables and the output variable (Takagi and Sugeno, 1985).

VI. WHY FUZZY LOGIC TO PREDICT THE WEATHER

There are many reasons why fuzzy logic seems ideally suited for weather forecasting.

1. A shallow analysis of language used in conventional forecasts will be more than sufficient to demonstrate that they are inherently and intentionally fuzzy because fuzzy set theory uses fuzzy variables. e.g. mostly clear , toward midnight, becoming cooler overnight, low 35 to 40 degrees, winds becoming westerly, light to moderate snow, occasional rain, widely scattered showers, increasing high cloudiness

All of these values, along with characteristic "hedge", "normalize" etc. words like "increasing" and "mostly," map nicely into the architecture of fuzzy sets.

2. The weather field meets the general conditions under which a fuzzy solution is thought to be appropriate:
   - It is a field where approximate solutions are acceptable.
   - It is a field where the value and range of important variables (e.g., wind direction, amount of cloud cover, temperature) can be represented numerically. Some or all of these have fuzzy margins due to error of measurement, observational error, or intentional approximation ("hedging").
   - It is a field where input-output relationships definitely exist but may not be well-defined or even consistent. Depending on the season and local geography, the same input weather conditions can lead to different output weather forecasts. Placing a fuzzy "black box" between these inputs and outputs adds degrees of freedom to the model, even permitting inconsistent forecasts to be issued for the same time period. This added flexibility is of some importance because, over a 12-hour period, forecasts of wet and dry can both be correct.
   - It is a field where either (a) no mathematical formula is available that can produce the desired result or (b) we have a formula but it is of such complexity that, running on the target processor, it will fail to produce results useful in real time.
   - It is a field where we wish to make more use of available information, but doing so would make an algorithmic solution too complex. Given the rapid obsolescence of weather forecasts, we see a need for the continual adjustment, correction or deprecation of forecasts by inclusion of additional local information not available at the time the forecast was originally prepared.

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