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DISCUSSION

Discussion on ''Applying fuzzy theory and genetic algorithm to interpolate precipitation'' by C.L. Chang, S.L. Lo, and S.L. Yu

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Summary Unfortunately, the present paper has many scientific mistakes even in the basic conception and application of the fuzzy theory and genetic algorithm applications in addition to the inverse distance weighting (IDW) method approach. For instance, although in the abstract the authors state that ''... combining the inverse distance method and fuzzy theory...'', in fact one of their misconceptions is that they regard the weighting factors in the IDW interpolation method and the membership function in the fuzzy theory to be same but have expressed in different words. This statement indicates that the authors arrived at such a conclusion on the basis of geometrical similarity between the weighting factors and membership functions, which is not valid.

Introduction

Fuzzy theory, artificial neural networks and genetic algorithm methodologies are fashionable techniques that can be applied to many engineering, earth sciences, social, and economic topics. They are the most advanced methods for artificial intelligence and expert system applications. Although they are very attractive as methodologies and human behavior related simulations, their applications in engineering must be cautiously evaluated and reviewed. Otherwise, misinterpretations, misuses and flaws are encountered even in the international journals. The attractive words of ''fuzzy'' and ''genetic'' may pave the way to scientific pitfalls with misleading applications and conclusions. In order to avoid all these dangers, it is necessary to concentrate on the basic philosophy of these methods rather than their mechanical uses through software. The authors (Chang et al., 2005) are to be commended for the application of such an innovative method for precipitation interpolation and estimating unknown rainfall data. However, for the improvement and support of the topic the following points are suggested.

Although the Kriging, the optimal interpolation and the weighted methods are commonly used to estimate precipitation, but they failed to cite different works along these

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lines from the literature, before embarking to fashionable methods of fuzzy theory and genetic algorithms.

The inverse distance method

It is not true that as a remedy, the weighted method is more flexible for adjusting the weighting factors to account for the relative influence exerted by each gauge. The weighting factors as the authors presented in the paper are based on geometrical concept of inverse distance method, whereas flexibility in the weighting factors should include the effects of precipitation amounts recorded in each gaugeç Although the classical Thiessen polygon fixes the station influence areas, the weighted percentage method as developed by Şen (1998) gives different influence percentages to nearby stations and hence refines the influence area, which causes estimation error reductions that reach even to 20% (Bayraktara et al., 2005). Why should the authors use the primitive method of inverse distance, whereas the literature is full of commonly employed weighting functions. However, any fuzzy variable such as distance or elevation in the paper could have few membership functions through fuzzification. For instance, the distance variable could be fuzzified into three sets as 'small', 'medium', and 'large' distances each with a membership function. The authors used only one membership function which is the IDW in the sense of relative influence only.

Fig. 1 shows various dimensionless weighting functions used in the meteorology literature so far by different researchers. Unfortunately, none of these functions are event dependent but have been suggested on the basis of logical and geometrical conceptualizations. However, in reality, it is expected that the weights should reflect to a certain extent the natural regional behavior in the occurrence of the phenomenon concerned. Hence, the main purpose is to propose naturally flexible and event dependent

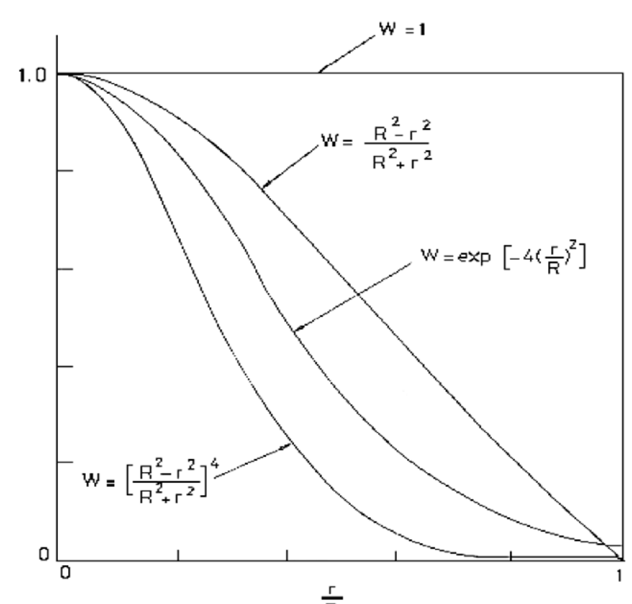

Figure 1 Cressman weighting function.

weighting functions by using, say for instance, the experimental semivarigram (SV) or cumulatıve SV (CSV) (Şen, 1997). The available weighting functions in the literature are proposed on logical basis by taking into consideration the site configuration only without experimental verification such as the one in the paper by Chang et al. (2005). However, there are different approaches in the literature for estimating weighting factors of each rainfall station by taking both site and logical phenomena into consideration (Hevesi et al., 1992a,b; Şen and Habib, 1998; Şen and Habib, 2001a,b, 2000a,b). In general, the following are the major drawbacks of the weighting functions available in the literature.

(a) They are based only on the configuration, i.e., geometry of the measurement stations and do not take into consideration the natural variability of the meteorological (rainfall) phenomenon from place to place. For instance, Cressman (1959) weightings are given as

$$W(r_{i,m}) = \begin{cases} \frac{R^2 - r_{i,m}^2}{R^2 + r_{i,m}^2} & \text{for } r_{i,m} \leqslant R \\ 0 & \text{for } r_{i,m} \geqslant R \end{cases} \tag{1}$$

where R is the radius of influence and it is determined subjectively by personal experience or ability dealing with the meteorological phenomenon concerned.

(b) Although they are considered universally applicable to all over the world, in fact, their validity even for small areas shows variabilities. For instance, within the same study area neighbor sites may have quite different weighting functions.

(c) Geometric weighting functions cannot reflect the regional variability of the meteorological phenomenon. They can only be considered as practical first approximation tools.

Thiebaux and Pedder (1987) have also suggested an extension of the Cressman model with extra exponent parameter α as

$$W(r_{i,m}) = \begin{cases} \left(\frac{R^2 - r_{i,m}^2}{R^2 + r_{i,m}^2}\right)^{\alpha} & \text{for } r_{i,m} \leqslant R \\ 0 & \text{for } r_{i,m} \geqslant R \end{cases} \tag{2}$$

One of the alternative weighting functions in Fig. 1 is for $\alpha = 4$. In Eq. (2) although the inclusion of α has alleviated the aforesaid drawbacks to some extent, but still its determination presents difficulties in the practical applications.

Again another form of geometrical weighting function was proposed by Sasaki (1960) and Barnes (1964) as (see Fig. 1)

$$W(r_{i,m}) = \exp\left[-4\left(\frac{r_{i,m}}{R}\right)^{\alpha}\right] \tag{3}$$

The weighting functions must reflect the behavior of the meteorological phenomena in addition to the station configuration geometry.

Fuzzy theory

In this part, they rely on a single so called membership function for the horizontal and vertical weightings with geometrical shapes that are different from the actually used