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An application of the intuitionistic fuzzy modal operator $E_{\alpha,\beta}$

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Abstract: Just like it is possible to examine pictures pixel by pixel, it is also possible to examine garden areas part by part. In previous studies, the greyness of the pictures was clarified. In the light of these studies, several improvements related to the problems of humidity, irrigation and pesticide spraying in agricultural areas were realized. As this process was carried out, the $E_{\alpha,\beta}$ operator which was defined over the contrast intensification operator (INT) and the intuitionistic fuzzy sets was used. Afterwards, the results were analyzed. The aim was to minimize the problems caused by the different plants, the different elevations and the different humidity values in the agricultural areas.
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1 Introduction

The theory of fuzzy set [1, 2] provides a suitable algorithm in analyzing complex systems and decision processes when the pattern indeterminacy is due to inherent variability and/or vagueness (fuzziness) rather than randomness. Since a grey tone picture possesses some ambiguity within pixels due to the possible multivalued levels of brightness, it is justified to apply the concept and logic of fuzzy set rather than ordinary set theory to an image processing problem. Keeping this in mind, an image can be considered an array of fuzzy singletons [1, 2] each with a membership function denoting the degree of having some brightness level [5]. This was used for the operator below. The contrast intensification operator (INT) on a fuzzy set A generates another fuzzy set $A' = INT(A)$, the membership function of which is:

$$\mu_{A'(x)} = \mu_{INT(A)}(X) = \begin{cases} 2[\mu_A(x)]^2 & 0 \leq \mu_A(x) \leq 0.5 \\ [1 - 2(1 - \mu_A(x))2] & 0.5 \leq \mu_A(x) \leq 1 \end{cases}$$

This operation reduces the fuzziness of a set A by increasing the values of $\mu_A(x)$ which are above 0.5 and decreasing those which are below it. Then this operator is used to improve the image of the agricultural field and we compare the results of the $E_{\alpha,\beta}$ operator with $\mu_{A'}(x)$ operator results.

$$E_{\alpha,\beta}(A) = \{\langle x, \beta(\alpha\mu A(x) + 1 - \alpha), \alpha(\beta\mu_A(x) + 1 - \beta)\rangle : x \in X\}$$

Shortly, Essential Humidity Level and Risk Humditiy Level are shown by EHL and RHL, respectively.

The data were obtained with the help of these two operators. As will be seen from Figure 1, the essential humidity threshold $EHL = 0.4$, risk humidity level $RHL = 0.3$ in this case, system to measure the moisture content obtained in different regions intervenes step by step as in Column 4. Table 2 presents the system value of the land without attention to the RHL primarily run the system in order to quickly reach the proper moisture value, then move the system to slow down EHL value. As can be seen from the Table 4, in the column, the system reduces the irrigation process by a decrease of drug action.

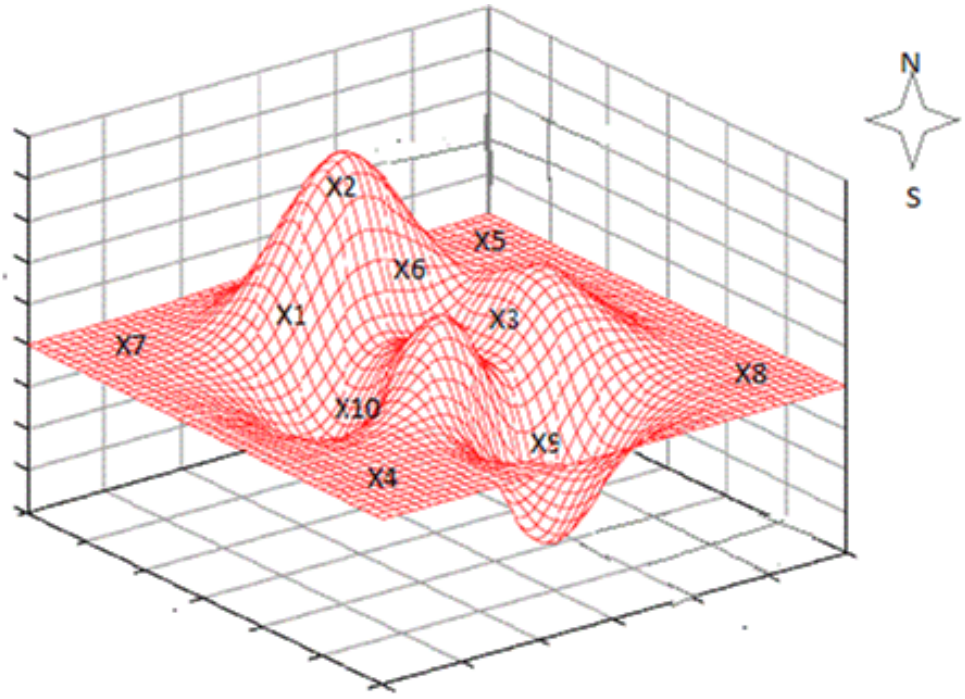

Figure 1:

We consider a farm in an area as shown in figure. We consider that different types of plants are cultivated on this farm land which has got different elevations and looks different directions. In

this case, this farm land can be separated domain by domain. All domains are separated according to directions and fruit trees.

In this study, we will use some properties of intuitionistic fuzzy sets and the modal operator $E_{\alpha,\beta}$, which is defined on the intuitionistic fuzzy sets to water this farm land. Other modal operators will be researched in different studies.

According to the definition of the $E_{\alpha,\beta}$ modal operator on IFS, membership degree is smaller than β and non-membership degree is smaller than α. In addition, α and β are between the values 0 and 1 and these α and β are independent from each other. By the means of some properties of $E_{\alpha,\beta}$ modal operator on IFS, we can solve this problem easily.

In the different cases of the moisture critical rate that soil needs for every domain, we can separate domains between themselves with respect to directions and elevations. Therefore, as a generalization, we suppose that the farm land has got same type of plants. In this case, our variables are elevations and directions of farm land. Naturally, these two features will create differences about the humidity rate in soil, but the humidity rate as needed by the plants is equal. A critical value can be determined for it. This critical value turns into β in the modal operator $E_{\alpha,\beta}$ IFS. The critical value which creates risk turns into α.

When the table which is below is analysed, if EHL and RHL values are close, then the response of operator on system determines closer values.

	$\mu_A(x)$	$\mu_{A'}(x)$	$E_{0.3,0.4}(A)$	$\mu_{E_{0.3,0.4}(A)}(x)$	$\nu_{E_{0.3,0.4}(A)}(x)$	$E_{0.3,0.4}(A')$
x_1	0.0	0.00	0.28	0.300	0.1568	0.2800 0.3000
x_2	0.1	0.02	0.292	0.288	0.1705	0.2824 0.2976
x_3	0.2	0.08	0.304	0.276	0.1849	0.2896 0.2904
x_4	0.3	0.18	0.316	0.264	0.1997	0.3016 0.2784
x_5	0.4	0.32	0.328	0.252	0.2151	0.3184 0.2616
x_6	0.5	0.5	0.34	0.24	0.2312	0.3400 0.2400
x_7	0.6	0.68	0.352	0.228	0.2478	0.3616 0.2184
x_8	0.7	0.82	0.364	0.216	0.255	0.3784 0.2016
x_9	0.8	0.92	0.376	0.204	0.2828	0.3904 0.1896
x_{10}	0.9	0.98	0.388	0.192	0.3010	0.3976 0.1824
x_{11}	1.0	1.00	0.400	0.180	0.3200	0.4000 0.1800

Table 2.

According to Table 2, when $EHL = 0.4$, $RHL = 0.3$, system responses the humidity rate measured different domains step by step as Column 4.

If the distance between EHL and RHL is larger, according to Table 3 below, in the case that the value of domain is close RHL, the values move speedly. When the values are close EHL, the value decreases its speed and responds in a controlled way.

	$\mu_A(x)$	$\mu_{A'}(x)$	$E_{0.1,0.8}(A)$	$\mu_{E_{0.1,0.8}(A)}(x)$	$\nu_{E_{0.1,0.8}(A)}(x)$	$E_{0.1,0.8}(A')$	
x_1	0.0	0.00	0.720	0.100	0.8432	0.7200	0.1000
x_2	0.1	0.02	0.728	0.092	0.8520	0.7216	0.0984
x_3	0.2	0.08	0.736	0.084	0.8606	0.7264	0.0936
x_4	0.3	0.18	0.744	0.076	0.8689	0.7344	0.0856
x_5	0.4	0.32	0.752	0.068	0.8770	0.7456	0.0744
x_6	0.5	0.50	0.760	0.060	0.8848	0.7600	0.0600
x_7	0.6	0.68	0.768	0.052	0.8923	0.7744	0.0456
x_8	0.7	0.82	0.776	0.044	0.8996	0.7856	0.0344
x_9	0.8	0.92	0.784	0.036	0.9066	0.7936	0.0264
x_{10}	0.9	0.98	0.792	0.028	0.9134	0.7984	0.0216
x_{11}	1.0	1.00	0.800	0.020	0.9200	0.8000	0.0200

Table 3.

According to Table 3, the system first works to reach the convenient humidity value by ignoring RHL value in a speedy way, after this process, EHL value plays the most important role by decreasing speed.

According to the complementary relationship between $E_{\alpha,\beta}$ and $\mathrm{E}_{\beta,\alpha}$ modal operators on IFS, the dual $E_{\alpha,\beta}$ is the risky and essential critical value of chemical pesticide, which is given to plants from leaves and soil. According to Table 4 belowm for these values, system decreases the speed of disinfestation and it is easily seen that system has a tendency to water farm land (agricultural response) in order to decrease the effect of chemical materials.

	$\mu_A(x)$	$\mu_{A'}(x)$	$E_{0.8,0.1}(A)$	$\mu_{E_{0.8,0.1}(A)}(x)$	$\nu_{E_{0.8,0.1}(A)}(x)$	$E_{0.8,0.1}(A')$	
x_1	0.0	0.00	0.020	0.800	0.0008	0.0200	0.8000
x_2	0.1	0.02	0.028	0.792	0.0016	0.0216	0.7984
x_3	0.2	0.08	0.036	0.784	0.0026	0.0264	0.7936
x_4	0.3	0.18	0.044	0.776	0.0039	0.0344	0.7856
x_5	0.4	0.32	0.052	0.768	0.0054	0.0456	0.7744
x_6	0.5	0.5	0.06	0.760	0.0072	0.0600	0.7600
x_7	0.6	0.68	0.068	0.752	0.0093	0.0744	0.7456
x_8	0.7	0.82	0.076	0.744	0.0116	0.0856	0.7344
x_9	0.8	0.92	0.084	0.736	0.0141	0.0936	0.7264
x_{10}	0.9	0.98	0.092	0.728	0.0169	0.0984	0.7216
x_{11}	1.0	1.00	0.100	0.720	0.0200	0.1000	0.7200

Table 4.

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As we can see from the Table 3 and Table 4, system decreases watering with decreasing the effect of pesticides.

There is no problem about farm land's directions, elevation and diversity of plants in the farm land which is made up of this system. This system paves the way for farmers to include less chemical materials than traditional method in growing vegetables and fruits and simultaneously respond to all points.

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