DECISION SUPPORT SYSTEM BY (ORDERED WEIGHT AVERAGING) OWA METHOD

Hooman Sharifnasab [1], Reza Alimardani [2], Mohammad Reza Akbari [3]

[1] *Assistant professor of Agricultural Engineering Research Institute (AERI) – hsharifnasab@yahoo.com*

[2] *Associate Professor, Biosystem Engineering College, Tehran University* - *rmardani@ut.ac.ir*

[3] *Researcher, of Agricultural Engineering Research Institute (AERI)-paymanakbari@yahoo.com*

Abstract: Nowadays, using the technology and computers for decision making in a particular field is one of the subjects which in the level of making decisions and industrial managements has been very much noticed. Especially, the decision which on the base of current specific condition is required, such as making decisions in the selection of suitable primary tillage equipment for given conditions of a farm.

Tillage consumes much more energy among all the other agriculture operation, so one mistake in optimum selection of tillage implements, not only wastes the huge amount of energy, but also it leads to serious impacts on soil, crop and other farm operation. The optimum selection of tillage implement is affected by environmental and geometrical conditions and factors and available facilities.

In this paper an attempt has been made to use the data fusion theory (Ordered Weight Averaging, OWA) to combine important factors to make a decision and to suggest a classified list of implements that can be used for primary tillage. By comparing the results obtained from the software and experts' suggestions it can be found that the software is compatible with scientific references by 99%, whereas experts' suggestions are compatible with scientific references only 94%.

Keywords: Tillage implements, Data fusion theory, Ordered weighted Averaging, Fuzzy rules, Decision support systems

1. INTRODUCTION

In farming age, human, came to know the land, plants and environment in order to provide his exigencies and food needs, endeavoring to get the most with the least input Nowadays, human has realized the importance of soil and other resources and has always tried to hold them long-lived.

Agricultural mechanization is a symbol of fusion between agriculture and industry. Today, terms of power and hardware has vanished and human asks for information and software instead; the storage and process of benefiting information plays an important role in many scientific fields such as *Information Technology*. (Sharifnasab H., et al, 2001)

The tillage which consists of different physical operations on the top or deep soil is aimed to prepare an appropriate seedbed for cultivation. Not considering this decisive operation causes loss of energy, and moreover contributes consequent disadvantages. By now, more than 150 implements with different configurations have been designed and manufactured for tillage operations in the field. They are expected to become even more complicated and variant by considering the need for integration of cultivation steps. Experts now believe that tillage must be performed in two different levels; one in deep soil and with more power, called "*primary tillage*" and the other on the top soil and slighter accordingly named "*secondary tillage*" (Shafii A., 1995).

In this paper, the *data fusion* theory was employed by using the technique of Ordered *Weighted Averaging* (namely called OWA operator) to develop software named *Decision Support System* (DSS) for defining all implements of different types. With regard to the environmental conditions, selection is made in order to choose the optimum primary tillage implement. This selection is based on the calculation made according to the values given to each implements so that, the best ones is offered to the user.

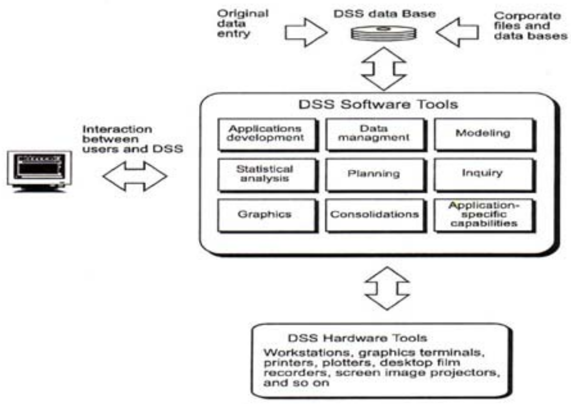

Figure 1-The DSS components (Sarafizade A., A. Alipanahi, 1384)

The significant feature of OWA operator is its great flexibility and simplicity to the user. The OWA operator has many applications, i.e. in decision making, expert systems, fuzzy control, database systems, image compression, etc. Numerous applications in various field, prove the OWA operator to be efficient and functional [(Cutllo V., J. Montero, 1994),(Engelmann K.J., et al,1992),(Kacprzyk J., 1990),(Yager R. R., 1992),(Yager R. R., D.P. Filev,1992),(Yager R.R., 1991)].

2. MATERIAL AND METHODS:

Tillage and related implements

Considering the two steps and numerous implements associated with tillage, this operation consumes the most energy. As shown in Table 1, priority of implement is ordered with the following fuzzy labels; Excellent, Good, Usable and Not Usable.

The goal of the DSS software is to search based on the defined conditions (by user) and to arrange the searched implements respectively, then it presents a ranked list to answer to the user.

Table 1- Fuzzy relation between the conditions and tillage implement (Sharifnasab H., 2001)

Category	Conditions	Implement type	Fuzzy label
Land Dimension	Wide land	Towed	Excellent
		Semi-mounted	Good
		Mounted	Usable
	Medium land	Semi-mounted	Excellent
		Mounted	Good
		Towed	Usable
	Small land	Mounted	Excellent
		Semi-mounted	Not Usable
		Towed	Not Usable
Geometric Shape	Equal land	Reversed	Excellent
		One way	Good
…	Unequal land	…	…

Table 2- Classification method in the DSS data base (Sharifnasab H., 2001)

Code set	Code details	Application
A	1	Primary tillage equipment
B	1	Moldboard plows
	2	Disk plows
	3	Chisel plows
	4	Subsoilers
	5	Rotary tillers
C	1	Mounted
	2	Semi-mounted
	3	Towed

The advantage of this method is that it allows the user to select other alternative if the introduced implement with superior abilities fails to help for any reason. The point is that some concepts indeed do not exactly signify to illustrate the situation. For example, if we define a 50 ha field as big, then a 49 ha field will not be regarded as big, whereas there is no significant difference between 49 ha and 50 ha to choose the tillage implement. Applying fuzzy concepts and take advantage of fuzzy labels, such as big, medium, small and etc, we can solve many problems.

Example: For defining an implement such as a mounted - one way moldboard plow with cylindrical moldboard and stubble bottom with simple shared equipped with adjustable landside, we can write:

A(1)-B(1)-C(1)-D(1)-E(1)-F(1)-G(1)-H(2)-I(0)-J(0)-K(0)-L(0)-M(0)-N(0)-O(0)-P(0)-Q(0) (1)

If we assume that all probabilities for providing the implements are existed, then the total number of implements, in which the software can list, will be equal to:

$$\text{No. Of Implements} = N_A * N_B * N_C * N_D * N_E * N_F * N_G * N_H * N_I * N_G * N_K * N_L * N_M * N_N * N_O * N_P * N_Q \quad (2)$$

$$\text{Total} = 161740800 \quad (3)$$

In which N_A presents the number of sub - tools in the category A.

As shown in table 3, some aspects are influenced by more than one factors (i.e. selecting of plow or bottom types), so considering only a single factor won't be accountable. Therefore, to account for all conditions in choosing an implement, we must employ a method in which all factors and priorities among the conditions should be explained with considering the influenced coefficient. For instance to choose a bottom, according to table 3, it's obvious that factors like: soil class, forward speed and plowing depth are influencing whereas we still don't know the priority of their influence and/or we can not assume their influence, alike.

Table 3- A survey of interrelation between the Influencing and Influenced aspects (Sharifnasab H. , 2001)

No	Influencing aspects	Influenced aspects	Codes
1	Land dimensions	Connection type	C
2	Land geometric shape	Implement orientation	D
3	Soil class	Bottom-moldboard-share-disk	E-F-G-L
4	Fertilizer existence	Plow type	B
5	Forward speed	Bottom	E
6	Soil humidity	Plow type	B
7	Land slope	Moldboard	F
8	Hard pan existence	Plow type	B
9	Plowing depth	Bottom	E
10	Plowing time	Plow type – share	B-G
11	Land use	Plow type – disk plow type	B-K

Information Technology in Management and Decision Making

Decision Support Systems (DSS) were contrived in the late 1970s and early 1980s considering the necessity for the systems to be able to assist organizations in trouble with analysis and proposing different solutions. These systems are commonly interactive and mostly designed for administrators. A DSS solves a particular problem which might be occasional and not routine. Supervisors can compensate information shortcoming with DSS and raise their decision's quality consequently. The main abilities of the DSSes are an applied program-providing tool, a data-managing tool, modeling, statistical analysis method, planning, inquiries and data fusion (Sarafizade A., A. Alipanahi, 2005).

Ordered Weight Averaging operator and its role in data Fusion

One of the important issues in decision making is integrating standards and forming the decision function (Azar A., H. Faraji , 2002). Sometimes we require all the standards to be accomplished and sometimes we may intend to fulfill at least one standard. These two requirements depend on "*and*" and "*or*" operators for standard functions fusion. The OWA operator performs a sort of collection which stands amid the mentioned cases; that's why it is called "*orand*" operator. It was first introduced by *Yager*, however new versions of this operator have been proposed by him to other researchers. An OWA operator with n dimensions is a $F: R^n \rightarrow R$ mapping, with an n-dependent vector $W = [w_1, w_2, w_3, \dots, w_n]$ with the condition

$$\begin{cases} w_j \in [0,1] \\ \sum_j w_j = 1 \end{cases}$$

so that:

$$F(a_1,\dots,a_n) = \sum_{J=1}^{n} w_j b_j \quad (4)$$

in which a_i is a factor for weight calculation (importance) and b_j is the j_{th} great factoramong a_js (Yager R. R., 1992).

The basic fact about this operator is that a weight like w_j is not relevant to a particular argument a_i, but relates to a collocated place. This collocation method indeed, makes this operator to behave non-linear. If B is a vector with n members signed as b_js, then OWA operator will be as follows (Kavoosi K.,2001).

$$F(a_1,\dots,a_n) = W^T B \quad (5)$$

3. RESULTS AND DISCUSSION

Results:

The most important task is to conduct the problem conditions based on Yager theorem for calculations associated with OWA operator.

Fuzzy rules allow us to find a proper "*Regular Increasing Monotone*"[1] (RIM) function to compute OWA weights. This method uses a RIM function such as "quantifier" to calculate the weights:

$$Q(r) = Q_a(r) \qquad (a \geq 0) \tag{6}$$

Thus:

$$w_j = Q\left(\frac{j}{T}\right) - Q\left(\frac{j-1}{T}\right) \quad ; \quad j = 1,2,\ldots,T \tag{7}$$

Where *T* is the number of weights and it's obvious that:

$$\sum_{j=1}^{T} w_j = 1 \tag{8}$$

But it's important how to choose "*a*" and Q_a (r) function. A proper way to choose *a* is constituting several fuzzy rules which determine the range of weights, then value of *a* will be achieved concerning the function definition (Yager R.R.,2001). Each question results in a specific weight, after modeling the answers of user [answers to user/questions of user], naturally different from another questions weight. The figure 2 illustrates the idea.

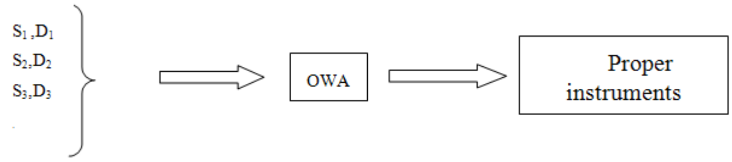

Figure 2- application of OWA on the User's data

In which, s is the data's value and D shows the data.

Obviously:

$D \in$ { field dimensions, geometric shape, soil class, fertilizer existence, Moving speed, humidity, land slope, plowing deepness, … } (9)

$0 \leq S_i \leq 1$ and $\sum^{n}_{i=0} S_i = 1$ (10)

The resultant optimum instrument will be formulated as follows:

$(S_a A_{ia}) (S_b B_{ib}) (S_c C_{ic}) (S_d D_{id}) (S_e E_{ie}) (S_f F_{if}) (S_g G_{ig}) (S_h H_{ih}) (S_i I_{ii}) (S_j J_{ij}) (S_k K_{ik})\ldots$ (11)

In which:

$$\begin{aligned} &0 \leq i_a \leq N_A \\ &0 \leq i_b \leq N_B \\ &0 \leq i_c \leq N_C \\ &. \\ &. \\ &0 \leq i_q \leq N_Q \end{aligned} \tag{12}$$

s values are determined according to the data bank and defined conditions by the user. So we have:

$S \in$ {*excellent, good, usable, not usable*} (13)

The following amounts have been equaled to quantify the above fuzzy labels:

$$S(\textit{excellent}) = 1 \\ S(\textit{good}) = 0.66 \\ S(\textit{usable}) = 0.33 \\ S(\textit{not usable}) = 0 \tag{14}$$

In order to achieve each point's weight in OWA formula, we must choose an appropriate quantifier. "*Yager*" believes that the following quantifier is not mathematically complicated, and also makes approximately true answers. So, we define it as follows (Moghadasi A., 1998):

$$Q(r) = r^{a} \qquad (a \geq 0) \tag{15}$$

Now, to calculate the weights (w), we have:

$$w_j = Q(\frac{j}{T}) - Q(\frac{j-1}{T}) \tag{16}$$

in which T is the total number of weights (the total number of maximum components in an instrument; currently A to Q: 11) the above equation also includes the condition: $\sum^{T}_{i=1} w_j = 1$

W_1 is the highest point's weight, w_2 is the next point's weight, ..., and w_{17} is the least point's weight in defined conditions by user. To calculate the best instrument and most fitting answers, we need to calculate the optimum a.

We'd better design and accomplish experiments to determine the importance of a properly beside other characteristics; For example,an experiment to show whether the land slope or humidity is more important to select a tillage instruments.

We'll obviously need $\frac{n^2 - n}{2} = \frac{11^2 - 11}{2} = 55$ experiments (currently) (Asgharpoor M.J., 1998); in which n is the number of different environmental conditions effective on choice, such as: land dimensions, geometric shape, soil class, etc. After performing the experiments, once again we can take advantage of OWA method by substituting the result values.

Presently, we need two border rules to limit upper and lower values of *a*.

The first rule:

If more than m percent of sub-tools in a tool, have a point more than y, the ultimate point must be greater than x.

The second rule:

If more than m percent of sub-tools in a tool, have a point less than y, the ultimate point must be smaller than x. Considering these two rules, the upper boundary edge of *a* will be as follows:

upper boundary edge :

$$w_1 = (1/T)^a - (0/T)^a \\ w_2 = (2/T)^a - (1/T)^a \\ w_3 = (3/T)^a - (2/T)^a \tag{17}$$

.
.
.
$w_j = (j/T)^a - ((j-1)/T)^a$

finally, adding up the weights will give:

$\sum_{i=1}^{J} w_i = (j/T)^{a}$ (18)

in which:

j = round up [(m/100) * T] (19)

Referring to the first rule, we can model the equations as:

$(j/T)^{a} * Y \geq x$ (20)

and this gives us :

$a \leq \ln(x/y) / \ln(j/T)$ (21)

Similarly, to determine the lower boundary edge and considering the 2nd rule, we'll have:

lower boundary edge:

(w1 + w2 + … + wT-j')*1 + (wT-j'+1 + wT-j'+2 + … + wT-1 + wT)* y' ≤ x

It is similar to formula (19):

j'= round up [(m'/100) * T] (22)

So, substitution will result:

$[(T-j')/T]^{a} * 1 + [1-(T-j')/T] * y' \leq x'$ (23)

and, consequently:

$a \geq [\ln (x'-y')/(1-y')] / [\ln (T-j') / (T)]$ (24)

So, ultimately (Yager R.R., 1991):

$[\ln(x/y) / \ln (j/T)] \geq a \geq [\ln [(x'-y') / (1- y')] / [\ln (T-j') /T]]$ (25)

4. DISCUSSION

You have read *a* wide preview in appointing these two conditions (upper & lower boundary edges) and every expert defines these conditions based on his experience and interest. In table 5 are several scenarios to determine the boundaries (Sharifnasab H., et al, 2001).

Table 5-Some different scenarios about the first condition

a	x	y	m
1.17	0.6	1	60
1.02	0.7	1	70

Table 6-Some different scenarios about the second condition

a	x'	y'	m'
0.99	0.45	0.33	80
1	0.72	0.66	80

The explanation of table 5 and 6 are as follows:

The first rule:

* If more than 60 percent of sub-tools are excellent, the ultimate value of that tool must be greater than 0.6 .

* If more than 70 percent of sub-tools are excellent, the ultimate value of that tool must be greater than 0.7 .

The second rule:

* If more than 80 percent of sub-tools are usable, the ultimate value of that tool must be greater than 0.45 .

* If more than 80 percent of sub-tools are good, the ultimate value of that tool must be greater than 0.72 .

Now, if we assign an upper and a lower rule for *a*, we'll be able to achieve a limit for *a*:

$$0.99 \leq a \leq 1.17 \tag{26}$$

The above unequal results in: $a = 1$

even considering the second scenario, we'll have :

$$1 \leq a \leq 1.02 \tag{27}$$

From which a =1 seems to be logical.

Noticing the calculated values for a, we accept (Sharifnasab H., et al, 2001): $a = 1$

Now, substituting a =1 in weight calculation equations, gives us uniform weight. Approximation of a with 1 shows that there is no superiority between factors and conditions (i.e. field area, land slope, humidity, etc.) and it means that there is no definite answer to the question "*which factor is more important to choose tillage implement, field area or Filed slope; and how much?*" until the complete experiments are accomplished. Currently, the only solution is to assume that the importance of all factors are equal (Sharifnasab H., et al, 2001).

The following results are achieved from a statistical analysis with "*chi-square*" method and using "*SPSS*" software.

Here is the analysis of the results:

* The software's answers, correspond with the reference with a (1-0.011)= 99% probability (Table 8).

Table 8-comparison of soft ware answers with reference Statistical trial

	Soft ware
Chi. Square	6.400
.df	1
Asymp. Sig.	0.011

* The expert's answers correspond with the reference with a (1-0.058)= 94% probability (Table 9).

Table 9-comparison of expert's answers with reference Statistical trial

	Soft ware
Chi. Square	3.600
.df	1
Asymp. Sig.	0.058

* The software's answers correspond with the expert's answers with a (1-0.058)= 94% probability (table 10).

Table 10-comparison of software answers with experts Statistical tria

	Soft ware
Chi. Square	3.600
.df	1
Asymp. Sig.	0.058

Considering the results, the reference is more in agreement with the software performance than the experts.

5. CONCLUSION

Applying the expert system software for choosing a tillage implement, not only decreases consultative costs, but also provides the option of reporting and well-timed consultation. The results of comparing software's answers with expert’s answers, indicate that the software provides better answers (closer to reference).

As illustrated in the article, coefficient "*a*" (based on which OWA weights are defined) was achieved greatly close to 1, because of lack of adequate information about conditions effecting on proper implement selection. It is evident that if enough experiments are accomplished to determine the parameter's priorities, then weights (w) will be calculated more accurately.

REFERENCES

Asgharpoor M.J., 1998, Multi Parameters in Decision making, Tehran University publication

Azar A., H. Faraji , 2002, Fuzzy Management science, Iranian center of Efficient study, Tehran

Cutllo V., J. Montero, 1994, Hierarchies of aggregation operators, International Journal of Intelligent Systems, Vol. 9

Engelmann K.J., H.E. Miller , Ronald Yager,1992 , Decision making with belief structures: an application in risk management, Technical Report # MII-1234 , Machine Intelligence Institute, Iona College

Kacprzyk J., 1990 , Inductive learning from considerably erroneous examples with a specify based stopping rule, Proceedings of the International Conference on Fuzzy Logic & Neural Networks , Iisula , Japan

Kavoosi K.,2001, Qualification of function of Intelligent method for software agent data fusion in internet, Msc. Thesis , Tehran University

Moghadasi A., 1998, Data fusion by intelligent software agent in internet, Msc. Thesis, Tehran University

Sarafizade A., A. Alipanahi, 2005, Management Information Systems, Tehran Mir Publication

Shafii A., 1995, Tillage Machines, Tehran university publication

Sharifnasab H., 2003 ,Development a decision support system software for tillage implements selecting, PhD. Thesis, Tehran university

Sharifnasab H., R. Alimardani, A.M. Borghaee, 2001, Intelligent Software usage in agriculture, Intelligent System conference, KN university

Yager R. R., D.P. Filev,1992, Fuzzy Logic Controllers with flexible structures . Proceeding of 2nd International Conference in Fuzzy Sets and Neural Networks

Yager R. R., 1992, Decision making under Dempster-Shafer, International Journal of General Systems. Vol 20

Yager R.R., 1991 ,Fuzzy quotient operators for fuzzy relational Data base .Proc. Int. Fuzzy Engineering Sym. Japan.

Yager R.R.,2001 , On Induced aggregation operators , Proceeding of a Eurofuse Workshop on preference Modeling and Applications , Canada