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FIS for Edge detection based on the method of convolution and a mixture of Gaussian and triangular membership functions

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Abstract: ***Fuzzy logic is a technique of emboding human like thinking into a control system. These find applications in modeling human brain and in the creation of behavioural systems. Fuzzy Logic based systems provides a more efficient and resourceful way to solve Control Systems. These systems are been used in business, hybrid modelling , Air conditioners, video game artificial intelligence , pattern recognition in remote sensing and expert systems. Mainly the use of Triangular and Gaussian membership functions for FIS based edge detection is to provide simplicity, reliability and robustness.***

Keywords: behavioural systems, expert systems, pattern recognition, video game artificial intelligence.

1. Introduction

FIS(Fuzzy inference systems) is a mapping function from input space to output space using fuzzy logic. It is also known as fuzzy models, fuzzy associate memories(FAM) or fuzzy controllers. Instead of making use of Boolean data, it makes use of fuzzy membership functions. Here fuzzy itself means not clear, distinct or blurred. Fuzzy logic means a form of knowledge representation suitable for notions that cannot be defined precisely, but which depend upon their contexts. Fuzzy logic uses continuum of logical values between 0(completely false) and 1(completely true). It deals with the degree of membership functions and degrees of truth. Such kind of systems which are based on fuzzy logic are flexible, tolerant to imprecise data, easier to understand and also based on natural language. Here in this paper Gaussian membership functions and triangular memberships functions associated with the convolution process is applied for input and output variables mapping , thus performing edge detection using FIS.

2. Fuzzy Models

The Figure 1 is a block diagram of a fuzzy controller of a washing machine:

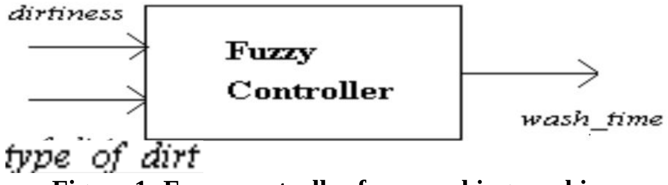


Figure 1: Fuzzy controller for a washing machine

This is the example of a washing machine. If dirtiness is large and type of dirt is grease, then wash time should be very long. Other rules can be applied for water level and spin speed. The general block diagram of a fuzzy controller is as shown in Figure 2.

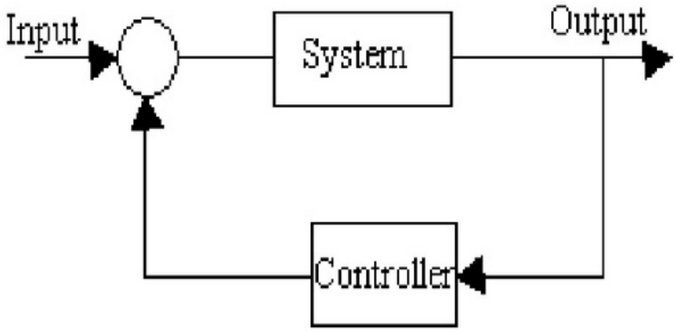
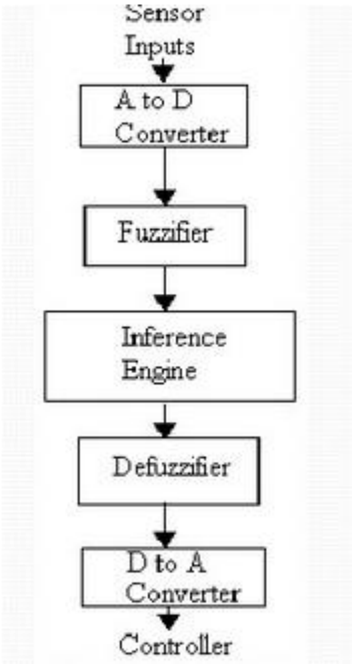


Figure 2 Fuzzy controller general block diagram

This fuzzy controller contains 3 main components:

1. Fuzzification
   -which scales and maps input variables to fuzzy sets.
2. Inference mechanism
   - which deduce control action by making use of approximate reasoning.
3. Defuzzification
   -which converts fuzzy outputs to control signals.
   The internal structure of a fuzzy controller is shown in Figure3.



Outputs

Figure 3: Fuzzy controller internal structure

Fuzzy sets:

Fuzzy sets can be represented by:

A={{x, A(x)}}

Where A(x) is a membership grade of element x in a fuzzy set.

Membership function:

-This defines the degree of element's membership in a fuzzy set.

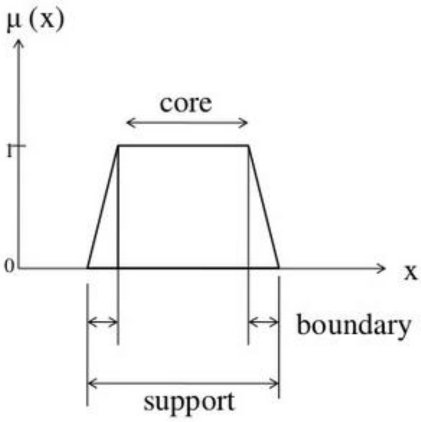


Figure 4: Membership function

There are 3 regions in a membership function(Figure 4):

a) **Core**: This is a region characterized by full membership in a fuzzy set A'. i.e. μ(X)=1.
b) **Support:** This is a region characterized by non-zero membership in set A'. i.e. μ(X)>0.
c) **Boundary:** This is a region characterized by partial membership in a set A'. i.e. 0<μ(X)<1.

Here is the graph(figure 5) that depicts the labels and membership functions of input variable type_of_dirt based on Fig1.

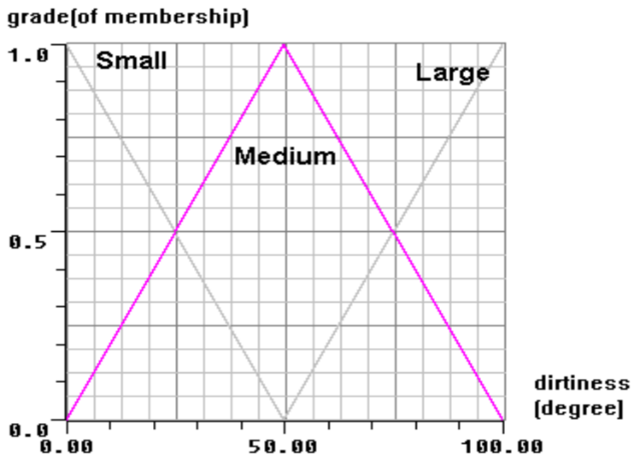


Figure 5: label and membership functions of input variable for Figure1

Next graph(figure 6) contains the label and membership functions of output variable, wash_time.

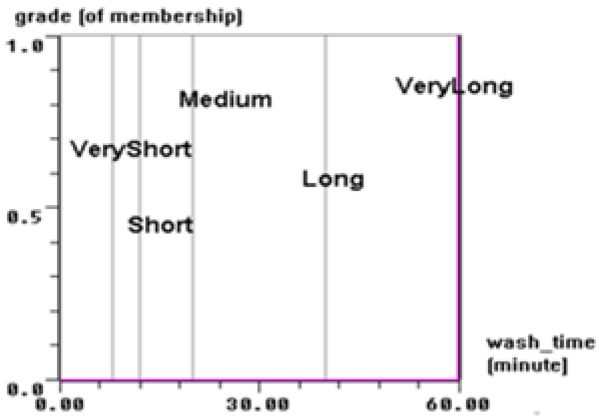


Figure 6: label and membership functions of output variable for Figure 1

These membership functions are usually designed from either of 3 approaches:

a. B y interviewing with those who are familiar with the concept
b. By constructing it automatically from the data
c. Learning based on feedback from system performance

Gaussian Membership function:

Gaussian membership function is defined by central value m and a standard deviation k>0

$$\mu_A(x) = e^{-\frac{(x-m)^2}{2k^2}}$$

The graph of such a function is depicted in figure 7.

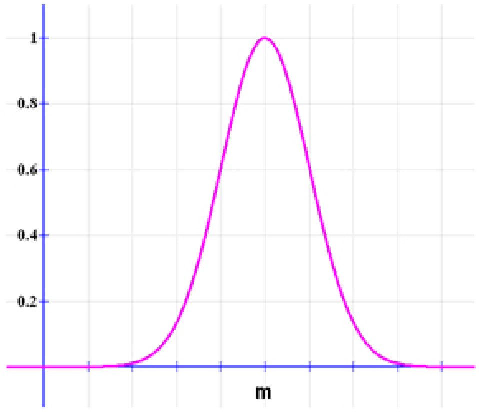


Figure 7: Gaussian membership function

Triangular Membership function:

This function defined by lower limit a, upper limit b and value m, where a<m<b. The graph of such a function is depicted in Figure 8.

$$\mu_A(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{m-a}, & a < x \le m \\ \dfrac{b-x}{b-m}, & m < x < b \\ 0, & x \ge b \end{cases}$$

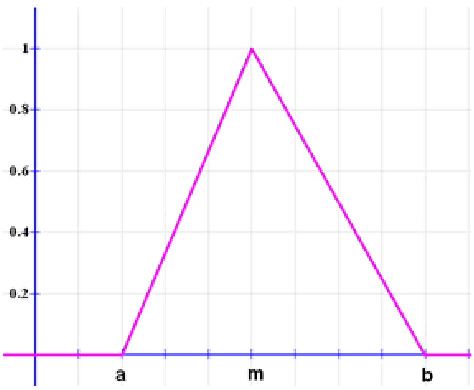


Figure 8: Triangular membership function

Next let's look at the FIS system which is depicted in figure 9.

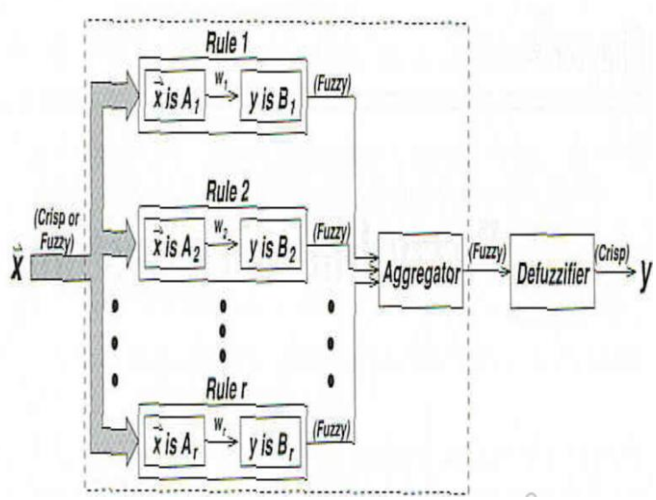


Figure 9 :FIS system

Rules in FIS is also known as Fuzzy Expert system(figure 10).
These are production rules of the form:
If p then q, where p and q are fuzzy statements.
For example, in a fuzzy rule:
If x is low and y is high then z is medium.
Here statements x is low, y is high, z is medium are fuzzy statements. Here x and y are input variables ; z is output variable and low, high, medium are fuzzy sets.

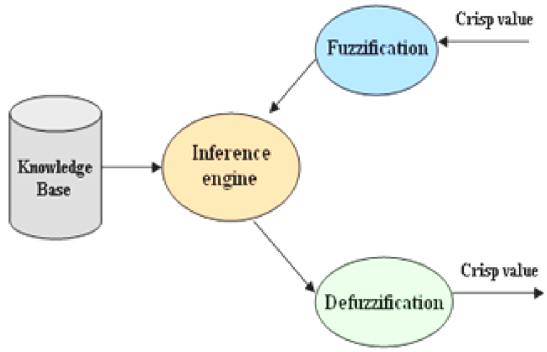


Figure 10: Fuzzy Expert system

The set of rules in fuzzy expert system is known as knowledge base.

Crisp Sets: Conventional or *crisp* sets are binary. An element either belongs to the set or doesn't.

Fuzzy sets: *Fuzzy sets*, on the other hand, have grades of memberships.

Note that the crisp membership functions are either 0 or 1. For example: Numbers greater than 10. Is denoted by
$A = \{x \mid x > 10\}$. This is depicted in Figure 11.

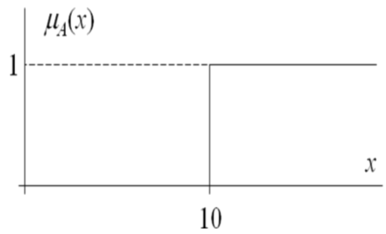


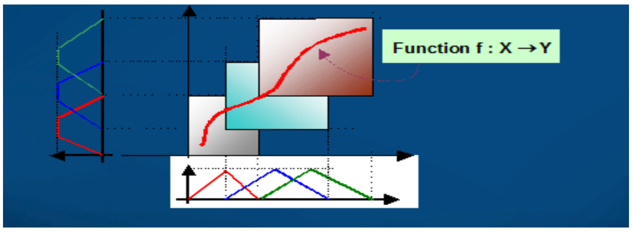
Figure 11: Crisp membership function for the example

Fuzzy Inference process comprises of 5 parts:

1. Fuzzification of input variables
2. Application of fuzzy operator in the antecedent
3. Implication from the antecedent to consequent
4. Aggregation of consequents across the rule
5. Defuzzification

Fuzzy approximation

- Fuzzy systems F: $\Re^n \rightarrow \Re^p$ use m rules to map vector x on the output F(x), vector or scalar.



Fuzzy Rules:

1) **FIR**, Fuzzy Implication Rules.
   -Logic of implications between fuzzy facts.
2) **FMR**, Fuzzy Mapping Rules.
   -Functional dependencies, fuzzy graphs, approximation problems.
3) **Mamdani type**:IF $MF_A(x)$=high then $MF_B(y)$=medium.
4) **Takagi-Sugeno type**: IF $MF_A(x)$=high then $y=f_A(x)$
5) **Linear $f_A(x)$** – first order Sugeno type.

3. Result Analysis of FIS based Edge detection by the method of convolution, Gaussian and triangular membership functions

The original image(Figure 13) is converted to grayscaled image(Figure 14) . Scaling factor is applied. Image gradient is then calculated for along both the axes, thus locating breaks in the uniform regions(Figure 15, Figure 16). Convolution is done with the image and its respective gradients along each axes. A fuzzy inference system(FIS) is specified. A zero-mean Gaussian membership function is specified for each input variable(as shown in Figure 17, Figure 18) and a triangular membership functions is specified for the output variable(as shown in Figure 19). Thus the plot of membership functions for input and output variables are constructed. Fuzzy rule applied is mamdani rule(Figure 12). Thus edges in an image were detected using FIS(as seen in Figure 21) comparing the gradient of every pixel in x and y directions. The execution time for Gaussian membership function is 0.011774 seconds whereas the execution time for triangular membership function is 0.043778 seconds.

```
ans =

1. If (Ix is zero) and (Iy is zero) then (Iout is white) (1)
2. If (Ix is not zero) or (Iy is not zero) then (Iout is black) (1)
```

Figure 12: Fuzzy Rule Applied

Figure 13: Initial rgb Image

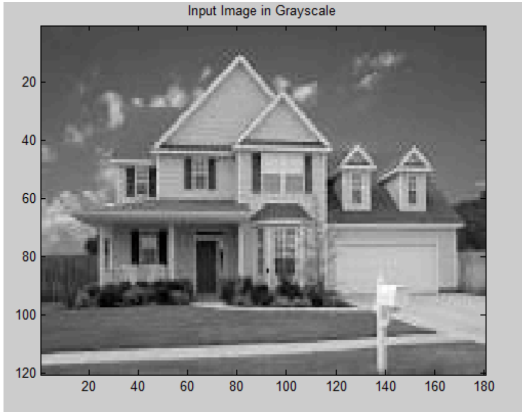


Figure 14: Grayscaled Image

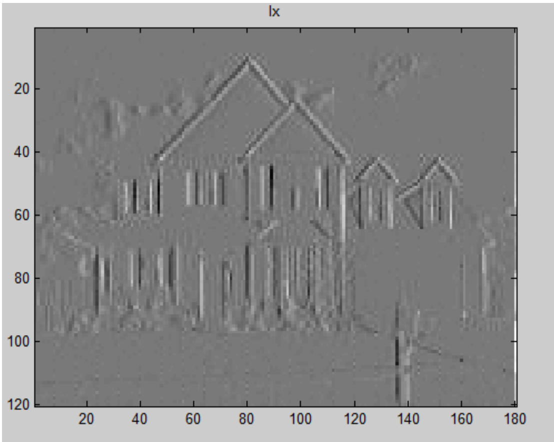


Figure 15: Image gradient along x-axis

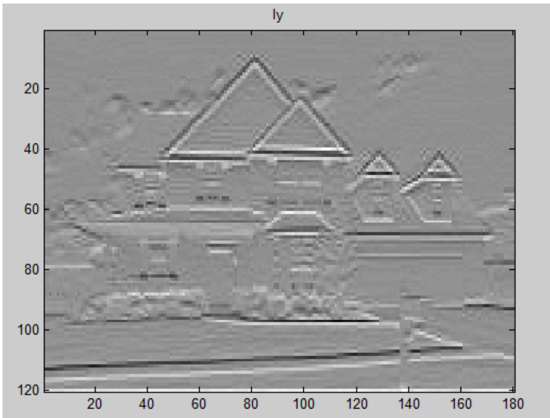


Figure 16: Image gradient along y-axis

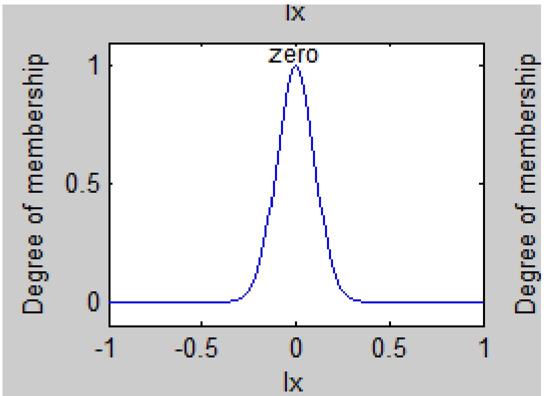


Figure 17: Membership function(Gaussian) for input variable x based on FIS

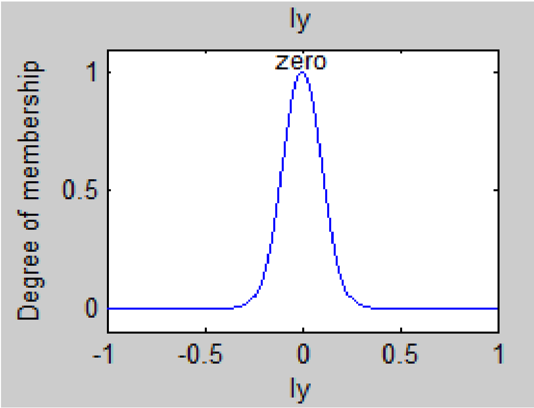


Figure 18:Membership function(Gaussian)for input variable y based on FIS

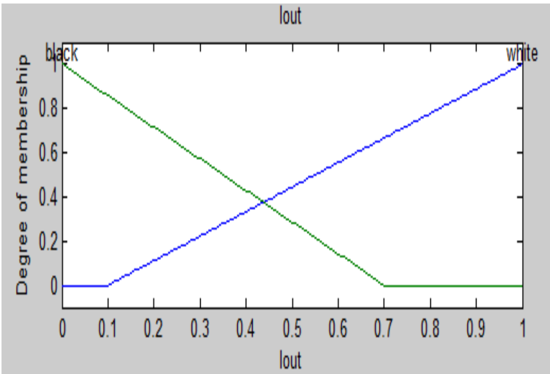


Figure 19:Membership function(Triangular) for output variable based on FIS

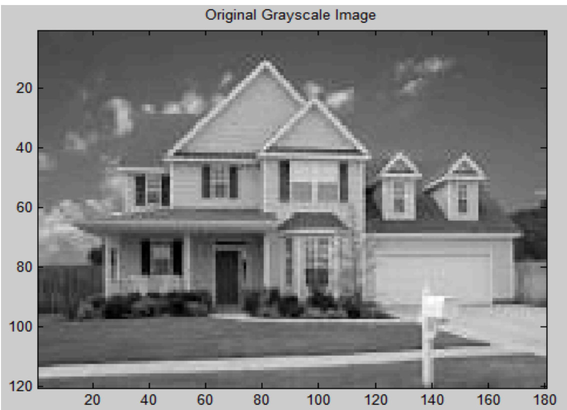


Figure 20: Original grayscaled image

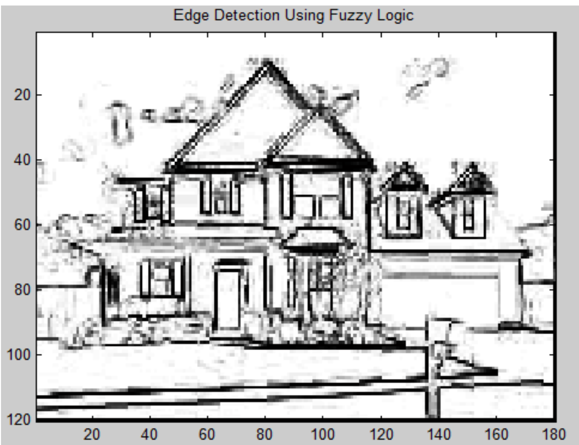


Figure 10 :Edge detection based on Fuzzy logic

4. Conclusions

Gaussian and triangular membership functions have been effective in performing the edge detection . Gaussian has been proved to be the fastest and also reliable and robust membership function when compared to triangular membership function .The use of triangular functions is mainly due to its simplicity in design . These fuzzy systems have their applications in automobile and other vehicle based subsystems, temperature controllers, cameras , home appliances etc. The speed and complexity of application production would not be possible without systems like fuzzy logic. Thus these systems have their significance even today. .

References

[1] Michela Fazzolari, Rafael Alcala, Yusuke Nojima, Hisao Ishibuchi, Francisco Herrera,"A Review of the Application of Multiobjective Evolutionary Fuzzy Systems: Current Status and Further Directions", IEEE TRANSACTIONS ON FUZZY SYSTEMS, VOL. 21, NO. 1, FEBRUARY 2013.

[2]X. Ji and W. Wang, "A Neural Fuzzy System for Vibration Control in Flexible Structures," Intelligent Control and Automation, Vol. 2, 2011, pp. 258-266.

[3]J. B. Savkovic-Stevanovic, "Fuzzy Logic Control Systems Modelling," International Journal of Mathematical Models and Methods in Applied Sciences, Vol. 3, No. 4, 2009, pp. 327-334.

[4]A. M. Ajofoyinbo, "Representation and Encoding of Fuzziness in Engineering Systems: The Case of Fuzzy Controllers," Ph. D. Thesis, University of Lagos, Nigeria, 2008.

[5]T. J. Ross, "Fuzzy Logic with Engineering Applications," John Wiley & Sons Ltd, Chichester, 2007.

[6]V. O. S. Olunloyo and A. M. Ajofoyinbo, "Fuzzy-Stochastic Maintenance Model: A Tool for Maintenance Optimization," International Conference on Stochastic Models in Reliability, Safety, Security and Logistics, Beer Sheva, 15-17 February 2005, pp. 266-271.

[7]D. Ruan and P. F. Fantoni (Eds.), "Power Plant Surveillance and Diagnostics—Applied Research with Artificial Intelligence," Springer, Heidelberg, 2002.

[8]J. E. Araujo, S. A. Sandri and E. E. N Macau, "A New Class of Adaptive Fuzzy Control System Applied in Industrial Thermal Vacuum Process," Proceedings of 8th IEEE International Conference on Emerging Technologies and Factory Automation, Vol. 1, 2001, pp. 426-431.

[9]H. R. Berenji and P. Khedkar, "Clustering in Product Space for Fuzzy Inference," 2nd IEEE International Conference on Fuzzy Systems, San Francisco, 1993, pp. 1402-1407.

[10]H. J. Zimmermann, "Fuzzy Set Theory and Its Applications," 2nd Edition, Kluwer Academic Publishers, Boston, 1991.

[11] I. B. Turksen, "Measurement of Membership Functions and Their Acquisition," Fuzzy Sets and Systems, Vol. 40, No. 1, 1991, pp. 5-38.

[12]N. Watanabe, “Statistical Methods for Estimating Membership Functions,” Japanese Journal of Fuzzy Theory and Systems, Vol. 5, No. 4, 1979, pp. 833-846.

[13]L. A. Zadeh, “Outline of a New Approach to the Analysis of Complex Systems and Decision Processes,” IEEE Transaction on Systems, Man, and Cybernetics, Vol. SMC-3, No. 1, 1973, pp.

[14]R. E. Bellman and L. A. Zadeh, “Decision-Making in a Fuzzy Environment,” Management Sciences, Vol. 17, No. 4, 1970, pp. 141-164.