FUZZYALGOL: Fuzzy Algorithmic Language for designing Fuzzy Algorithms

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Abstract
The imprecise, crisp, inexact, inconsistent and incomplete problems are fall under fuzzy problems. These fuzzy problems are soled using fuzzy algorithms, fuzzy programs and fuzzy languages. Fuzzy algorithms are the single sentence form and difficult to solve fuzzy problems. Fuzzy Algorithmic Language (FUZZYALGOL) is necessary to describe the fuzzy algorithms for computation of fuzzy problems. In this paper, FUZZYALGOL is proposed based on the fuzzy algorithms, fuzzy programs, fuzzy languages. The computation Procedure is discussed for FUZZYALGOL to solve fuzzy problems by taking Examples.

Key words
Fuzzy logic, fuzzy algorithms, fuzzy reasoning and fuzzy Algorithmic Language.

1 Introduction
In problem solving environment, the information available to the system may be inexact, imprecise and incomplete. There are many inexact, imprecise and incomplete problems faced by humans in the real world[11]. The problems include driving a car, parking a car, recognizing a character, speech and image, Cooking a meal e.t.c., encounters some of the inexact problems in the real world. For instance, we encounter situations “go about 100 meters, until the bank, turn right, go about 50 meters until the restaurant then you will find the station after about a few minutes walk”. These problems usually fall under the category of inexact, incomplete and imprecise problems falls under fuzzy problems[6,11,18]. Fuzzy logic[5,6, 13, 17, 18] play an important role to solve the inexact, imprecise and incomplete problems. It is difficult to solve such problems using conventional algorithms. Fuzzy algorithms and fuzzy programs are used to solve real world fuzzy problems[1,10,16]. Fuzzy algorithmic language is necessary to design efficient fuzzy algorithms for fuzzy problems. FUZZYALGOL is designed with the as set of fuzzy algorithms.

2 Fuzzy Logic and Fuzzy Reasoning
It is necessary to discuss briefly the fuzzy sets and related concepts[12, 15] in the following to describe FUZZY ALGOL.

For a given universe of discourse X, a fuzzy subset A of X is defined by its membership function μA taking values on the unit interval [0, 1], i.e.

\[ \mu_A: X \rightarrow [0,1] \]

Suppose X is universe of discourse. The fuzzy set A of X is defined as

\[ A = \mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + \ldots + \mu_A(x_n)/x_n \]
where ‘+’ is union
Suppose X is having individuals x₁, x₂, x₃, x₄, x₅ the fuzzy subset SMALL for small, takes values in the unit interval [0, 1] and it may be represented as
\[
\text{SMALL}=0.1/x₁+0.5/x₂+0.3/x₃+0.7/x₄+1/x₅
\]

There is an alternative to define fuzzy subset with functions [4]
Consider a proposition “X is young”, where YOUNG for young is a fuzzy subset.

\[
\text{YOUNG may be defined as}
\]
\[
\text{YOUNG} = \frac{\mu_{\text{YOUNG}}(x)}{\mu(x)} = 1 \quad \text{if} \quad x \in [0, 25]
\]
\[
\mu_{\text{YOUNG}}(x) = \left[1+ \left(\frac{x-25}{25}\right)^2\right]^{-1} \quad \text{if} \quad x \in [25,100]
\]

The combination of fuzzy sets are given below
Let \(A, B, C\) be three fuzzy subsets, \(\mu_A, \mu_B, \mu_C\), the membership functions for fuzzy subsets \(A, B\) and \(C\) respectively.

\[
\text{A \lor B}=\max (\mu_A(x), \mu_B(x))/x \quad \text{(disjunction)}
\]
\[
\text{A \land B}=\min (\mu_A(x), \mu_B(x))/x \quad \text{(conjunction)}
\]
\[
\neg A=1-\mu_A(x)/x \quad \text{(negation)}
\]
\[
A \rightarrow B= \min(1,1-\mu_A(x)+\mu_B(x))/x \quad \text{(implication)}
\]
\[
A \times B =\min(\mu_A(x), \mu_B(y))/x \quad \text{(relation)}
\]
\[
\mu_{\text{Proj}}(x) = \max \{\mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + ...+\mu_A(x_n)/x_n\} \quad \text{(projection)}
\]

The proposition containing quantifiers reduces to simple propositions by using power operators. The square operator is used for “very”, “most” (concentration), etc. The square root operator is used for “more or less” (diffusion), etc.

For instance
\[
\mu_{\text{very young}}(x) = \mu_{\text{YOUNG}}(x)^2
\]
\[
\mu_{\text{not very young}}(x) = 1-\mu_{\text{YOUNG}}(x)^2
\]
\[
\mu_{\text{more or less old}}(x) = \mu_{\text{old}}(x)^{1/2}
\]

Fuzzy reasoning is a drawing conclusion from fuzzy propositions using fuzzy inference rules[15]. Some of the fuzzy inference rules are given bellow

R1: x is A \hspace{2cm} R2: x is A
x and y are B \hspace{1cm} x or y is B

\[
\text{y is A \land B}
\]

R3: x and y are A \hspace{1cm} R4: x or y are A
y and z are B \hspace{1cm} y or z are B

\[
y \text{ and } z \text{ are B}
\]

R5: x is A
if x is A then y is B

\[
y \text{ is } A \circ (A \rightarrow B)
\]

R6: \(f_1\)
\(f_2\)

.  

.  

.
\[ f_n = f_1 \circ f_2 \circ \ldots \circ f_n = \min \{ f_1, f_2, \ldots, f_n \} \]
where \( f_1, f_2, \ldots, f_n \) are fuzzy statements.

3 Fuzzy Algorithmic Language (FUZZYALGOL)

Fuzzy algorithms and fuzzy programs are used to solve the fuzzy problems[12,16]. Fuzzy Algorithmic Language is defined as sequence of fuzzy statements. The FUZZYALGOL is used to design fuzzy algorithms to solve inexact, imprecise and incomplete problems and capture procedure for given fuzzy problems. FUZZYALGOL is proposed by consolidation fuzzy algorithms, fuzzy programs and execution of fuzzy programs[1,2,7,12,16].

A procedure is given to describe the fuzzy algorithms for fuzzy problems. FUZZYALGOL is defined as sequence of fuzzy statements to design algorithm for a particular fuzzy problem. The FUZZYALGOL consists of fuzzy variables, fuzzy expressions, fuzzy conditions, and fuzzy loops, etc. These constructs are used for designing fuzzy algorithms for given fuzzy problems.

1. BEGIN initial
   END terminal
2. input variables
   output variables
3. read fuzzy variables
   write fuzzy variables
4. fuzzy statement
   fuzzy variables \( \leftarrow \) fuzzy expressions
   Where
   fuzzy expression \( \leftarrow \) fuzzy expression/fuzzy variable
   For instance
   \( \text{Big} \leftarrow \text{Height and weight} \)
5. fuzzy conditions
   If fuzzy condition then fuzzy statement
   For instance
   If \( x \) is \( A \) then \( y \) is \( B \)
   If \( x \) is \( A \) then \( y \) is \( B \) else \( y \) is \( C \)
6. fuzzy loop
   \( \text{for}(i=1; i<=10; i++) \)
   \( R_i(x) = \text{if } x_i \text{ is } A_i \text{ then } x_i \text{ is } B_i \)
   where \( A_i \) and \( B_i \) fuzzy sets and \( x \epsilon X \) and \( R_i(x) \) are fuzzy statements.
   For instance
   \( \text{for}(i=1; i<=10; i++) \)
   \( \mu_{\text{YOUNG}}(x_i) = [1 + ((x_i-25)/25)^2]^{-1} \)
7. fuzzy while .. do..
   while fuzzy condition do fuzzy statement
   For example
   While taste < satisfaction do pour some salt into dish
8. fuzzy repeat ... until ...
repeat fuzzy expression until condition
For instance
Repeat turn left, turn right until restaurant
9. return fuzzy expression
For instance
return A, where A is fuzzy variable.
10. label :fuzzy statement
    GO TO label

4. EXAMPLE
4.1 Example 1
Consider the following fuzzy problem to design fuzzy algorithms using FUZZYALGOL.
“go about 100 meters and turn right at the circle, go about 50 meters, turn left and right until restaurant, then you could find school after about a few minutes walk”.
“What is fuzziness to reach the School.”
The procedure of fuzzy algorithm may be described using FUAL as follows
Procedure: fuzzy algorithm to find School
Fuzzy variable: about 100 meters
          about 50 meters
                 right
                 left
                 few minutes
BEGIN
  go about 100 meters
  turn right at the circle
  go about 50 meters
repeat
  turn left
  turn right
until restaurant
  go about few minutes walk
END

The fuzzy instruction like “go about 100 meters” has to be transformed into precise form. The instructions for “about 100 meters” may be defined as “$l00-2$ meters”, “$l00-1$ metres”, “$100$ meters”, “$100+1$ meters”, “$100+2$ meters” and the fuzzy set is assigned grades between $[0, 1]$.
About $l00$ meters = \{ 0.4/$l00$-2, 0.5/$l00$-1, 0.7/$l00$, 0.5/$l00$+1 ,0.4/$l00$+2 \}
The highest grade is selected using the Projection operator for precise instruction.
Projection :
\[
\mu_{\text{Proj}}(x) = \max \{ \mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + \cdots + \mu_A(x_n)/x_n \}
\]
About $l00$ meters = \{ 0.7/$l00$ \}
The execution of fuzzy instruction selects 100 meters with fuzziness 0.7 for “about 100 meters”.

Quasi-fuzzy instruction:
A Quasi-fuzzy instruction is just machine instruction if a single machine instruction is available. For instance, “turn left” and “turn right”. If more than one machine instruction is available for a quasi-fuzzy instruction, then the program selects for an instruction with highest grade membership.

The execution of fuzzy instruction selects 1 for “turn left”.

The following procedure will find the solution. Using FUZZALGOL

BEGIN
    go t about 100 meters {0.7 }
About 100 meters= { 0.4/100-2, 0.5/100-1, 0.7/100, 0.5/100+1 ,0.4/100+2 }
    turn right at the circle {1.0 }
    go about 50 meters { 0.6 }
About 50 meters= { 0.4/50-2, 0.5/50-1, 0.6/50, 0.5/50+1 ,0.4/50+2 }
    repeat
        turn left {1.0 }
        turn right (1.0 )
    until restaurant { 1.0 }
    restaurant = { 0.0, 1.0 }
    go about few minutes walk { 0.7 }
few minutes = { .2/10 + .4/6 + 0.6/4 + 0.7 }
    may find School = min { 0.7, , 1.0, 0.6, 1.0, 0.7 }
        = { 0.6 }
END

“0.6 is fuzziness to reach the School.”.

4.2 Example 2
Consider another example[22]
Robert leaves office between 5:15pm and 5:45pm. When the time of departure is about 5:20pm, the travel time is usually about 20min; when the time of departure is about 5:30pm, the travel time is usually about 30min; when the time of departure is about 5:40pm, the travel time is about 20min. usually Robert leaves office at about 5:30pm
What is the probability that Robert is home at about t pm?
The above problem can be solved using FUZZALGOL.

5. Conclusion
Fuzzy algorithms are used to solve inexact, imprecise and incomplete problems. These algorithms are single fuzzy statements. fuzzy algorithmic language (FUZZALGOL) is studied to design the fuzzy algorithms for inexact, imprecise and incomplete problems. Examples are given these problem solutions are designed using FUZZALGOL. The execution procedure also discussed. for further fuzzy programming. The compiler is to be designed for FUZYALGOL. The fuzzy problems can be programmed by transforming FUZZALGOL into conventional algorithms.
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