FUZZYALGOL: Fuzzy Algorithmic Language for designing Fuzzy Algorithms

Venkata Subba Reddy Poli

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P. Venkata Subba Reddy
Department of Computer Science and Engineering, College of Engineering, Sri Venkateswara University, Tirupathi-517502, India.

Abstract

The imprecise, crisp, inexact, inconsistent and incomplete problems are fall under fuzzy problems. These fuzzy problems are soled using fuzzy algorithms, fuzzy programsand 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.

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

$$A = \mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + \ldots\ldots\ldots\ldots + \mu A(x_n)/x_n$$

where '+' is union

Suppose X is having individuals x_1, x_2, x_3, x_4, x_5 the fuzzy subset SMALL for small, takes values in the unit interval [0, 1] and it may be represented as

$$SMALL=0.1/x_1+0.5/x_2+0.3/x_3+0.7/x_4+1/x_5$$

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.

YOUNG may be defined as

$$YOUNG= \mu_{YOUNG}(x)/X=\mu(x)=1 \qquad \text{if } x \in [0, 25]$$
$$\mu_{YOUNG}(x) = [1+((x-25)/25)^2]^{-1} \qquad \text{if } x \in [25,100]$$

The combination of fuzzy sets are given below

Let A,B,C be three fuzzy subsets, μ_A, μ_B, μ_C, the membership functions for fuzzy subsets A,B and C respectively.

$A \vee B=\max(\mu_A(x), \mu_B(x))/x$ (disjunction)

$A \wedge B=\min(\mu_A(x), \mu_B(x))/x$ (conjunction)

$\neg A=1-\mu_A(x)/x$ (negation)

$A \rightarrow B= \min(1,1-\mu_A(x)+ \mu_B(x))/x$ (implication)

. $A \times B =\min(\mu_A(x), \mu_B(y))/(x,y)$ (relation)

$\mu_{Proj\ A}(x) = \max \{\mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + ..+\mu A(x_n)/x_n\}$

                     (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

$\mu_{very\ young}(x) = \mu_{YOUNG}(x)^2$

$\mu_{not\ very\ young}(x) = 1-\mu_{YOUNG}(x)^2$

$\mu_{more\ or\ less\ old}(x) = \mu_{old}(X)^{1/2}$

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   R2: x is A

    x and y are B   x or y is B

   —————————   —————————

    y is $A \wedge B$ y is $A \vee B$

R3: x and y are A   R4: x or y are A

    y and z are B   y or z are B

   —————————   —————————

    y and z are B   x or z are B

R5: x is A

    if x is A then y is B

   —————————

    y is A o $(A \rightarrow B)$

R6: f_1

    f_2

     .

     .

$$\overline{f_1 \ o \ f_2 \ o \ \dots \ o \ f_n} = \min \{ \ f_1, f_2, .., f_n \ \}$$

where $f_1, f_2, .., f_n$ 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
        Big $\leftarrow$ 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
 for(i=1;i<=10;i++)
$R_i(x)$=if x_i is A_i then x_i is B_i
  where A_i and B_i fuzzy sets and $x \in X$ and $R_i(x)$ are fuzzy statements.
  For instance
for(i=1;i<=10;i++)
    $\mu_{YOUNG}(x_i) = [1 + ((x_i-25)/25)^2]^{-1}$
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 l00 meters" has to be transformed into precise form. The instructions for " about l00 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= { 0.4/100-2, 0.5/100-1, 0.7/100, 0.5/100+1 ,0.4/100+2 }
　　The highest grade is selected using the Projection operator for precise instruction.
Projection :
$\mu_{Proj\ A}(x) = \max\ \{\mu_A(x_1)/x_1+$
　　　　　　　$\mu_A(x_2)/\ x_2+………………+\mu A(x_n)/x_{n}\}$
　　About l00 meters= { 0.7/l00 }
　The execution of fuzzy instruction selects 100 meters with fuzziness 0.7 for "about l00 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 l00 meters= { 0.4/l00-2, 0.5/l00-1, 0.7/l00, 0.5/l00+1 ,0.4/l00+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 anther 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 FUZZYALGOL.

5. Conclusion
Fuzzy algorithms are used to solve inexact, imprecise and incomplete problems. These algorithms are single fuzzy statements. fuzzy algorithmic language (FUZZYALGOL) is studied to design the fuzzy algorithms for inexact, imprecise and incomplete problems. Examples are gven these problem solutions are designed using FUZZYALGOL. 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 FUZZYALGOL into conventional algorithms.

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