EasyChair Preprint

№ 11774

Fuzzy Robotics and Fuzzy Algorithms

Poli Venkatasubba Reddy

January 15, 2024

Fuzzy Robotics and Fuzzy Algorithms

Poli Venkats Subba Reddy
Computer Science and Engineering
Sri Venkateswara University
College of Engineering
Tirupati-517502, India
Email:vsrpoli@hotmail.com

***Abstract*— Robotics handles the problem with complete information. Sometimes Robotics has to handle with incomplete information. The incomplete information is fuzzy. Fuzzy algorithms may be used for Robotics to handle incomplete information. In this paper, fuzzy Algorithmic Language is discussed. Fuzzy algorithms are discussed for Robotics to handle incomplete information. Some examples are discussed.**

Keywords—fuzzy logic, fuzzy robotics, fuzzy algorithm, mean-ends analysis

I. INTRODUCTION

Robotics is area of Artificial Ontelligence. Robots play important role in problem solving ranging from Indutrial manufacturing to participating in war. There are many incomplete problems by Robots in the real world. The problems include manufacturing car, driving a car, parking a car, cooking a meal etc. encounters some of the inexact problems in the real world. For instance, "go about 100 meters until the circle and turn right, and go about 50 meters until find restaurant". These problems usually fall under the category of incomplete problems and fall under fuzzy problems. The fuzzy algorithmic language is used to solve such problems. Robotics acts as humans to solve some problems.

Zadeh [15] introduced fuzzy set theory to deal with incomplete information. Zadeh [18] discussed calculus of fuzzy restrictions to compute fuzzy statements. Chang [2] discussed fuzzy programs. Reddy [11] discussed fuzzy algorithmic language for fuzzy problems.

II. ROBOTICS

Robots have some kind of mechanical construction, a frame, form or shape designed to achieve a particular task. For example, a robot designed to travel across. The mechanical aspect is completing the assigned task and dealing with the physics of the environment around it. .

a. Robotic sensing

Sensors allow robots to receive information about a certain measurement of the environment. This is essential for robots to perform their tasks, and act upon any changes in the environment to calculate the appropriate response.

b. Touch

Robotics has developed a tactile sensor array that mimics the mechanical properties. The artificial touches the forces received.

c. Vision

In most practical computer vision applications, the Robotics are pre-programmed to solve a particular task, Computer vision systems rely on image sensors which detected. . The sensors are designed using solid-state physics.

II. FUZZY LOGIC

Zadeh [21] has introduced fuzzy set as a model to deal with imprecise, inconsistent and inexact, vague and incomplete information. The fuzzy set is a class of objects with a continuum of grades of membership.

The fuzzy set A of X is characterized as its membership function $A = \mu_A(x)$ and ranging values in the unit interval [0, 1]

$\mu_A(x)$: $X \rightarrow [0, 1]$, $x \in X$, where X is Universe of discourse.

$A = \mu_A(x_1)/x_1 + \mu_A(x_2)/x_2 + \ldots + \mu_A(x_n)/x_n$, "+" is union

For instance, the fuzzy proposition "go 100 meters"

go100meters=0.4/50+0.5/60+0.7/75+0.8/90+1/100

The Graphical representation is shown in fig1.

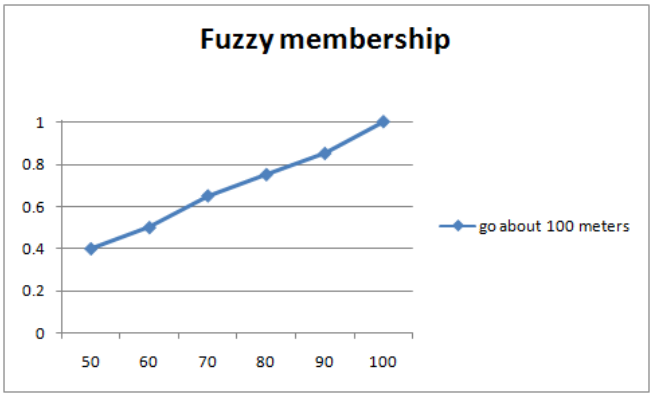

Fig.1. Fuzzy Membership Function

The fuzzy logic [17,20] is as combination of fuzzy sets using logical operators. Some of the logical operations are given below

Let A, B and C be the fuzzy sets. The operations on fuzzy sets are given as

Negation

If x is not A

$A' = 1 - \mu_A(x)/x$

Conjunction

x is A and y is B $\rightarrow$ (x, y) is A x B

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

If x=y

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

Disjunction

x is A or y is B $\rightarrow$ (x, y) is A' x B'

$A' \times B' = \max(\mu_A(x), \mu_B(y))(x,y)$

If x=y

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

Implication

if x is A then y is B

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

Composition

A o R= min $_x$ $\{\mu_A(x), \mu_R(y)\}/(x,y)$, where R=A→B

A o R==min$\{\mu_A(x), \mu_R(x,y)\}/y$

If x = y

A o R==min$\{\mu_A(x), \mu_R(x)\}/x$

The fuzzy propositions may contain quantifiers like "very", "usually" (concentration) , "more or less" , "unlikely" (diffusion}. These fuzzy quantifiers may be eliminated as

Concentration

$\mu_{very\ A}(x) = \mu_A(x)^2$

Diffusion

$\mu_{more\ or\ less\ A}(x) = \mu_A(x)^{0.5}$

Generalized Constraint

The Generalized Constraint Language[15] is used to deal the fuzzy propositions like "tallest builds City"

"most tallest buildings City" = Σcount(tall-buildings.City/City) is most

Σcount(A/B)=$\Sigma_i\ \mu_i * v_i/\Sigma_i v_i$, where conjunction "*" may be taken "min" as t-norm[4].

For instance most=0.6 and count =0.65

"most tallest buildings City=min{0.6,0.65}=0.6

III. FUZZY ALGORITHMIC LANGUAGE

The fuzzy algorithms are used to solve the fuzzy problems[7,18]. The fuzzy algorithmic language is discussed for designing efficient fuzzy algorithms for incomplete information [11]. The Fuzzy Algorithmic Language is defined as sequence of fuzzy statements.

The fuzzy algorithmic language is to design the fuzzy algorithms for fuzzy problems. The fuzzy algorithm language(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 fuzzy variables
   output fuzzy variables

for instance

fuzzy variable ←best

3. read fuzzy variables
   write fuzzy variables
4. fuzzy statement
   fuzzy variables ← fuzzy expressions
   fuzzy expression→ fuzzy expression/fuzzy variable

For instance

Big ←Height and weight

5. fuzzy conditions
   if fuzzy variables(and/or) then fuzzy variable

For instance

if x is A then y is B

if x is A or x is B and x is C then x is D

if x is A then y is B else y is C

For instance

If fan is low voltage then fan is low speed

6. fuzzy for loop
   for i←1 to about 10
   $R_i(x)$=if x_i is A_i then x_i is B_i

where A_i and B_i are fuzzy sets and, x∈X Universe of discourse, and $R_i(x)$ is fuzzy condition.

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 fuzzy expression

For instance

repeat turn right until find restaurant

9. return fuzzy expression/variable

For instance

return best

where best is fuzzy variable.

Projection

Proj A = max$\{\mu_A(x_1)/x_1 , \mu_A(x_2)/x_2 , \ldots , \mu_A(x_n)/x_n\}$

The fuzzy instruction like "go about l00 meters" has to transform into precise form. The fuzzy instructions for " about l00 meters" may be defined as

About l00 meters= { 0.4/80, 0.7/90, 0.9/l00, 0.7/l10 ,0.4/l20}

The highest grade is selected using the Projection operator for precise instruction.

Proj about l00 meters= { 0.9/l00 }

The execution of fuzzy instruction selects 100 meters with fuzziness 0.9.

Some tomes Center of Gravity(COG) may be used for defuzzification.

Quasi-fuzzy instructions

A Quasi-fuzzy instruction is just machine instruction if a single machine instruction is available[17].

The quasi-fuzzy instruction is fuzzy instruction is defined as

$\mu_A(x)$→(0 or 1) , where A is quasi-fuzzy set

For instance, "turn right". If turn right" is 1 otherwise 0.

Time complexity

The time complexity for fuzzy algorithm is given by

Θ(g(n))

t_n >=cg(n), where t_n is time taken for input n, c is constant and g(n) is function of n.

For linear fuzzy programming problem, the complexity is given by

programming + projection of fuzzy instructions

O(n)+kO(n)=(k+1)O(n) ϵ Θ(n)

Example

Consider General 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". "you will reach School.". This is fuzzy programming problem.

The procedure of fuzzy algorithm may be described as follows

Fuzzy algorithm: fuzzy algorithm to find/ programming School

BEGIN

Fuzzy variable: about 100 meters, right, left, few minutes

about 50 meters(0.9 by projection) =0.2/20+0.4/30+0.6/40+0.9/50+0.6/60)

right(1.0)

left(1.0)

few minutes(0.9 by projection)=(0.8/5+0.7/10/0.6/20/0.5/40)

go about 100 meters(0.9 by projection)=(0.6/60+0.7/70+0.8/80+0.9/90)

turn right at the circle(1.0)

go about 50 meters(0.9 by projection) =0.6/20+0.7/30+0.8/40+0.9/50)

repeat

turn left(1.0)

turn right(1.0)

until restaurant(1.0 if restaurant found)

go about few minutes' walk(0.9 by projection)=(0.8/5+0.7/10/0.6/20/0.5/40)

until School found(1.0)

END

Where turn left and turn right are Quasi-fuzzy instructions.

Example

Consider the real world fuzzy problem. The local information is given to find/ programming venue at NTUST, Taipei. "From International Airport, get Bus Ticket go to Tanyoan HSR, From HSR go to Taipei MRT, From MST there are two ways one is Xindian and other Nanshjian, take Xindian to go to Gonggan station and From Gagguan MRT Take Left and go about 4 minutes until reach NTUST.

The following procedure will find the solution. using FUZZALGOL

BEGIN

From Airport go to Tanyoan HSR {1.0{

go to Taipei MRT{1.0}

go to Gonggan station{1.0 by selection}={1 if Xindian, 0 Nanshjian}

From Gagguan MRT take left{1.0}

go about 4 minutes {0.9by projection}={ 0.6/1+0.7/2+0.8/3+0.9/4)

until reach NTUST { 1.0 }

END

Where "take left" is Quasi-fuzzy instruction.

IV. FUZZY MEAN-ENDS ANALYSIS

Intelligent behavior as studied in AI is *goal-based* problem solving, a framework in which the solution to a problem can be described by finding a sequence of *actions* that lead to a desirable goal. A goal-seeking system is supposed to be connected to its outside environment . Search is the process of discovery of sequences of actions that will lead from a given state to a desired state [4], The process of mean-ends analysis is that there are many operations in between starting sate to goal state.

Fuzzy mean-ends analysis process is detection of differences between current state and goal state. For instance driving a car with Robotics has starting point to goal point. The process is mean-ends analysis. The mean – ends analysis need algorithms. The fuzzy algorithms are need for incomplete information.

	carry	Pick up	Push down	place
Move object	V			
Move robot				
Clear object		V		
Get arm empty			V	
Get object on object		V	V	V
Hold object		V		

Consider General fuzzy problem to design fuzzy algorithms for Robotics

The Robot has to pick up the object and carry the object until find another object and place on another object properly. PICK-UP(obj)

CARRY(obj,1)

PUSH-DOWN(obj)

PLACE(obj, 1)

GO(distance)

Consider example of driving the car

PUSH(clutch.1)^PUSH(gear,1)

PUSH(accelator,1)^RELEASE(gear,1)

GO(distance,06)

PSSH(break,0.6)

TURN(right,0.2)

GO(distace,0.8)

PUSH(BREAK,1) N

STOP

".

ACKNOWLEDGMENT

The author thanks Conference chair for accepting this paper.

REFERENCES

[1] B. Bouchon-Meunier, R.R. Yager, L.A. Zadeh (eds), Uncertainty in Intelligent and Information Systems, Advances in Fuzzy Systems—

Applications and Theory, World Scientific, Singapore, 2000.
[2] C.L. Chang, " Implementation and Execution of fuzzy programs " ,in fuzzy sets and their applications to cognitive and decision processes, L.A. Zadeh , King-Sun FU , Kokichi Tanaka, Masamichi Shimura, Eds.: (New York, Academic press, pp.191-218,1975.
[3] Daniel Sánchez Alvarez and Antonio F. Gómez Skarmeta , "A fuzzy Language", fuzzy Sets and Systems, vol.141, no.3, pp.335-390, 2004.
[4] Elaine Rich, Artificial Intelligence, McGra-Hill, 1983.
[5] W. Pedrycz and F. Gomide, Introduction to fuzzy Sets, Cambridge, MIT, 1998.
[6] N. Rescher, Many-Valued Logic, McGrow-Hill, New York, 1969.
[7] Sánchez Alvarez Daniel and Antonio F. Gómez Skarmeta , "A fuzzy Language" fuzzy Sets and Systems, vol.141, issue 3, ,pp. 335-390,2004.
[8] E. Santos , " fuzzy algorithms", Information and Control , vol.17, 1970.
[9] H.A. Simon , " The structure of ill structured problems" , Artificial Intelligence ,vol. 4,pp.181-201,1973.
[10] B. Siciliano and O. Khatib, Springer Handbooks of Robotics, Spronger, 2008.
[11] P. Venkata Subba Reddy, " FUZZYALGOL: Fuzzy Algorithmic Language for Design Fuzzy Algorithms", International Journal of Computer Science and Engineering, vol.2, issue2,2010.
[12] P. Venkata Subba reddy "Fuzzy Conditional Inference for Mediagnosis", Second International Conference on Fuzzy Theory and Technology, Proceedings, Abstract and Summaries of FT&T1993, University of North-Carolina, Duke University, October 13-16, USA, pp.193-195,1993.
[13] P. Venkata Subba Reddy, "Generalization of Fuzzy Sets Type-2, Fuzzy Quantifiers Sets , α-Cut Fuzzy Sets Fuzzy Temporal Sets, Fuzzy Granular Sets and Fuzzy rough Sets for Incomplete Information", Proceedings of International Conference on Fuzzy Sets and Its Applications, iFUZZY 014, November 26-28, 2014, Kaohsung,Taiwan.
[14] L.A.Zadeh, A New Direction in AI-Towards Computional Theory of Perceptions,AI Magzine,vol.22, issue 1, pp.73-84, 2001.
[15] L. A Zadeh, "Calculus of Fuzzy Restrictions", In Fuzzy Sets and their Applications to Cognitive and Decision Processes, L. A. Zadeh, King-Sun FU, Kokichi Tanaka and Masamich Shimura (Eds.), Academic Press, New York, ,pp.1-40,1975.
[16] L.A.Zadeh , "fuzzy Algorithms" ,Information and Control , vol.12,pp.94-104, 1968.
[17] L.A.Zadeh , "fuzzy Logic" , IEEE Computer , pp.83- 92,1988.
[18] L.A. Zadeh, fuzzy sets, In Control, vol.8,338- 353,1965.
L.A. Zadeh, Precipitated Natural Language (PNL), AI Magazine, vol.25, issue 3,pp.74-91,2004