EasyChair Preprint

№ 3533

# Fuzzy Conditional Inference on Fuzzy Constructs: An Application to Data Analytics

Venkata Subba Reddy Poli



June 2, 2020

# Fuzzy Conditional Inference on Fuzzy Constructs An Application to Data Analytics

Poli Venkata Subba Reddy

**Abstract**

We consider fuzzy inference of the form "if $\cdots$ then $\cdots$ else $\cdots$ "and "and/or ". We developed logical constructs based on logical intuitions developed by Fukami. With the propose method of fuzzy inference and causal logic , we apply on logical constructs. We try to show the fuzzy inference satisfy all intuitions under several criteria.

*Keywords:* fuzzy logic, fuzzy conditional inference, fuzzy intuitions, Complicated

sectionIntroduction Zadeh [7] and Mamdani [1] proposed the fuzzy conditional inference methods. Mizumoto [2] developed logical constructs and proved that Zadeh and Mamdani fuzzy conditional inference is not fit for intuitions. Mizumoto adapted the Godel definition and Standard sequence methods to prove some fuzzy intuitions. In the following, we developed logical constructs based on logical constructs developed by Muzumoto. We shown the our fuzzy inference method satisfy all the intuitions under several criteria. The fuzzy intuitions are studied for "and/or "and "if $\cdots$ then $\cdots$ else $\cdots$ ".

**Type-1**
If $x$ is $P$ and $x$ is $Q$ or $x$ is $R$ then $y$ is $S$
$x$ is $P_1$ and $x$ is $Q_1$ or $x$ is $R_1$

---

$y$ is ?

If $x$ is Supply or $x$ is Demand and $x$ is Price then $x$ is increase Profit
$x$ is more Supply or $x$ is very Demand and $x$ is more Price

---

$y$ is ?

**Type-2**
Consider fuzzy inference

If $x$ is $P$ then $y$ is $Q$ else $y$ is $R$
$x$ is $P_1$

---

$y$ is ?

If $x$ is Demand then $x$ is Profit else $x$ is Loss
$x$ is very Demand

---

$y$ is ?

## 1. Some Methods of Fuzzy Conditional Inference

The fuzzy conditional propositions of the form "if (precedent part) then (consequent part)".

Mamdani [5] fuzzy conditional inference given as $A \rightarrow B == \{A \times B\}$.
if $x_1$ is $A_1$ and $x_2$ is $A_2 \cdots x_n$ is $A_n$, then y is $B$
$=\min\{\min(A_1, A_2, \cdots, A_n), B\}$

The consequent part is derived from precedent part for fuzzy conditional inference [5].
if $x$ is $A$ then $y$ is $B$= $A$
$B$= $A$ is $B \subseteq A$ and $A \subseteq B$ (2.1)
if $x_1$ is $A_1$ and $x_2$ is $A_2 \cdots x_n$ is $A_n$ then y is $B$=$x_1$ is $A_1$ and $x_2$ is $A_2 \cdots x_n$ is $A_n$

The fuzzy conditional inference is given by using Mamdani fuzzy conditional inference
if x is A then y is B= $\{A \times B\}$
if $x_1$ is $A_1$ and $x_2$ is $A_2$ and $\cdots$ and $x_n$ is $A_n$ then $y$ is $B$
$=\{(A_1$ and $A_2$ and $\cdots$ and $A_n) \times (A_1$ and $A_2$ and $\cdots$ and $A_n)\}$
$= \min\{A_1, A_2, \cdots, A_n, B\}$

The fuzzy conditional inference is give as [5]

if $x_1$ is $A_1$ and $x_2$ is $A_2$ and $\cdots$ and $x_n$ is $A_n$ then $y$ is $B$=$\{\min(A_1, A_2, \cdots, A_n)\}$

if $x$ is $A$ then $y$ is $B$= $\{A\}$ (2.2)

## 2. Fuzzy Inference on Fuzzy Intuitions

Consider the causal logical inference [11]

**Modus Pones**

$P \rightarrow q$

P

——

q

**Modus Tollens**

$p \rightarrow q$

q'

——

P'

**Generalization**

$p \vee q = p$

$p \vee q = q$

**Specialization**

$p \wedge q = p$

$p \wedge q = q$

**Fuzzy plausibility**

Plausibility theory will perform inconsistent information into consistent.

**Generalization**

$p\vee$ q, $\mu$ =p, $\mu$

$p\vee$ q, $\mu$ = q, $\mu$

**Specialization**

$p\wedge$ q , $\mu$=p, $\mu$

$p\wedge$ q = q, $\mu$

The inference is given using generalization and specialization $p \wedge q \vee r, \mu = p, \mu$

$p \wedge q \vee r, \mu = q, \mu$

$p \wedge q \vee r, \mu = r, \mu$

Consider fuzzy inference Type-1

The fuzzy inference is given for Type-1 using generalization and specialization

If $x$ is $P$ then $y$ is $S$
$x$ is $P_1$
---
$y$ is $S_1$

If $x$ is $Q$ then $y$ is $S$
$x$ is $Q_1$
---
$y$ is $S_1$

If $x$ is $R$ then $y$ is $S$
$x$ is $R_1$
---
$y$ is $S_1$

Confider fuzzy inference Type-2

The fuzzy inference is given for Type-2 using generalization and specialization

If $x$ is $P$ then $y$ is $Q$
$x$ is $P_1$
---
$y$ is $Q_1$

If $x$ is $P'$ then $y$ is $R$
$x$ is $P_1$
---
$y$ is $R_1$

From fuzzy conditional inference Type-1 and Type-2, the two criterions may be given as

**Criteria-1**

if $x$ is $P$ then $y$ is $S$

$x$ is $P_1$

---

$y$ is
textit$S_1$
**Criteria-2**
if $x$ is $P$' then $y$ is $R$
$x$ is $P_1'$

---

$y$ is $R_1$

## 3. Fuzzy Intuitions using New Fuzzy Inference

The fuzzy intuitions are give for Criteria-1.

Table 1: Fuzzy inference for Criteria-1

| Intuition | Proposition | Inference |
|---|---|---|
| I-1 | $x$ is $P$ | y is $S$ |
| I-2 | $y$ is $S$ | x is $P$ |
| II-1 | $x$ is very $P$ | y is very $S$ |
| II-2 | $y$ is very $S$ | x is very $P$ |
| III-1 | $x$ is more or less $P$ | y is more or less $S$ |
| III-2 | $y$ is More or less $S$ | is more or less $P$ |
| IV-1 | $x$ is not $P$ | y is not $S$ |
| IV-2 | $y$ is not $S$ | x is not $P$ |

The fuzzy intuitions are give for Criteria-2.

Table 2: Fuzzy inference for Criteria-2

| Intuition | Proposition | Inference |
|---|---|---|
| I'-1 | $x$ is $P'$ | y is $R$ |
| I'-2 | $y$ is $R'$ | x is $P'$ |
| II'-1 | $x$ is very $P'$ | y is very $R$ |
| II'-2 | $y$ is very $R$ | x is very $P'$ |
| III'-1 | $x$ is more or less $P'$ | y is more or less $R$ |
| III'-2 | $y$ is More or less $R$ | is more or less $P'$ |
| IV'-1 | $x$ is not $P'$ | y is not $R$ |
| IV'-2 | $y$ is not $R$ | x is not $P'$ |

If $x$ is $P$ and $x$ is $Q$ or $x$ is $R$ then $y$ is $S$
$x$ is $P_1$ and $x$ is $Q_1$ or $x$ is $R_1$

---

$y$ is $S_1$

The inference is given using generalization and specialization
If $x$ is $P$ then $y$ is $S$
$x$ is $P_1$

---

$y$ is $S_1$

If $x$ is $Q$ then $y$ is $S$
$x$ is $Q_1$

---

$y$ is $S_1$

If $x$ is $R$ then $y$ is $S$
$x$ is $R_1$

---

$y$ is $S_1$

Fuzzy conditional inference may be given by combining inferences using Criteria-1

Consider fuzzy conditional inference Type-2

If $x$ is $P$ then $y$ is $Q$ else $y$ is $R$
$x$ is $P_1$

---

$y$ is $R_1$

If $x$ is $P$ then $y$ is $Q$ else $y$ is $R$ may be given by [4]
$(if x is P then y is Q) \vee (if x is P' then x is R)$
$x$ is $P_1$

---

$y$ is $R_1$

If $x$ is $P$ then $y$ is $Q$

$x$ is $P_1$

---

$y$ is $R_1$

Fuzzy conditional inference may be given as Criteria-1

If $x$ is $P'$ then $y$ is $R$
$x$ is $P_1$

---

$y$ is $R_1$

Fuzzy conditional inference may be given using criteria-1 or Criteria-2

## 4. Application to Fuzzy Intuitions

The Business intelligence needs reasoning. The Business data is defied with fuzziness with linguistic variables.

If $x$ is *Demand* then $y$ is *Profit*
$x$ is $P_1$

---

$y$ is $R_1$

Consider the fuzzy data sets for production The fuzzy conditional infer-

Table 3: Fuzzy data set Demand

| Item No. | Demand |
|---|---|
| Item1 | 0.3 |
| Item2 | 0.5 |
| Item3 | 0.7 |
| Item4 | 0.8 |
| Item5 | 1.0 |

ence using is given by

if x is Demand then x is Profit

The fuzzy conditional inference using (3.1) given by The fuzzy conditional inference for Criteria-1 is given by

Table 4: Fuzzy data set Profit

| Item No. | Profit |
|---|---|
| Item1 | 0.3 |
| Item2 | 0.5 |
| Item3 | 0.7 |
| Item4 | 0.8 |
| Item5 | 1.0 |

Table 5: Fuzzy conditional inference

| Item No. | I-1 | I-2 | II-1 | II-2 | III-1 | III-2 | IV-1 | IV-2 |
|---|---|---|---|---|---|---|---|---|
| Item1 | 0.3 | 0.3 | 0.09 | 0.09 | 0.55 | 0.55 | 0.7 | 0.7 |
| Item2 | 0.5 | 0.5 | 0.25 | 0.25 | 0.71 | 0.71 | 0.5 | 0.5 |
| Item3 | 0.7 | 0.7 | 0.49 | 0.49 | 0.84 | 0.84 | 0.3 | 0.3 |
| Item4 | 0.8 | 0.8 | 0.64 | 0.64 | 0.89 | 0.89 | 0.2 | 0.2 |
| Item5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 |

If $x$ is *not Demand* then $y$ is *Loss*
$x$ is $P_1$

---

$y$ is $R_1$

The fuzzy conditional inference using is given by
if x is not Demand then x is Loss
The fuzzy conditional inference using (3.1) given by The fuzzy conditional

Table 6: Fuzzy data set Loss

| Item No. | Loss |
|---|---|
| Item1 | 0.7 |
| Item2 | 0.5 |
| Item3 | 0.3 |
| Item4 | 0.2 |
| Item5 | 0.0 |

inference for Criteria-2 is given by

Table 7: Fuzzy conditional inference

| Item No. | I'-1 | I'-2 | II'-1 | II'-2 | III'-1 | III'-2 | IV'-1 | IV'-2 |
|---|---|---|---|---|---|---|---|---|
| Item1 | 0.7 | 0.7 | 0.49 | 0.49 | 0.84 | 0.84 | 0.7 | 0.7 |
| Item2 | 0.5 | 0.5 | 0.25 | 0.25 | 0.71 | 0.71 | 0.5 | 0.5 |
| Item3 | 0.3 | 0.3 | 0.09 | 0.09 | 0.84 | 0.84 | 0.3 | 0.3 |
| Item4 | 0.2 | 0.2 | 0.04 | 0.04 | 0.55 | 0.55 | 0.3 | 0.3 |
| Item5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 |

## References


[1] E.H.Mamdani,Application of Fuzzy Logic to Approximate Reasoning Using Linguistic Synthesis. IEEE Trans. Computers. vol.26, no.12, pp.1182-1191, 1977.

[2] S. Fukami, M. Muzumoto,K. Tanaka, Some Considerationas on Fuzzy Conditional Inference, Fuzzy Seta and Systems, vol.4, pp.243-273, 1980.

[3] C. Howson, Successful Business Intelligence, McGraw-Hill, 2014.

[4] N. Rescher, Many-valued Logic, McGrow-Hill, New York, 1969.

[5] M.Sugeno and G.T Kong "Fuzzy Modeling and Control of Multilayer Incinerator", Journal of Fuzzy Sets Systems,vol.18,no.3,pp.329-345 ,1986.

[6] T. Takagi and M.Sugeno, "Fuzzy Identification of Systems and Its application to Modeling and control", IEEE Transactions on Systems Man and Cybernetics. vol.15,no.1, pp.116-132.-13, 1985.

[7] Poli Venkata Subba Reddy, M. Syam Babu, Some methods of reasoning for conditional propositions, Fuzzy Sets and Systems, vol.52, no.3, pp.229-250, 1992.

[8] Poli Venkata Subba Reddy, Fuzzy conditional inference for medical diagnosis, Proceedings, Second International Conference on Fuzzy Theory and Technology, Durham, FT&T'93, vol.3, pp.193-195, 1993.

[9] Poli Venkata subba reddy, Fuzzy logic based on Belief and Disbelief membership functions, Fuzzy Information and Engineering, Vol.9, no.4, pp.405-422, 2017.

[10] L. A Zadeh, "Calculus of fuzzy Restrictions", In Fuzzy set s 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.

[11] L.A. Zadeh, Fuzzy sets. Information and Control, vol.8, pp.338-353., 1965.

[12] A. Bochman, A logic for causal reasoning,Proceedings IJCAI2003,Morgan Kaufmann,2003.