

Computational Intelligence (CI)

Introduction to Fuzzy set

Dr. Dayal Kumar Behera

School of Computer Engineering
KIIT Deemed to be University, Bhubaneswar, India

Uncertainty: *lack of sureness*. It refers to epistemic situations involving imperfect or unknown information. Uncertainty arises in partially observable or stochastic environments, as well as due to ignorance, indolence, or both.

What will happen next, this is an example of uncertainty.
Outcome of tossing a coin – head or tail (not sure/doubt)

Vagueness: *lack of clarity* (vagueness is associated with the difficulty of making sharp or precise distinctions or the boundaries of a word's meaning are not well defined)

Is hot? Vague as there is no particular temp that represents hot.
Tall? Vague as there is no well defined boundary that represents tall

Ambiguity: *more than one interpretation/inexactness* (exists when a term can reasonably be interpreted in more than one way)

Bank – can refer to a financial institution or riverside

What is Fuzzy?

- Dictionary meaning of Fuzzy is **not clear** or **vague**

Example:

- Is the picture always fuzzy on your TV?
- Ravan's head is little fuzzy (= he cannot think clearly)

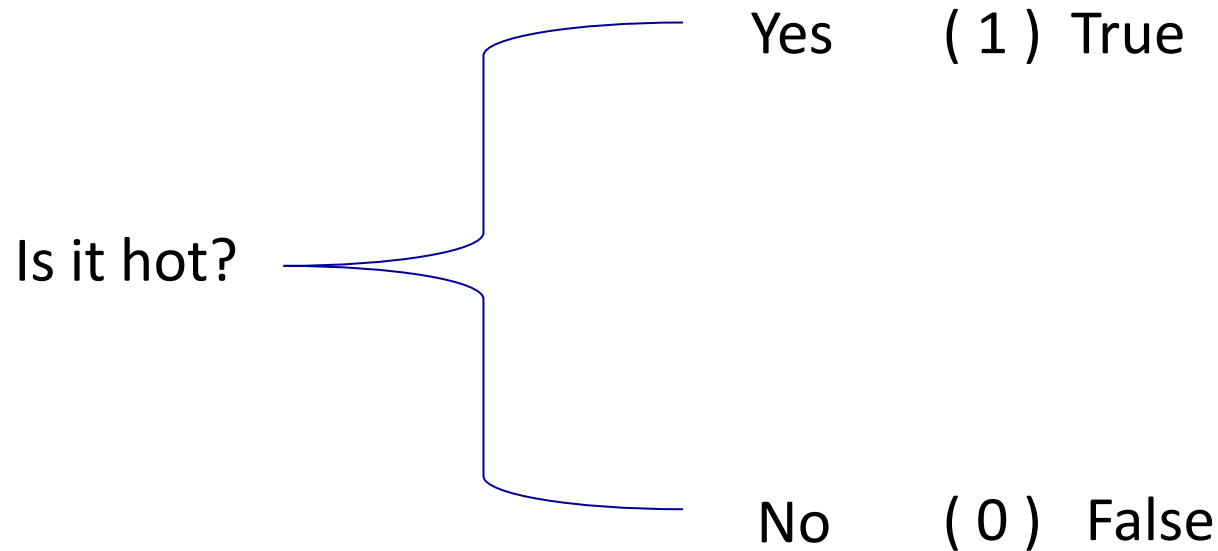
- Antonym of fuzzy is **crisp**.

Example:

- Is the picture quality crisp?

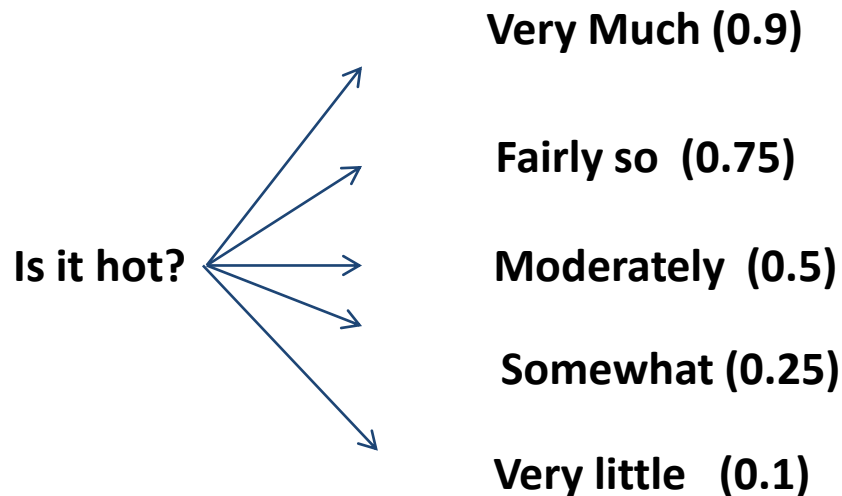
Boolean Logic/ Crisp Logic

It is an approach to computing based on Boolean value.



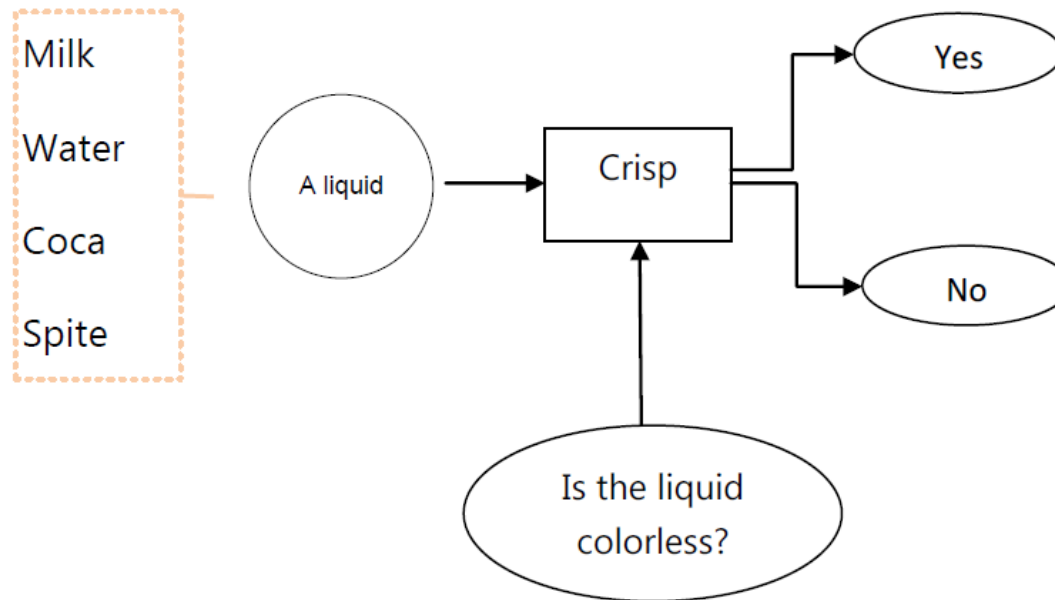
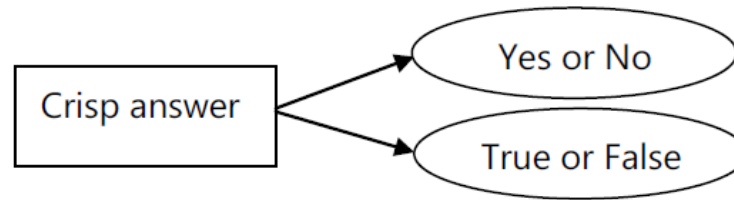
Modern computer is based on Boolean logic.

- It is an approach to computing based on many-valued logic.
- It is employed to handle the concept of **partial truth (degrees of truth)**, where the truth value may range between completely false (0) and completely true (1) .
- It is a mathematical means of representing **vagueness** and **imprecise** information (hence the term fuzzy).

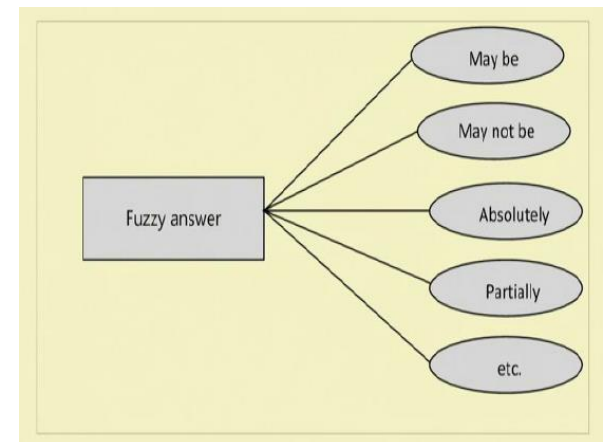
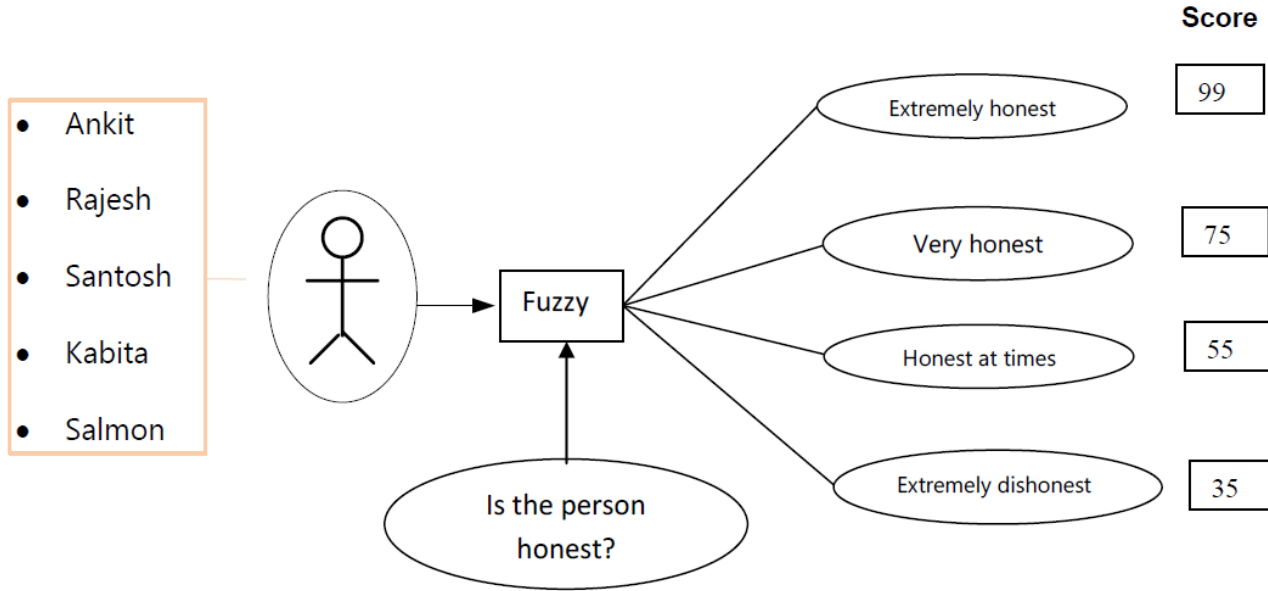


Human decision making process is based on fuzzy logic.

Crisp vs Fuzzy Logic



Crisp vs Fuzzy Logic



Why fuzzy?

Fuzzy logic allows handling **uncertain and imprecise** knowledge and provides a powerful framework for reasoning.

Fuzzy logic deals with **fuzzy set** or fuzzy algebra.

Concept of a **fuzzy set** represents a basic mathematical framework for dealing with **vagueness**.

Concept of a **fuzzy measure** is a general framework for dealing with **ambiguity**.

- In medicine, fuzzy logic is used for computer-aided diagnoses, based on factors such as symptoms and medical history.
- In natural language processing, fuzzy logic is used to determine semantic relations between concepts represented by words and other linguistic variables.
- In environmental control systems, such as air conditioners and heaters, fuzzy logic determines output based on factors such as current temperature and target temperature.
- fuzzy logic may be used to calculate students grade according to predetermined criteria.
- And many more

Classical or Crisp set is a set with fixed and well-defined boundary.

Universal set or universe of discourse (X) is a set consisting of all possible elements.

Example:

X : Students of KIIT

A : CSE students of KIIT

B : IT Students of KIIT

Representation of Crisp Set

1. $A = \{a_1, a_2, a_3, a_4\}$

2. $A = \{x \mid P(x)\}$

set A contains all x belonging to X that have the property P.

Property P is defined by a characteristic function as follows

$$\mu_A(x) = \begin{cases} 1, & \text{if } x \text{ belongs to } A, \\ 0, & \text{if } x \text{ does not belong to } A. \end{cases}$$

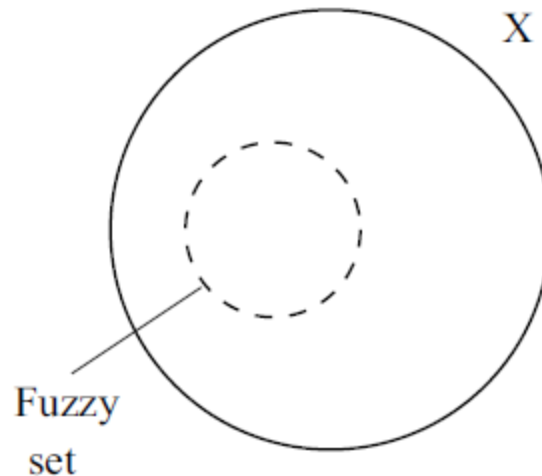
Example: let $X = \{a_1, a_2, a_3, a_4, a_5, a_6\}$

$$A = \{a_1, a_2, a_3, a_4\}$$

Fuzzy sets are the sets with imprecise (vague) boundaries.

It is an extension of classical crisp set.

True and False is sometimes insufficient when describing human reasoning.



A Schematic representation of fuzzy set

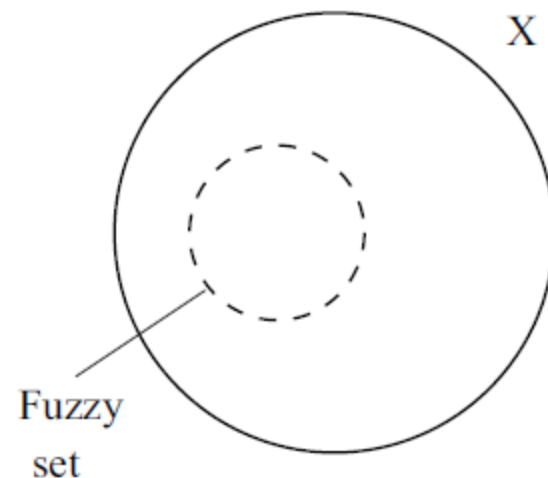
Example of Fuzzy Set

Let $X = \{g1, g2, g3, g4, g5\}$ be the reference set of students.

Let \tilde{A} be the fuzzy set of “smart” students, where “smart” is fuzzy term.

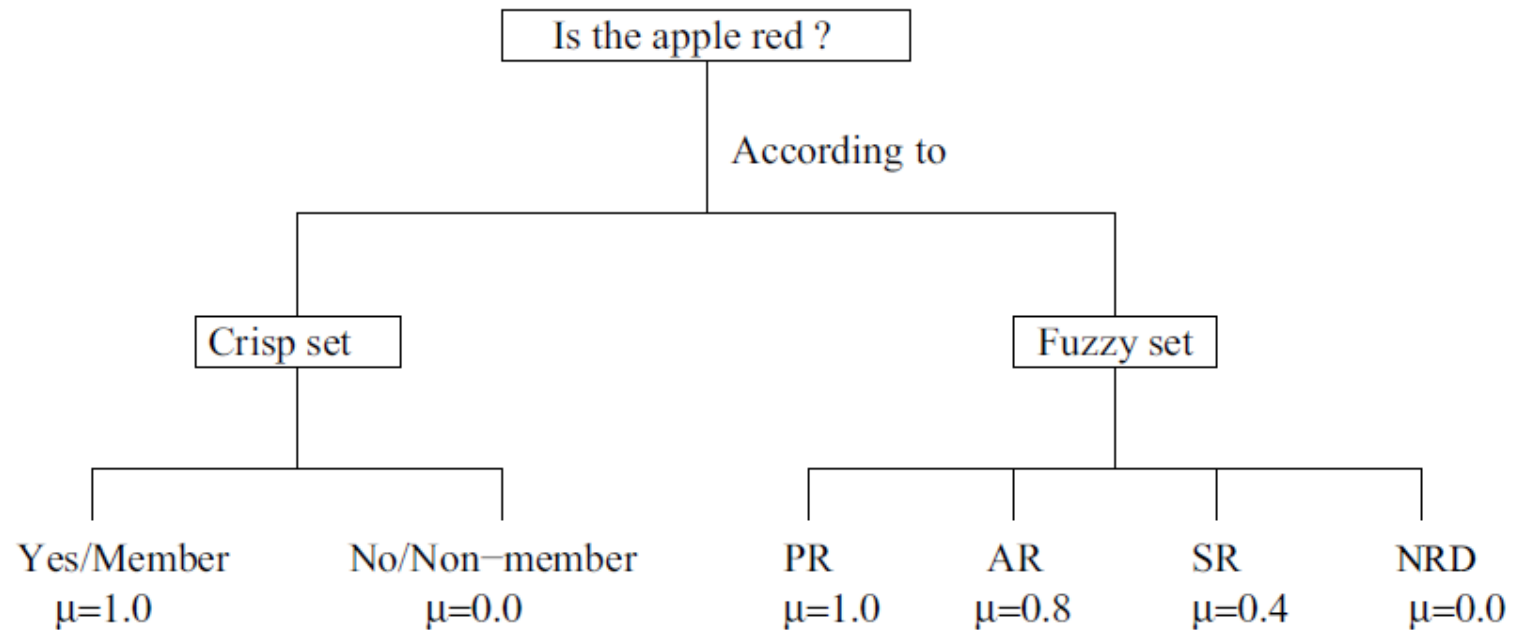
$$\tilde{A} = \{(g1,0.4)(g2,0.5)(g3,1)(g4,0.9)(g5,0.8)\}$$

Here \tilde{A} indicates that the smartness of $g1$ is 0.4 and so on.



A Schematic representation of fuzzy set

Crisp vs. Fuzzy Set



PR: Perfectly Red

AR: Almost Red

SR: Slightly Red

NRD: Not Red

μ : Membership value

Crisp vs. Fuzzy Set

Crisp Set	Fuzzy Set
1. $S = \{ s \mid s \in X \}$	1. $F = (s, \mu) \mid s \in X \text{ and } \mu(s) \text{ is the degree of } s.$
2. It is a collection of elements.	2. It is collection of ordered pairs.
3. Inclusion of an element $s \in X$ into S is crisp, that is, has strict boundary yes or no .	3. Inclusion of an element $s \in X$ into F is fuzzy, that is, if present, then with a degree of membership .

Used in digital system design.

Used in fuzzy controller.

“
*Each of your
actions will
have an
impact on your
future.*

A rectangular image with a dark, textured background. It contains a quote in a white, handwritten-style font.

Once you know
who is walking
with you on your path.
you will never
be afraid.

Thank you