

Computing with words using intuitionistic fuzzy logic programming

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Abstract

Computing with words is the terminology to indicate a set of numbers and words. It is the base for natural language processing and computational theory of perceptions. It is the art to combine both human and machine perception and find a solution for the real world problems left unsolved due to improper mechanism. Animal voice interpreter, lie detector, driving a vehicle in heavy traffic, and natural language interpreter are the applications need to be automated for the next generation. The computational theory is a group of perceptions used to express propositions in a natural language. The concept of the research is to utilize intuitionistic fuzzy logic to interpret perceptions to solve vague problems. The output of the research shows that the performance of proposed method is better than the existing methods.

Keywords: Fuzzy Logic; Intuitionistic Fuzzy; Computing With Words; Computing Perception; Natural Language Processing.

1. Introduction

The concept of computing with words and number (CW) is the manipulation of perception to handle words, numbers and pictures. Human beings tends to use words to express their feelings. Words are simple and easy to use than symbol and numbers. The introduction of fuzzy sets into the field of computer science made a paradigm shift in the representation of data and information. The computational theory of perception (CTP) has laid the path for generalized constraint language (GCL). GCL is the core in the infrastructure of CW and more flexible for natural language processing. The fig. 1.1 represents the perception computing. Words are taken as input by the CW – Engine and encoder encode the words for the transaction and decoder decoded the processed words and delivered as the knowledge for the user [1]. GCL applies a constraint on the linguistic variable such as time, price, age, size, etc., IFL can represent the values in a multi – valued form. CW can be automated by IFL to extract knowledge from perception. An inference engine needs a translator to convert natural language into GCL. Translation work will be done in the form of encoder and decoder [2]. The existing form of CW needs renovation to adapt new technologies to carry out the complex processes. There is no standard and structure available for the GCL and difficult to formalize the CW, and there is no proper methodology available to deduce rules for CW. There is a need for the database to infer rules and keep time to process the perception. Mishandling of standards leads to loss of information and CW is not able to model complex natural language propositions [3]. A conventional computing has only Boolean values to represent the inference and there is no value to represent fuzziness. Measurements are crisp, and perceptions are fuzzy. Granule is the concept introduced to handle CW and defined as cluster of objects contains proximity, similarity, and complexity. Granules are fuzzy as deals with perception.

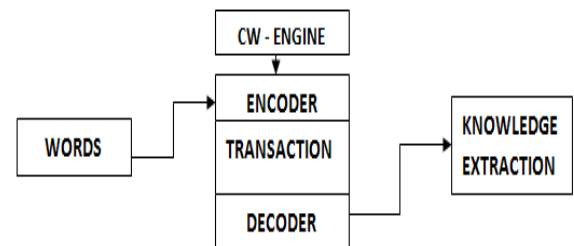


Fig. 1: Perception Computing.

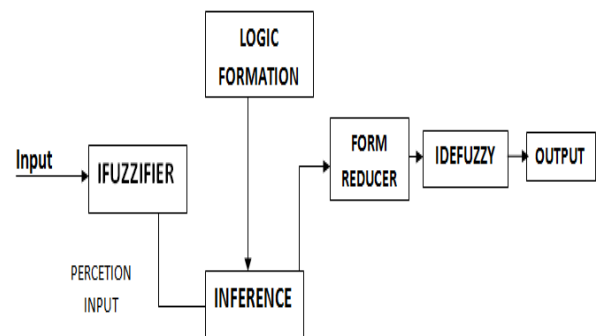


Fig. 2: IFL Methodology.

There are different types of granules such as f-granules and c-granules to represent different kinds of data. Granules are associated with fuzzy attributes and perception data. Perception based system is a system to handle perception with input, output and state transition function. The reasoning is nothing but a perception and in the form of computation [4]. The fig. 1.2 illustrates the methodology of IFL, input enters into the IFuzzifier to recognize the type of input and formation of logic will be formed with the

association of inference generator and the set of input will be sent to the form reducer to modify the form to be adaptable by Defuzzifier to generate the output [5]. The paper focusses on the demerits of existing CW and designs a method with the help of IFL. The further part of the paper discusses the existing literature and proposed methods with the conclusion.

2. Review of literature

Dubois, Fargier, and Prade 1993 presented the reasons for the malfunction of AI to address the problem of reasoning and decision making with perception-based information. Natural language is a description of perceptions. CW is a way for computing, reasoning and decision making described in natural language. The research described the methodology implemented in the automatic planner and compared its runtime and solution – length behavior with HSP method. The paper stated that the boundaries of the perceived classes are unsharp, and the attributes are a clump of values drawn together by similarity, proximity and function. The computational theory of perceptions enhances the ability of AI to deal with real world problems in which decision-relevant information is a mixture of measurements and perceptions [5].

Zadeh, 2002 proposed a system to manipulate perceptions. The author described the fuzziness of perceptions is the preponderant partiality of human concepts to point out the validity of most human concepts is a matter of degree. The concept of granule depends upon the boundaries. CW organizes propositional logic, predicate logic, and modal logic. CW is an expressive language for knowledge representation and a versatile machinery for computation. Natural language provides the variety of constraints about which the basic constraints form an important class called generalized constraints. CW is widely used in decision analysis to manipulate numerical validation [6].

Schryen, and Hristova, 1996 did a survey on the concept of duality and fuzzy in linear programming. The paper provided a comprehensive literature on duality in fuzzy linear programming. Linear programming and duality theory belong to the best-understood fields in computational mathematics. The major contribution of duality theory is its economic interpretation. The survey provided the following description (i). Fuzzy optimization defines fuzzy order as well as maximization regarding membership functions and thus retains the initial fuzzy uncertainty in the operation. (ii). Duality theory defines the comparison of fuzzy numbers using a binary relation and uncertainty raises from the fuzzy order will be lost as the comparison between fuzzy numbers. (iii). The ranking function used to prove duality theorems by allowing them to do all the proof analogously to the crisp case [7].

3. IFL and CW

The combination of IFL and CW is flexible to compute the perception very easy and simple. The following algorithm is the process carried out in the proposed method.

- Step 1: Set of words and numbers
- Step 2: Process words, numbers and pictures and transform into processing format for fuzzification.
- Step 3: Fuzzification of inputs
- Step 4: Inference engine start to read the fuzzified input with guidance of logic information engine.
- Step 5: Defuzzification delivers the output.
- Step 6: Goto 3; if no further input then goto 8.
- Step 7: Collection of output.
- Step 8: Stop the process.

The following figure 3 shows the flow of the process involved in the proposed method

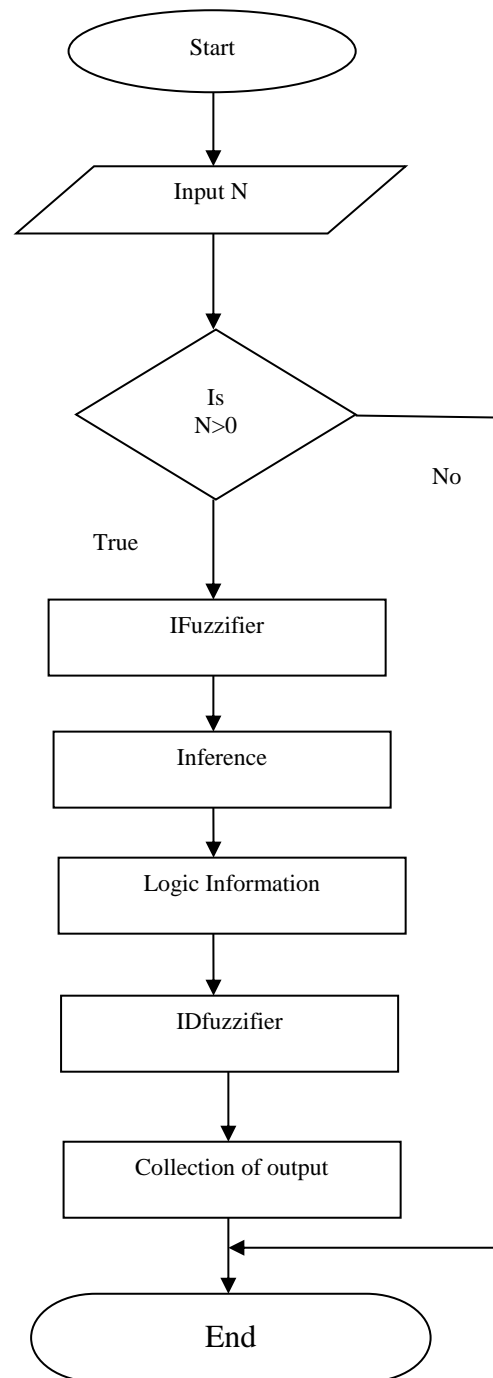


Fig. 3: Process Flow.

4. Proposed method

The research focuses on the process to automate the perception for CTP with the use of CW. The work produces set of formulae using IFL to define perception [8]. IFL can produce $4n$ results as the number of logical values are 4. Normally fuzzy logic aims to formalize the approximate reasoning, so IFL obviously does the same with its state of art techniques to solve the complex problem where the existing system lacks to find a solution [9]. The approximate reasoning is the part of multi – valued logical systems. GCL is in the infancy level; still research is going on to formulate a valid formula for the predicate logic, and universal quantifiers are generalized to IFL quantifiers [10].

The definitions of rules lead to a valid formula for GCL and CTP. GCL lacks to match the inferences with existing deduction rule (Schryen, Hristova, 1996). It is possible to define an infinite number of the proposition for perceptions in natural language. Formation of cost – effective database to store primary deduction rules will be useful to deduce knowledge using CW with IFL.

4.1. Logic formation

- If $f \leftarrow$ IFL and I is a granule then “ f is I ” a logic.
- If $f \leftarrow$ IFL and I is a granule then “ f is KI ” is a logic, where k is a IFL modifier.
- If α is a logic! α is also a logic.
- If α and β are logic then $\alpha + \beta$ is also a logic.
- If α and β are logic then $\alpha * \beta$ is also a logic.
- If α , β and γ are logic then $(\alpha \rightarrow \text{True})? B: \gamma$ is a logic.

The logics defined above can be used as a grammar to represent perceptions in GCL. For example, the grammar for the sentence “Some millionaire are illiterate” can be defined as some (Millionaire (A), Illiterate (B)) \rightarrow Illiterate (A, B). A resilient backward propagation (rbP) methods followed to answer a query posed to the system. Generally, a query may have one or more values.

4.2. Knowledge extraction

Knowledge can be extracted relevant to the query by organizing a tree structure to perform rbp. Conversion of perception into rules described in the previous section and symbolic representation of initial inferences by creating subqueries is useful to deduce knowledge from the query [11].

4.3. Parser

Rbp will be carried out to propagate the constraint with the relevant query. Each sub query will be traversed and combined with the user query, and top most level will be reached to complete the process. To evaluate the procedure discussed above, two scenarios of investigating a patient developing diabetes and heart attack will be screened by the following statements.

Diabetes is the common disease for all age factors. In India, Female aged above 30 having 30% of chances to get diabetes and for male the percentage will be 25% if they above 30 and for children will be 10%. Pregnant women are having more chance to get diabetes. The important reasons for diabetes are obese, stress and genetic. For the knowledge of interest, a lady aged 35 having following details will be screened for diabetes. Age = 35, Weight = 85 kgs, Height = 180 cm, stress factor = 90 /100, Family background = Father and Mother had diabetes. Physical Activity = Nil. Assume the above information is translated to GCL as follows

- If $\text{age}(A) \geq 30$ then Risk = 30%
- If $\text{weight} \geq 70$ then Risk = Risk + 20%
- If $\text{pregnant} = \text{True}$ then Risk = Risk + 5%
- If $\text{family background} = 2$ then Risk = Risk + 10%
- If $\text{Stress factor} \geq 75$ then Risk = Risk + 25%
- If $\text{Physical Activity} = 0$ then Risk = Risk + 10

The GCL expressions can be converted to canonical form.

Risk_factor_Diabetes(A, Age(A), Weight(A), Height(A), Sfactor(A), Fback(A), Pact(A)) and after inserting the values for the above form the risk factor for the lady will be 95% as the lady is not pregnant.

Heart attack is also a common disease for all age factors. In India, Male aged above 30 having 25% of chances to get major stroke and for female the percentage will be 15% if they above 30 and for children will be 5%. Obese Men and Women are having more chance to get Minor and Major strokes / Heart attack. The important reasons for Heart attack are obese, stress and blood pressure. For the knowledge of interest, a man aged 30 having following details will be screened for Heart attack. Age = 30, Weight = 85 kgs, Height = 180 cm, stress factor = 70 /100, Blood pressure 95/150. Physical Activity = Nil. Assume the above information is translated to GCL as follows

- If $\text{age}(A) \geq 30$ then Risk = 25%
- If $\text{weight} \geq 70$ then Risk = Risk + 10%
- If $\text{stree factor} \geq 70$ then Risk = Risk + 5%
- If $\text{lblood pressure} \geq 90$ and $\text{hbloodp pressue} \geq 150$ then Risk = Risk + 10%
- If $\text{Physical Activity} = 0$ then Risk = Risk + 10

The GCL expressions can be converted to canonical form.

Risk_factor_Heart attack (A, Age(A), Weight(A), Height(A), Sfactor(A), bpressure(A), Pact(A)) and after inserting the values for the above form the risk factor for the man will be 60%.

The following table shows the performance evaluation of proposed and existing methods. The proposed method is implemented with Matlab a2012b in the windows 10 professional environment. The inference and logic information engines were constructed inside the system. The table 1 shows the accuracy values of the proposed IFL and ordinary FL with variation data from 100 to 500 inputs. The figure 4 shows the comparison of methods used in the research.

Table 1: Accuracy of Existing and Proposed Methods

Methods / No. of Inputs	IFL	FL
100	85	80
200	87	78
300	88	82
400	82	82
500	83	76

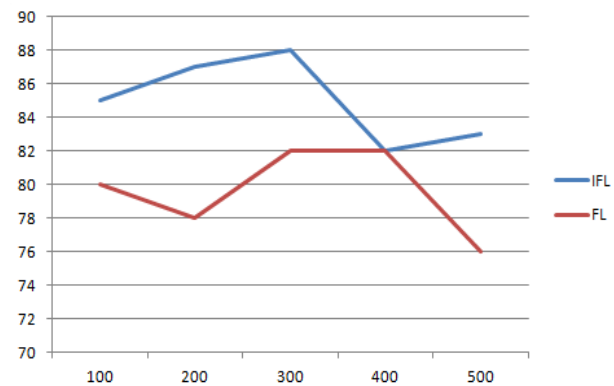


Fig. 4: Comparison of Accuracy.

5. Conclusion

The proposed work generated successful result and automation of CW for GCL with IFL is a new methodology to handle perception without loss of information. A formal grammar for GCL having possibility distribution with predicate logic proposed in the research and the evaluation shows that the performance is better than the existing system. The encoder and decoder for handling CW work better and there is no loss of data during the transaction. The canonical form of CW performed by the system is optimum and rules are very simple to automate by GCL. Necessary database selected to deduce rules to handle the perception. The future work of the proposed work is to develop a comprehensive grammar for GCL with a fuzzy set. The performance of the system should be improved to meet the difficult situation.

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