New Developments in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics Volume II: Applications

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Dedicated to Professor Beloslav Riečan on his 75th anniversary

Introducing reputation into decision making process

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Abstract

In this paper we consider how to incorporate a reputation factor into group decision making process and how it influences the final decision. We choose generalized IF-set theory to model reputation and we use relative scalar cardinality of IF-sets to construct an algorithm of group decision making.

Keywords: decision making, reputation, intuitionistic fuzzy set theory, IF-set theory.

1 Introduction

Decision making under imprecision and uncertainty of information is a challenging problem addressed by many researchers (e.g. [2], [5], [7]). In the paper we focus on an aspect of quality of information taken from different sources, assuming that this quality can be equated with a reputation value of a source.

At the beginning let us consider two simple examples of decision making problems, in which reputation of participants plays important role.

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Case 1

We are looking for a proper english translation of a polish word ”według”. Then we come across the problem of choosing the best translation among many given by different translators, e.g:

- Google:
  - by, according to, under
- PWN-Oxford
  - according to, under, based on
- Translatica
  - according to, by

To make the right decision which translation to choose it would be useful to have an additional information about reliability (or reputation) of those translators.

Case 2

A group of friends is going to see a movie. They have to choose one out of the following three movies:

- *”The Skin I Live In”*
- *”Colombiana”*
- *”Midnight in Paris”*

Again, the choice is difficult if their opinions are not consistent. However, an additional, useful information can be extracted from the network of relationships between friends, depicted in Figure 1 — each node represents a friend and each edge with a value assigned represents a similarity in movie taste.

Two presented cases are very simple examples of a more general situation when a decision that is to be made is based on information taken from many different sources of possibly different quality. In Case 1 those sources are translators with different reliability (reputation); in Case 2 each friend is a source of an opinion about a movie, and at the same time each friend can be assign a ”quality value” reflecting a level of trust (reputation) of all the other friends in his or her movie taste. Another example could be data integration process when data taken from

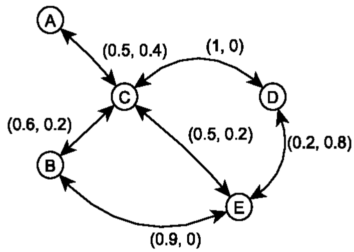

Figure 1: A social network with similarity relation for Case 1

different data sources could be contradictory, incomplete, ambiguous. In such circumstances reputation of data sources can help to filter the data.

In the next section we define a notion of reputation and we present a method to model reputation. Next we construct an algorithm of decision making that takes into account reputation of decision makers. We finish with numerical examples and conclusions.

2 Modeling reputation

According to Wikipedia definition, reputation "is a belief about others' evaluations of the target with regard to a socially desirable behavior". In this paper we assign a reputation value to a decision maker (an individual that is involved in decision making process). This value is "socially desirable" in the sense that we assume that a group agree that an individual with the highest reputation value has the biggest influence to the final decision.

If individual is assigned a high reputation value we would say that he or she is "highly reliable". As we can see most often reputation is a gradated phenomenon. Therefore we have chosen a generalized form of IF-set theory (Atanassov's intuitionistic fuzzy set theory, described in [1]) to model reputation in a flexible and adequate way.

Generalized IF-set ([3]) is a pair of fuzzy sets ([8]), corresponding to positive and negative information about an IF-set:

$$X = (X^+, X^-)$$

where

$$X^- \subset (X^+)^c.$$

Uncertainty area is thus a set defined as:

$$X^? = (X^+)^c \cap_T (X^-)^c$$

where T is a t-norm, e.g. minimum: $aTb = a \wedge b$, algebraic t-norm: $aT_a b = a \cdot b$ or Łukasiewicz t-norm: $aT_Ł b = 0 \vee (a + b - 1)$, and c is a complement of a set, induced by a strong negation ν (e.g. Łukasiewicz negation $\nu(x) = 1 - x$).

Below we give some examples of reputation value modeled with IF-set:

- (1, 0): a source is highly reliable, with no uncertainty;
- (0.6, 0.2): a source is partially reliable, uncertainty is greater then 0;
- (0.1, 0.8): a source is highly unreliable, uncertainty is greater then 0.

A bipolar perspective on the reputation has many benefits. It is possible to distinguish between two different situation: lack of knowledge - (0, 0) and lack of reliability - (0, 1). Moreover, generalized uncertainty value, when calculating using e.g algebraic t-norm, gives us additional information about decisiveness of an opinion about reputation - e.g. for more decisive opinion (0.9, 0.1) uncertainty factor is equal to 0.09, but for (0.5, 0.5) it is greater and equals 0.25. This model is thus convenient when introducing new, unknown individual into a group of decision makers. Then we can assign it a value (0,0) that will be clarified later, during a lifetime of a system.

3 Reputation in decision making process

3.1 Construction of an algorithm

In this section we present a draft of an algorithm of decision making with reputation.

Let us have:

- $P = p_1, ..., p_m$ - an IF-set of individuals (decision makers) with a reputation value assigned
- $O = o_1, ..., o_n$ - a set of options
- $R = [r_i^k]$ - a set of preferences of p_k about option o_i, possibly an IF-set.

The main idea of the algorithm can be summarized in a command:

Find an option such that most of reliable individuals prefer it

Theoretical background of this command includes calculating relative scalar cardinality of two IF-sets - IF-set of individuals that prefer given option to an IF-set of all individuals.

Relative scalar cardinality of IF-sets X and Y is defined as:

$$\sigma_I(Y|X) = \frac{\sigma_I(Y \cap X)}{\sigma_I(X)} = \frac{[\sigma(Y^+ \cap_T X^+), \sigma((Y^-)^c \cap_T (X^-)^c)]}{[\sigma(X^+), \sigma((X^-)^c)]} \quad (1)$$

where

$$\sigma(A) = \sum_{x \in supp(A)} f(A(x))$$

is a scalar cardinality of fuzzy set A with f being a non-decreasing function $f : [0,1] \to [0,1]$ such that $f(0) = 0$, $f(1) = 1$ called cardinality pattern.

The solution of decision making process is an IF-set defined as:

$$S_Q = Q(\sigma_I(P_1|P)) \, /o_1 + ... + Q(\sigma_I(P_n|P)) \, /o_n \quad (2)$$

where Q is a linguistic quantifier of a "most" type.

3.2 Examples

Let us consider once more two examples described in introductory section. For simplicity we take identity function to represent cardinality pattern f and "most" quantifier Q.

Case 1.

The first step is to assign reputation values to translators. These values may be subjective or objective - may depend on our previous experience or can be assigned by an external certifier. Let us assume that we consider PWN-Oxford as most reliable - (0.9, 0), then we assign (0.8, 0.2) to Translatica and (0.6, 0.2) to Google.

Next we construct a preference matrix - for each translator and each option (o_1*: "by",* o_2*: "according to",* o_3*: "under",* o_4*: "based on"*) we put a value of preference.

On the bases of previous information we construct IF-sets: P is an IF-set of reliable decision makers, and $P1..P4$ are IF-sets of decision makers that prefer option $o_1..o_4$, respectively.

Table 1 demonstrates those IF-sets and a solution of decision making procedure according to formula (2), where two different t-norms were used for calculating intersections of IF-sets: minimum t-norm $T = \wedge$ and algebraic t-norm $T = T_a$. It can easily be seen that the best option (preferred by the most of reliable translators) is option o_2 - "according to".

Table 1: A solution for Case 1.

	P	P1	P2	P3	P4
Google	(0.6, 0.2)	(1, 0)	(0.8, 0)	(0.6, 0)	(0, 0)
PWN-Oxford	(0.9, 0)	(0, 0)	(1, 0)	(0.8, 0)	(0.6, 0)
Translatica	(0.8, 0.2)	(0.8, 0)	(1, 0)	(0, 0)	(0, 0)
$S_Q =$	$T = \wedge$	(0.54, 0)	(0.88, 0)	(0.54, 0)	(0.23, 0)
	$T = T_a$	(0.48, 0)	(0.84, 0)	(0.42, 0)	(0.21, 0)

Case 2.

In this example reputation is taken directly from a social network. Having trust values between pairs of users we may calculate global trust values (reputation) of each of the user (one way to do this was described in [4]). This reputation was calculated and the result is depicted in Figure 2 - for each node (a friend) a value of reputation is assigned.

Next we follow similar steps as in Case 1 and we get IF-sets presented in Table 2.

After applying formula (2) we get the resulting IF-set. The best choice for the group seems to be the option o_3 - *"Midnight in Paris"*.

Table 2: A solution for Case 2.

	P	P1	P2	P3
A	(0.13, 0.1)	1	0	0
B	(0.38, 0.05)	0.1	0.3	0.6
C	(0.65, 0.2)	0.2	0	0.7
D	(0.3, 0.2)	0.5	0.5	0.5
E	(0.4, 0.25)	0	0.5	0
$S_Q =$	$T = \wedge$	(0.17, 0.09)	(0.24, 0.3)	(0.32, 0.03)
	$T = T_a$	(0.11, 0.16)	(0.11, 0.43)	(0.2, 0.18)

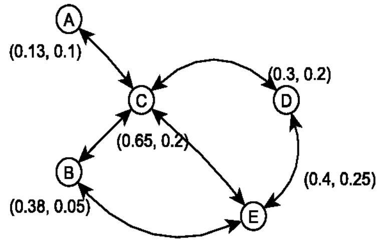

Figure 2: A social network with reputation value

4 Conclusions

The presented algorithm of decision making enables to find the best option taking into account a reputation of decision makers. The whole process of decision making is based on the theory of IF-sets - reputation is modeled as a (generalized) IF-value and calculations are done based on relative scalar cardinality of IF-sets. Such approach is consistent and gives a possibility to build on the achievements of this theory.

Acknowledgment

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The papers presented in this Volume 2 constitute a collection of contributions, both of a foundational and applied type, by both well-known experts and young researchers in various fields of broadly perceived intelligent systems.
It may be viewed as a result of fruitful discussions held during the Tenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2011) organized in Warsaw on September 30, 2011 by the Systems Research Institute, Polish Academy of Sciences, in Warsaw, Poland, Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences in Sofia, Bulgaria, and WIT - Warsaw School of Information Technology in Warsaw, Poland, and co-organized by: the Matej Bel University, Banska Bystrica, Slovakia, Universidad Publica de Navarra, Pamplona, Spain, Universidade de Tras-Os-Montes e Alto Douro, Vila Real, Portugal, and the University of Westminster, Harrow, UK:

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The consecutive International Workshops on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGNs) have been meant to provide a forum for the presentation of new results and for scientific discussion on new developments in foundations and applications of intuitionistic fuzzy sets and generalized nets pioneered by Professor Krassimir T. Atanassov. Other topics related to broadly perceived representation and processing of uncertain and imprecise information and intelligent systems have also been included. The Tenth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2011) is a continuation of this undertaking, and provides many new ideas and results in the areas concerned.

We hope that a collection of main contributions presented at the Workshop, completed with many papers by leading experts who have not been able to participate, will provide a source of much needed information on recent trends in the topics considered.

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