Negotiation as Creative Social Interaction Using Concept Hierarchies

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Abstract. Negotiation is a process that ranges from international issues to common society interactions. We present approaches to facilitate the process by exploring alternative spaces for this process. We base the approach on exploring alternative terminology that can resolve conflicts in the negotiation solution. Concept hierarchies can provide higher level concepts that can be used to obtain agreement between parties in the negotiation.

Keywords: Negotiation, Concept Hierarchy, Generalization, Partitions, Consensus.

1 Introduction

In this paper we propose an approach to the negotiation process which views this inexact process as a co-operative societal interaction among concerned parties. Negotiation can be defined as a process in which explicit proposals are put forward for the purpose of reaching agreement on an exchange or on the realization of common interest when conflicting interests are present [1]. Specifically we focus on ways to overcome barriers in negotiations due to differences in the semantics of language and concepts used by the negotiating parties. Since this is a complex issue we can view solutions as representing creative aspects of problem resolution.

A specific mechanism we utilize to assist in this resolution is the use of concept hierarchies to generalize specific terminology that occurred during the negotiations. We will assume that for each party there is a space of concept hierarchies that captures the semantics of terms under discussion in one or more relevant conceptual contexts. Thus when differences arise, some searching of the space of these concept hierarchies could discover common generalizations for the terms in dispute. Such generalizations can then be used to cast the discussions into a broader context that is more acceptable or amenable to both parties avoiding the otherwise contentious implications of the original terminology.

2 Background

In this section we provide an overview of the generalization approach that can be used in exploration of the space of alternative terminology for the negotiation process. Next creativity as related to generalization and the exploration of alternatives is described.

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2.1 Generalization

Generalization is a broad concept that has been used in several contexts. One is the idea of data summarization, a process of grouping of data, enabling transformation of similar item sets, stored originally in a database at the low (primitive) level, into more abstract conceptual representations. Summarization of data is typically performed with utilization of concept hierarchies [2,3], which in ordinary databases are considered to be a part of background knowledge In fuzzy set theory an important consideration is the treatment of data from a linguistic viewpoint. From this an approach has been developed that uses linguistically quantified propositions to summarize the content of a database, by providing a general characterization of the analyzed data [4-7]. There have also been several approaches to the use of fuzzy hierarchies for data generalization [8-10]. Fuzzy gradual rules for data summarization have also been considered [11]. In a previous research effort [12] we developed an approach to data summarization that involves aspects of generalization and compression. The use of concept hierarchies, ontologies, to provide categories to be utilized in this process has been well established [13].

Now consider an example of data generalization letting D= {Oakland, San Jose, …., Sacramento} be a set of cities. However for a particular application, this data may be at too low a level, i.e. too specific.

Figure 1 illustrates part of a concept hierarchy H_1 for an attribute Location, describing US cities based on the geographical location. This concept hierarchy represents some of the domain background knowledge we have a priori.

By ascending the hierarchy, for the attribute Location in the set D, the values San_Francisco, Santa_Cruz, Oakland, and San_Jose are generalized to the higher level category (also called the hypernym) Bay_Area, while the value (or hyponym) Sacramento is generalized to Sacramento_Metropolitan_Area. Thus R_1 = G (D, H_1) = {Bay_Area, Sacramento_Metropolitan_Area. }.

As we have discussed depending on a semantic context there may be other hierarchy for the data being generalized. These may represent another application for the data or another context that is desired to be related to the original one. For the domain of cities we have discussed, another context might be the classification of the city based on population compared to the geographical context of Figure 1. This is illustrated by H_2 below in Figure 2.

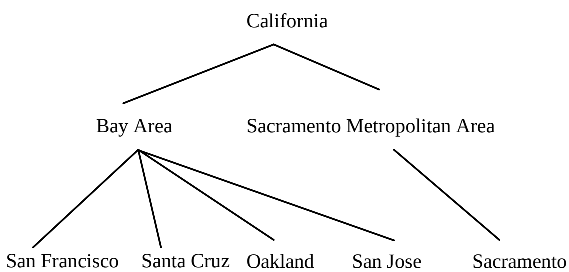

Fig. 1. Example Concept Hierarchy for Cities in California

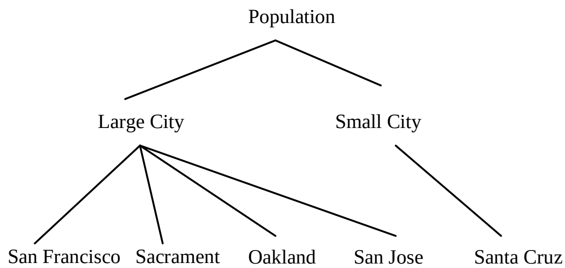

Fig. 2. Concept Hierarchy Based on Population Size

2.2 Creativity

Generalization construed broadly is a central facet of intelligent behavior, an inductive process going from the specific to the general. Here we focus on a data generalization process **G** for which relevant concept hierarchies are used to reduce the specific set of terms T into a small set of general concepts by an induction process.

There have been a number of approaches to evaluating machine creativity and we discuss here some aspects relevant to generalization [14, 15]. Usually it is desired to use domain independent criteria to be as broadly applicable as possible. A creative act can be thought of in two stages – generation and evaluation. The basis for the evaluation of creativity can be viewed as an assessment of the output of a generation process after factoring out the input to the process.

The input to the process can be considered as the implicit and explicit knowledge termed the inspiring set I by Ritchie [16] If we denote by R the results of the generation, then the items to be considered as creative must lie in R/I, i.e. R-I. For the generalization process **G** we are considering that $I = T \cup H_i$, where T is some set of terms and $H_i \in \{H_1, H_2, \ldots H_n\}$ is one hierarchy of the set of hierarchies that may be used for generalization. $R_i = \mathbf{G}(I)$ therefore is the result of the generalization process on T using H_i.

Often it may become difficult to exactly specify the input I so strong and weak versions of I have been introduced [15]. I_S contains those values specifically known to the generalization process **G**, so a creative item must be completely new. Often the influence of other information on the process is difficult to quantify so I_W is introduced, containing items that are known to have influenced the generalization. Since this information may be difficult to identify exactly, it may be desirable to consider I_W as a fuzzy set.

3 Negotiation

The process of negotiation is a pervasive activity in human society ranging from negotiations between nations to individual negotiations in everyday life. The importance of negotiation is reflected by article 33, paragraph 1 of the United Nations charter which states that negotiation should be the first method to be used for peaceful settlement of international disputes [17].

In order for a negotiation to be successful, there must be common ground between parties for the process to bridge their respective positions. This is an issue our approach addresses by investigating techniques to explore the space of concepts and terms used in negotiations by the involved parties.

3.1 Formalization of Negotiation

We can provide a general description of the negotiation process with respect to how generalization can be used. Assume the negotiation involves N issues $\{I_1,\ldots,I_N\}$ and these issues encompass a domain X of the terminology involved relative to the issues under consideration. Also let there be two hierarchies over X: H_1 and H_2 for sides 1 and 2 respectively in the negotiation. Each specific issue I_k involves some set of terms $T_k \subseteq X$. So the problem can be described as that in order to negotiate an issue both sides must be in agreement A on a *sufficient* number of terms.

Let an agreement A be a simple one – assume each side has partitioned the terminology space X into two sets – terms with a *positive* import P and terms with a *negative* import N. Then for issue I_k and the term set T_k, side 1 has $T_k = P1_k \cup N1_k$. Similarly for side 2, $T_k = P2_k \cup N2_k$. Obviously if there is not *enough overlap* in positive / negative terms for both sides negotiations will not succeed.

The negotiation process must obtain *sufficient* agreement to succeed. Let us assume in this case a simple agreement A is obtained for the positive terms, $A(P1_k, P2_k)$ and for the negative $A(N1_k, N2_k)$. The objective is that the positive terms agreed upon should *mostly* cover the term set T_k under negotiation and the negative terms agreed upon should *mostly* be avoided in the negotiation issue I_k. This means $A(N1_k, N2_k) \cap T_k$ should be *small*. In order to achieve these agreements the sets of terms in dispute can be generalized by the two sides' hierarchies H_1 and H_2. Then it might be possible that there are more general concepts that the two sides can accept as agreeable. We will illustrate in the next section approaches to find consensus among the possible partitions of term sets induced by the hierarchies.

Clearly much of the inexact negation process involves subjective and soft criteria mentioned above such as "sufficient" agreement or "most" coverage. The representation of such linguistic terms used during the negotiation can be assisted by the concept of linguistic quantifiers. Zadeh [18] noted that human dialogue makes considerable use of terms such as *most*, a*bout 50%*, *some*, *all* which he referred to as linguistic quantifiers. These terms are used to provide a linguistic explanation of some proportion and can be represented by fuzzy subsets over the unit interval such that the membership measures the satisfaction to the concept. In figure 3 we illustrate a typical graphical representation of the concept "Most".

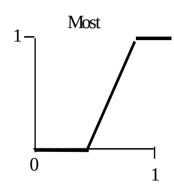

Fig. 3. Example for criterion. "Most"

A specific example of this sort of function is illustrated by the function F1 below:

$$F1(x, a, b) = \begin{cases} 0 & x < a \\ (x-a) / (b-a) & a \le x < b \\ 1 & x \ge b \end{cases}$$

where the values of a and b might be 0.75 and 0.85 respectively.

Often the negotiation process involves negotiators who are agents representing the actual parties. If parties are unable to resolve differences by negotiation, a third party may step in to lead the parties to a solution by compromise. This is termed mediation. A mediator may even play an active role in this process and be flexible or innovative enough to obtain some consensus. Such an individual should have psychological understanding to appreciate the way in which the two parties are visualizing the issues between them.

For example labor union representatives must produce a contract that the union members will ratify; lawyers, in a divorce case, must satisfy both wife and husband in the settlement. Often this will concern the varying interpretations of the language in the contract and so a final stage is the actual acceptance by the concerned parties. So as part of the overall process, the negotiation agents may have to explore phrasing that can satisfy the involved parties [19].

Assume there are two negotiators N1 and N2 and that they agree to take an action A1. Next they must explain this to their constituents or audience. Here there are a number of language semantics issues that must be considered. Let the action A1 involve some set of terms in a subset X' of the space X. Then each audience has their own decomposition of X' in the line of positive, negative and indifferent.

D1 – $X' = P1 \cup N1 \cup I1$; and their own reduction rules

D2 – $X' = P2 \cup N2 \cup I2$; and their own reduction rules

Can the negotiators explore this space of possibilities to obtain an agreement between D1 and D2? For example consider that there are 3 definite subsets of X, S1, S2 and S3. These are sets that generalize to some specific concept(s) in a given hierarchy H. The remaining elements of X, $S0 = X – S1 \cup S2 \cup S3$. This is a set of undifferentiated elements that the party has no preference for generalization – so they might consider that the domain has positive and negative terms for them but the remaining ones – S0 – are undifferentiated and the person has no preferences relative to them. Note this means that S0 doesn't have specific constraints in the context.

Assume we have two elements of S0 – a and b. These could be generalized to multiple concepts – C and C' – could be included in the generalization to say S2, could generalize independently to different concepts, etc, etc. This leads us to consider the issues of partially generalizing hierarchies and a space of concept hierarchies. – a partially partitioned space. So we consider the process of trying to reach agreements to do negotiations as a search thru this space – an exploration of such a space. This fits into the aspect of creativity – exploration. So we can see that inherently the process of negotiation can be viewed as a creative process.

3.2 Consensus and Partitions

One approach to searching a space of hierarchies can be based on the how different the original data generalized from different hierarchies appears to be. We consider the idea of a consensus of generalized data [20, 21] in terms of the concept of congruence.

One approach is to introduce a measure of similarity, congruence, between two partitions using the underlying equivalence relations. Here we now consider formulating a congruence measure from the perspective of the partitions themselves.

Assume we have two partitions of the set D,

$P_1 = A_1, ..., A_q$

$P_2 = B_1, ..., B_p$

where $D = \bigcup_{j=1}^{q} A_j$ and $A_i \cap A_j = \varnothing$ for $i \neq j$ and $D = \bigcup_{j=1}^{p} B_j$ and $B_i \cap B_j = \varnothing$ for $i \neq j$.

Without loss of generality we shall assume q = p. If q > p we can augment the partition P_2 by adding q - p subsets, $B_{P+1} = B_{P+2} = ...= B_q = \varnothing$. Thus in the following we assume the two partitions have the same number of classes, q.

We now introduce an operation called a pairing of P_1 and P_2, denoted $g(P_1, P_2)$, which associates with each subset A_i of P_1 a unique partner B_j from P_2. Formally if $Q = \{1, 2, ..., q\}$ then a pairing is a mapping $g: Q \rightarrow Q$ that is bijective, one to one and onto. Essentially g is a permutation of Q. We then have that a pairing $g(P_1, P_2)$ is a collection of q pairs, $(A_j, B_{g(j)})$.

We shall now associate with each pairing a score, $Score(g(P_1, P_2))$, defined as follows. Denoting $C_{g.j} = A_j \cap B_{g(j)}$ for j= 1 to q we obtain

$$Score(g(P_1, P_2)) = \left(\sum_{j=1}^{q} Card\,(C_{g.j})\right) / \,Card\,(D)$$

Example: Now we consider an example of a labor negotiation for a faculty union at a university for which the issues are D = [Medical, Retirement, Raises, Tenure, Intellectual Property}. Based on negotiating positions of the two sides possible partitions might be: P_1 consisting of: A_1 = [Medical, Retirement, Tenure, Raises}, A_2 = { Intellectual Property }; and a partition P_2 is B_1 = [Medical, Retirement, Intellectual Property, Raises }, and B_2 = {Tenure}. In this case there are two pairings.

One pairing is g(j) = j in which case we get the pairs (A_1, B_1), (A_2, B_2). From this

$C_{g.1} = A_1 \cap B_1$ = { Medical, Retirement, Holidays }

$C_{g.2} = A_2 \cap B_2 = \varnothing$

In this case $Score(g(P_1, P_2)) = 3/5$.

The other pairing is g(1) = 2, g(2) = 1 and here our pairs are (A_1, B_2), (A_2, B_1). and

$C_{g.1} = A_1 \cap B_2$ = {Tenure}

$C_{g.2} = A_2 \cap B_1$ = { Intellectual Property }

In this case $Score(g(P_1, P_2)) = 2/5$

We now shall use this to obtain a measure of congruence, $Cong_2(P_1, P_2)$. Let G be the set of all pairings, $g \in G$. We define

$$Cong_2(P_1, P_2) = \underset{g \in G}{Max}\ Score(g(P_1, P_2))$$

Thus this measure of congruence is the score of the largest pairing. We see that for any pairing g, $0 \leq \sum_{j=1}^{q} \text{Card}(C_{g,j}) \leq \text{Card}(D)$. From this it follows that $0 \leq \text{Cong}_2(P_1, P_2) \leq 1$. More precisely since for any two partitions we can always find a pairing g in which $\sum_{j=1}^{q} \text{Card}(C_{g,j}) \geq 1$ we see that

$$\frac{1}{\text{Card(D)}} \leq \text{Cong}_2(P_1, P_2) \leq 1$$

So this measure allows us to compare partitions produced by generalization using different hierarchies.

Now we can discuss how to apply consensus measures to issues concerning negotiation. Consider the terms that might be part of the dispute in the negotiation. For example one of disagreement on terms is seen in the set

$$D1 = P2 \cap N1$$

By generalizing this set D1 of contentious terms we can, so to speak, cast these into a different phrasing as higher level concepts on which the parties may be able to achieve more agreement. Again recall that negotiation is an inexact process so the degree of agreement on these concepts need not be complete but by mediation the agreement can be phrased as “Mostly” agreed upon. Since it is more likely that agreement can be found on a smaller set of higher level concepts, the search of the space of hierarchies to find a better consensus is the overall objective. Another way of viewing the result of the generalization is that a higher level concept corresponds to (covers) a larger subset of the terms in dispute. Each of the sides in the negotiation may then be able to focus on different aspects or components of such a subset and which they may then find more satisfactory.

Finally if there was not a satisfactory solution obtained, a creative approach could be to consider various combinations of partitions utilizing the sets of terms the parties are indifferent towards. This would mean that the set D1 could be extended prior to generalizations. Let S2 be the set of terms that the second party is indifferent towards. Note not all of these would be indifferent to the other side, indeed some might be viewed as positive, negative, or indifferent. Certainly the subset of S2 viewed negatively ($S2 \cap N1$) would not be included in an extension. A variety of choices are to include some of the positive and / or indifferent terms of S2 in the extension depending on what negotiators or mediators think would be most beneficial to obtaining a satisfactory resolution.

4 Summary

In this paper we described an approach to the negotiation process which views this inexact process as a co-operative social interaction. Negotiation is a process that ranges from international issues to common society interactions. We presented approaches to facilitate the process by exploring alternative spaces for this process. We based the approach on exploring alternative terminology that can resolve conflicts in the negotiation solution. Concept hierarchies were shown to provide higher level concepts that can be used to obtain agreement between parties in the negotiation

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