Agreement Spaces for Counselor Agents
(Extended Abstract)

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ABSTRACT
This paper presents a model of agreement context as an euclidean space that can be solved as a Constraint Satisfaction Problem. This will allow to have a mediator (Counselor Agent) that models the agreement as an space, checks the viability of the agreement as it is being built, and even gives some counsels about the agreement terms being formulated.

Categories and Subject Descriptors
I.2 [**Artificial Intelligence**]: Multiagent systems

General Terms
Algorithms, Management, Theory

Keywords
agreement, context, CSP, counselor

1. INTRODUCTION
An agreement is an arrangement between two or more entities to make something. This agreement assumes or implies a context in which it is going to be carried out. This paper focuses in the way to model contexts in which agreement takes place by means of a multi-dimensional Euclidean space approach. This modeling will allow to use geometrical properties or operations to work with such agreements and to model the agreement problem as a constraint-satisfaction problem (CSP). A mediator (counselor) could be able to on-line evaluate the feasibility of such an agreement or give some advises as the agreement negotiation evolves.

One of the main differences between this approach and previous works related with agreements and agents is the focus of the approach. In works as *Contract-related agents* [2], the focus is in the agent and how he may deal with the concept of contract, whilst this work focuses in the concept of agreement as an upper abstraction over the idea of agent, organization or other entity. This agreement modeling can be really useful to a counselor mediating in such agreement.

2. AGREEMENTS CONCEPTS

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An *agreement* is the definition of a working context for two or more entities.

Definition 1 (Agreement): is defined as $Ag = (E, Cx)$, where: (i) $E = \{E_1, E_2, \ldots E_n\}$ is a set of entities participating in the agreement, so that $\forall E_i, i = 1, \ldots n, \exists! O_i = \{o_{ij}\}, j = 1, \ldots m$, the ontology known by E_i; and (ii) Cx is the context defining the situation to be fulfilled by all the entities in E, so that $Cx \subseteq \bigcup_i O_i$.

Definition 2 (Agreement Discourse Universe -ADU-): of an agreement Ag is the whole set of concepts known by all the entities participating in the agreement. So, if O_i is the set of all the ontologies known by the entity E_i participating in the agreement Ag $(i = 1..n)$, then $D = \{o/o \in O_i \triangle O_k, \forall i \neq k/i, k = 1..n\}$ (the symmetric difference of all the agreement participating entities' ontologies). The Agreement Discourse Universe of Ag is defined as $ADU(Ag) = \bigcup_i O_i - D$

The ADU is formed by all the concepts that at least one pair of entities participating in the agreement share. If this set of concepts is empty, entities have not anything in common and they can not reach any kind of agreement.

The process of an agreement Ag has two phases:

1. Reaching an agreement (defining the agreement context Cx): It comprises the negotiation process between two or more entities (belonging to E) to reach an agreement. In fact, this agreement is decided in two levels. The first one, to take a decision about what are the concepts around which such agreement is going to be related, that is, $Cx \subseteq ADU(Ag)$. After that, the specific terms of such agreement must be fixed, that is, the values or intervals for the concepts in Cx.

2. Agreement execution: In this phase, each entity must fulfill the accomplished agreement executing the needed actions or calculus according to the context defined by such agreement. This execution could not even imply any kind of additional coordination.

An agreement can be seen as the definition of a common context. In this way, an space metaphor such as the one used in Context Spaces [3] can be used to express such contexts. So, in the same way an application context space is defined, an *agreement space* can be defined.

Definition 3 (Agreement Discourse Space –ADS–): of an agreement Ag is defined by considering as a dimension (in an Euclidean space) each concept included in an ADU of an agreement Ag.

That is, the ADS of an agreement Ag is an n-dimensional space, where n is the cardinality of the ADU of Ag (number of common terms).

According to the first phase of an agreement, a decision must be taken about the concepts, that is, the dimensions in which the agreement will be expressed.

Definition 4 (Agreement Space –AS–): is a projection of the ADS onto the dimensions defining the agreement. That is, this space will be defined by the features the different entities E_i making the agreement are going to negotiate, each one of such features defining a dimension in this space ($\forall i : d_i \in dim(E_i, Ag)$).

In order to be possible an agreement Ag, for each entity E_i participating in it there will exist at least one other participating entity E_j so that $dim(E_i, Ag) \cap dim(E_j, Ag) \neq 0$. The AS is, then, the result of eliminating the unnecessary dimensions that are not relevant for the agreement. In this way, the outcome of the first phase of the agreement will be the definition of this AS, fixing the satisfying values for each one of the different dimensions comprising this space. In this way, the second phase of the agreement will be to carry out the execution of the agreement taking into account that it has to be carried out inside the previously defined AS.

Definition 5 (Local Agreement Space): for entity E_i in the agreement Ag is defined as the projection over the dimensions of interest of entity E_i in such AS.

3. AGREEMENT SPACES FOR COUNSELORS

After the AS is defined, the different entities involved in the agreement must fix some concrete values or intervals for the different AS dimensions. These satisfying intervals may be expressed as constraints for the different dimensions that should be satisfied for the agreement. So it can be seen as the solution of a CSP, defined by the whole set of constraints. The *agreement counselor* should be able to detect if an agreement is possible, taking into account if there exists an AS as a result of all these constraint planes intersection.

An AS is the solution space of a CSP and an agreement is built by applying entities' conditions as constraints in the space (applying the $HSA \neq$[4] algorithm). A solution is reached if all constraints are consistent. Furthermore, if the resulting space is convex then it can be ensured that all interactions are inside the AS.

An Agreement Space (AS) is defined by a set of entities and their context (E, Cx), where the context is composed by variables, their domains an all the constraints.

Definition 6 (Agreement Space): is formed by: (i) a finite number of entities $E = E_1, \ldots, E_m$; and (ii) a context defined by: (ii.a) a finite set of n variables $x_1, \ldots, x_n$; (ii.b) n sets $D_1, \ldots, D_n$ that, for every $i = 1, \ldots, n$, D_i is the *domain* of x_i; and (ii.c) a finite number of constraints, where each constraint $C_{i_1,\ldots,i_m}$ is a subset of some Cartesian product $D_{i_1} \times \ldots \times D_{i_m}$, $m \leq n$, where all i_j are different; $C_{i_1,\ldots,i_m}$ is a constraint on the variables $(x_{i_1}, \ldots, x_{i_m})$.

The AS has to be a convex set of points and it can be seen as the *convex hull* of the space defined by the constraints. There are well known algorithms that calculate the convex hull of a set of points in n dimensions[1].

The *Counselor* would choose a more or less risky approach to keep the agreement space convex, according to different kind of mediation strategies, or depending on the kind of process of negotiation used. Convex spaces are interesting due to the fact that any point between two points belonging to a convex space also belongs to that convex space.

The Counselor has the responsibility of helping the participants in the agreement to find the AS. It is an iterative process that adds new constraints one by one, guaranteeing that the new constraint is consistent with the previous ones. The set of all constraints defines an hyperpolyhedron which union defines the limits for the valid values for all the variables involved in the agreement. Consistence and redundancy are checked using the $HSA\neq$ algorithm. When a new constraint C_i arrives, the algorithm checks if each vertex of the current hyperpolyhedron satisfies C_i. If none vertex satisfy C_i then the constraint is inconsistent and it is rejected. On the other hand, if all vertexes satisfy C_i then the constraint is redundant. In any other case, the constraint is consistent and it is added to the hyperpolyhedron.

When all constraints are added to the AS and the resulting set is not empty then there is an agreement among all the participants. If the AS is not empty, then it is ensured that it is convex due to the construction process, so any 'movement' between two points inside this space is always inside it. Therefore, it is guaranteed that any negotiation process produced inside the agreement terms will never violate the agreement.

4. CONCLUSIONS

Context Spaces seem to be a valid approach to model agreements using CSPs techniques to reach agreements and to control their executions. The agreement is modeled as an object in the Euclidean space.

The conjunction of all the agreement restrictions will define an hyperpolyhedron delimiting the *agreement space*, that is, the space where all the computations fulfilling such agreement will be carried out, the *context* of such computations. As the agreement context is defined, it is very interesting that the resulting hyperpolyhedron defines a convex space, so the evolution of such space can be more flexible.

Counselors can be used during the negotiation process to reach an agreement to check that any additional constraint keeps the convexity of the space, along with controlling the feasibility of the agreement.

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