Agent-based agreement over concept meaning using contrast sets

Kemo Adrian [a,b] Enric Plaza [a]
[a] *IIIA, Artificial Intelligence Research Institute*
CSIC, Spanish Council for Scientific Research,
Campus UAB, 08193 Bellaterra, Catalonia (Spain) enric@iiia.csic.es
[b] *Universitat Autònoma de Barcelona, kemo.adrian@iiia.csic.es*

Abstract. We develop a model for 2 agents to reach agreement over concept meaning in specific contexts. The model is based on an argumentation-based communication that engage the agents in a process of mutual adaptation using argumentation to reach an agreement over concept meaning. Our approach is to model concept meaning using the semiotic triangle and the notion of contrast sets. We implement and evaluate present three common sense scenarios where two agents argue and reach agreements over the contextual meaning of concepts.

Keywords. Multiagent systems, shared semantics, agreement technologies

Introduction

Languages are a way to exchange information. However, those languages are used in a particular perspective and follows particular rules that determines the meaning of linguistic signs. If either the perspective or the rules are not completely shared by two speakers it can lead to a disagreement over the meaning.

Our long term research goal is to develop a computational model of contextual meaning agreement in a multiagent system (MAS) setting. Our assumption is not only than meaning is context-dependent, but an agreement on meaning is often negotiated among participating agents in a specific context. The approach we take is that two agents, using argumentation-based communication, can detect misunderstandings (disagreements), and engage in a process of mutual adaptation, also using argumentation, to reach an agreement over meaning (with respect of the concepts used in some context). In order to do so, we implemented agents with contrast sets. A contrast set contains different segregates of the environment [2], each of them linked to a particular sign. Each contrast set is associated to a particular social context. To model the process of argumentation, we choose to represent our signs as a part of a semiotic triangle [5] along with an intensional and an extensional definition. Using the semiotic triangle with the argumentation theory [3] we show that it is possible to solve disagreements in several basic scenarios, including synonyms and hyponyms, by creating new contrast sets.

The structure of this paper is as follows: we start by presenting the motivation of our goals and the main background notions we use (semiotic triangle and contrast set), then Section 2 presents our approach to reach those goals in a set of limited scenarios, that are later explained in Section 3, where we also explain the results of a prototype implementation. The closes with a discussion on the current approach and future work on more generic scenario.

1. Motivation

Our approach to model contextual meaning is based on the notion of *contrast set* developed in ethnographic studies of how people actually use (give meaning to) words [2]. A contrast set is a collection of segregates, and a *segregate* is a "terminologically distinguished array of objects". For instance, a buyer can enter an eatery and ask "What kind of sandwiches ya got besides hamburgers and hot dogs?", to which the seller responds "How about a ham 'n cheese sandwich?". Here the collection of words describing the different kinds of products one can eat are the contrasts set: hamburgers, hot dog, ham 'n cheese sandwich, etc. However, the way one person segregates and the word or sign used to reference them is contextual, which can lead to misunderstandings that will require, to be resolved, some adaptation of the intended meaning. An example of misunderstanding (from [2]) is the client complaining with a sentence like this: "Hey, that's no hamburger; that's a cheeseburger!". The origin of the misunderstanding is that the client is considering *hamburger* and *cheeseburger* as two different in the contrast set he is using to conceptualize the eating options, while the common (or default) meaning of cheeseburger is that it is a *kind of hamburger*.

The "meaning as usage" paradigm comes from Wittgenstein's *Philosophical Investigations*, and is the underpinning of ethnographic notions like a contrast set in a particular context or language game. We will approach this large problem in a limited way, in scenarios where agents can negotiate an agree on meaning by building new contrast sets in a new context.

As a running example of context-dependent meaning we will use the common sense domain of *Furniture Shopping*. Let's assume they have some default meaning of some concepts (often called Ontologies in Artificial Intelligence), for instance about furniture. If we ask the agents before they interact if an armchair is a chair they would probably answer affirmatively. For our purposes, we can set that armchair is a sub-concept of the chair concept. Now, imagine the buyer enters the shop and tells the seller this: "I wan to buy one armchair and four chairs". If the seller understands the meaning intended by the buyer no misunderstanding arises, and the will keep talking about "chairs" and referring to particular objects in the shop that are "chairs" without any disagreement on any specific object. And, nevertheless, they are not using "chair" as the same concept as before: now the concept chair in fact means "chairs without arms". This so because the buyer has created the contrast set {*armchair*, *chair*}, and by doing so he has (implicitly) decided to use the word "chair" with a new intended meaning. If the two agents consistently use the term "chair" to refer only to objects in the shop that are chairs and are not armchairs, we say they have achieved an agreement on meaning. This "shift" in the meaning of a term or word is so pervasive that we humans are hardly aware of it, but we would consider very wrong if the seller tried to sell three armchairs and two chairs without arms (which is consistent with the default meaning of chair and armchair).

Now, the issue we need to address is how to represent concept meaning in a way that allows us to have a computational model in which this "shift" in the meaning by creating contrast sets. The approach is semiotic, in which a *concept* is represented by a semiotic triangle $\langle S, I, E \rangle$ with three components: a sign S, a meaning (or *intensional definition*), and an object or reference (or *extensional definition*) [5]. In this view, a sign like "chair" can have two different meanings in the *Furniture shopping* scenario by being in two different semantic triangles. What we called the default meaning is that often found in dictionaries and ontologies, that specifies the typical or more frequent sense of a sign like "chair", and could be expressed in a semiotic triangle $\langle$ *"chair"*$, I, E \rangle$ where I is the default meaning of chairs (including armchairs and other sorts of chairs), and E is the objects that can be referred to by that sign. However, after the buyer introduces the new contrast set {armchair,chair}, the meaning of the sign "chair" needs to change. In the *Furniture Shopping* scenario, the agreed meaning of that sign can be expressed in a new semiotic triangle $\langle$ *"chair"*$, I', E' \rangle$, where now the agreed meaning I' is that of chairs without arms (because when referring to those the agents would use the "armchair" sign); moreover, the set of objects that are reference of the sign is also changed, since E' is about objects that are chairs but not armchairs.

Specifically, our computational model will assume two agents with possibly different contrast sets, and we assume that each term in a contrast set is a sign S_1 are represented as a semiotic triangle, in which the segregate corresponds to extensional definition E_1 of that triangle. Moreover, disagreements and negotiation of an agreement over meaning will be performed by an argumentation-based communication between two agents, explained in Section 2.

1.1. Related work

Ontology alignment has been studied on database schemas, XML schemas, taxonomies, formal languages, entity-relationship models, and dictionaries. Formally, while matching is the process of finding relationships or correspondences between entities of different ontologies, alignment is a set of correspondences between two (or more) ontologies (by analogy with molecular sequence alignment, according to [1]). Thus, the alignment is the output of the matching process.

There are two families of approaches to ontology alignment: (1) syntactic approaches establish matchings among predicates, terms or other structural properties of a formalism, essentially focusing on a notion of similarity; semantic approaches establish logical equivalence correspondences among ontology terms, essentially focusing on a notion of semantic equivalence —in the logical sense of "semantic". We propose a third approach, a semiotic viewpoint that takes into account both the extensional and intensional definitions of a concept. Moreover, we have an agent-based approach: here each concept mapping is performed inside each individual agent, not by a third party comparing two (external) ontologies. Finally, we do not deal with files specifying a set of concepts (ontology), as is the

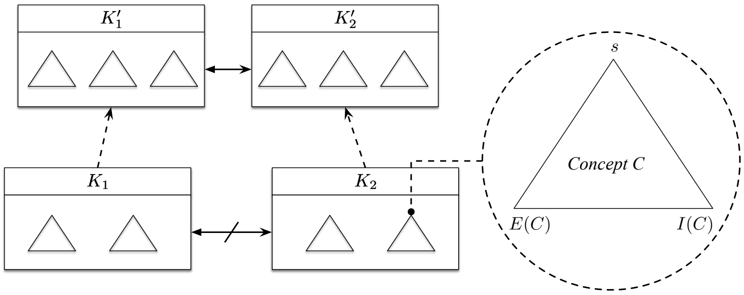

Figure 1. A contrast set is a set of concepts that partition a domain of examples. To mutually adapt their meaning of concepts, each agent can create a new contrast set (in addition the old one) that allows it to reach an agreement over the meaning of a concept that arises a disagreement in the old contrast set.

common approach, we deal with agents that argue and agree over concepts based on how the concepts are *used* in a particular context. Indeed, the present work expands the agent-based "concept convergence" approach in [3], where argumentation and agreement among was not contextual and focused on a single, isolated concept, not a contrast set.

2. Approach

In this section we will present with more details the general ideas introduced in the previous part. Then, we will describe the argumentation protocol which allows the mutual ineligibility between speakers (agents) in different scenarios where the meaning is context dependent.

2.1. Concepts and Contrast Set

As we said, a concept C_i is understood as a semiotic triangle, i.e. composed of a sign s_i, an intensional definition $I(C_i)$ and an extensional definition $E(C_i)$. We use the notation $C_i = \langle s_i, I(C_i), E(C_i) \rangle$ to represent a concept C_i (Fig. 1). $E(C_i)$ is understood as the set of objects or examples known by the agent as belonging to concept C_i. The intensional definition $I(C_i)$ contains a set $\alpha_1 \dots \alpha_m$ of generalizations such that $\forall e \in E(C_i), \exists \alpha \in I(C) : \alpha \sqsubseteq e$ and $\forall \alpha \in I(C), \exists e \in E(C_i) : \alpha \sqsubseteq e$. We will use the notation $I(C_i) \sqsubseteq e$ when there is a generalization in the intensional definition that subsumes the example e, and to say that an example belongs to the concept which sign is s_i we will also use the notation $s_i \sqsubseteq e$.

We introduced the notion of contrast set as a collection of concepts that induces a partition on a domain; we will now define a contrast set in which concepts are represented by the semiotic triangle with our terminology. A contrast set K consists of a collection concepts $K = (C_1, \dots C_n)$, with a collection of signs $s(K) = (s_1, \dots, s_m)$, a collection of intensional definitions $I(K) = (I(C_i), \dots, I(C_m))$, and set of examples $E(K) = E(C_1) \cup \dots \cup E(C_m)$ belonging to those concepts. Since a contrast set determines a partition of the elements in $E(K)$, now each intensional definition $I(C_i) \in I(K)$ has to comply with the following property: $\forall e \in E(K) \setminus E(C_i) : I(C_i) \not\sqsubseteq e$ —i.e. the generalizations in $I(C_i)$ shouldn't subsume an example also subsumed by a generalization from an intensional definition of another concept in the contrast set.

To explore the notion of agreement over the meaning, we use a scenario with two agents that have individual (and possibly different) contrast sets over the same domain. The agents jointly observe new elements in this domain, and categorizing elements in one of the concepts of their individual contrast sets. Disagreement arises when the *signs* of the concepts in which an element is categorized are different. Upon disagreement, the agents engage in an exchange of arguments to adapt their individual contrast sets to one another until the disagreement is solved. This is an iterative process in which both agents build two new contrast sets that are closer: $K_1 \xrightarrow{adapt} K_1' \rightleftarrows K_2' \xleftarrow{adapt} K_2$ (see Fig. 1 and Fig. 2).

2.2. Communication Protocol

We assume that our agents already share the language $\mathcal{L}$ and are able to exchange information trough a communication protocol that we will specify in the next section using messages from the following list:

- *Assert*(s, e): this message asserts that the sending agent considers e to be an example belonging to the same concept as the sign s ($s \sqsubseteq e$).
- *Accept*(s, e): this message asserts that the sending agent agrees on fact that e is in the concept whose sign is s ($s \sqsubseteq e$).
- *Refuse*(s, e): this message asserts that the sending agent disagrees on fact that e is in the concept whose sign is s ($s \not\sqsubseteq e$).
- *Ask*(s, e): this message asks to the other agent which generalization, in the concept whose sign is s, subsumes e.
- *Answer*(s, β, e): sends the generalization β, in the concept whose sign is s, that subsumes e ($\beta \sqsubseteq e$).

In order to explore the possibilities offered by the use of contrast sets, we implemented three different scenarios that we present in the next part. We will now present the protocol used by two agents to build and organize their contrast sets in order to achieve a mutual agreement. A sketch of the protocol is as follows:

1. The two agents are waiting (*Initial state*)
2. An example e_x is presented to the agents. Each agent A_i categorizes the example with a sign s_i and sends *Assert*(s_i, e_x) to the other agent.
3. Each agent verifies whether the received sign s_j is in its contrast set. If the sign is unknown the agent goes to step 5, otherwise they go to step 4.
4. Each agent verifies whether $s_j \sqsubseteq e_x$ in its individual contrast set:
    - if it is true, the agent has no disagreement over the meaning of s_j ($s_i = s_j$) and sends the message *Accept*(s_j, e_x). The the agent goes to step 1.
    - if it is not true, the two agents are going to create new concepts in order to reach an agreement over the contextual meaning of the sign used. They go to step 5.

5. There is at least one agent which does not know one of the exchanged signs, e.g. s_i, then this agent sends a message $Ask(s_i, e_x)$ to the other agent.
6. The other agent sends back an $Answer(s_i, \alpha_m, e_x)$ where α_m is the generalization that subsumes e_x ($\alpha_m \sqsubseteq e$).
7. The agent that did not know s_i uses the received generalization α_m to check if the unknown sign is a synonym or an hyponym of an already-known concept $I(C_j)$ (more details are given at the end of the scenario):
   - in case of synonymy, the agent creates a new concept for the sign s_i.
   - in case of hyponymy, it creates two new concepts; one for s_i (the unknown sign) and one other for s_j (the sign this agent sent when categorizing e_x).
   - otherwise, the agent sends a $Refuse(s_i, e_x)$.
8. The agent incorporates those concepts:
   - if no new contrast set has been created for the current social context yet, the agent creates one and put the new concept(s) into it, while including also the rest of the concepts from the first contrast set that are not affected.
   - if a contrast set has already been created, C_i is removed from it and the new concept(s) is/are added.
9. The agent returns to 3 (although this time they will not disagree at 4).

We will now provide more details about the internal process occurring during the step 7. When an agents receives the message $Answer(s_i, \alpha_m, e_x)$, it starts by creating the set of examples $E(C_i^*)$ that contains all the examples e_i^* from the extensional definition $E(K_l)$ of its current contrast set K_l which verify the property $\alpha_m \sqsubseteq e_i^*$. Then, $\forall C_j \in K_l$:

- if $\exists C_j : E(C_j) = E(C_i^*)$, then the agent recognizes s_i as a synonym.
- if $\exists C_j : E(C_j) \subset E(C_i^*)$, the agent recognizes s_i as an hyponym (Fig. 2).

In the case of a synonym, the new concept created is: $C_a = \langle s_i, I(C_j), E(C_j) \cup e_x \rangle$. Since there is a synonymy, there is no need to change the extensional and intensional definitions from the old concept C_j, except from adding the new example e_x to the extensional definition of course.

However, in the case of an hyponymy, the agent creates a second new extensional definition $E(C_j^{**}) = E(C_j) - E(C_i^*)$. At this point, the agent has created two new concepts, namely $C_a = \langle s_j, I(C_a), E(C_j^{**}) \rangle$ and $C_b = \langle s_i, I(C_b) = \alpha_m, E(C_i^*) \cup e_x \rangle$. After these two concepts are incorporated to the current contrast set we still need to generate the intensional definition of the C_a concept. Now, in order to create this intensional definition $I(C_a)$, we use an argumentation-based inductive learning method [4] that takes set of examples $E(K_n)$ an positive examples, and the rest of examples in the contrast set as negative examples.

3. Scenarios

We present three scenarios to test the agents' ability to reach an agreement over some concept meaning. The examples used during those scenarios are in part of

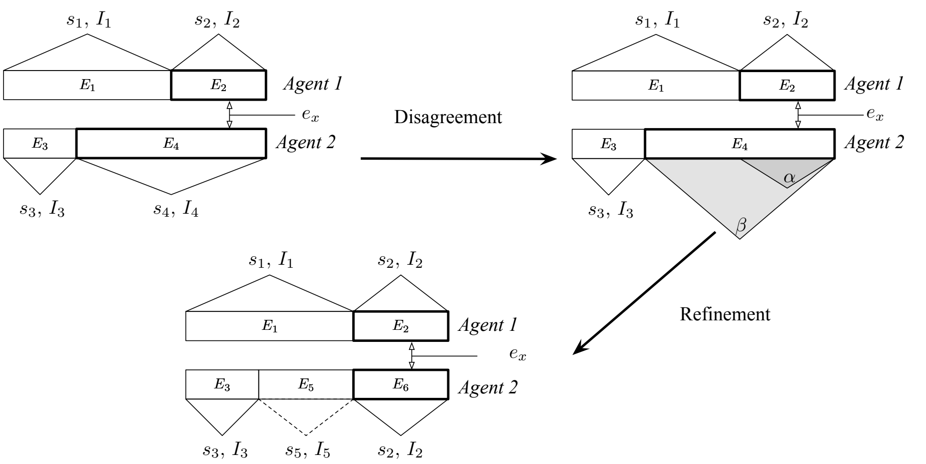

Figure 2. When a new concept is needed, the agent asks the relevant generalization from the other agent's intentional definition of that concept; this generalization (e.g. α) leads to a split of the previous extensional definition E_4 in two: E_5 (examples subsumed by α) and E_4' (the rest).

the common sense domain of *seats*. Specifically, examples of seats are divided in three categories (Chairs, Armchairs and Stools), where we are using their typical definitions: (1) a Stool has no back and no arms, (2) a Chair has a back but no arms, and (3) an Armchair has a back and arms. In every scenario, agents A_1 and A_2 start with their own individual contrast set. Given a new example e_x, they will try to solve their disagreement when it occurs.

3.1. Concept Hyponymy

In the first scenario the two agents have initially their contrast sets K_1 and K_2, shown in Table 1. The first example e_1 presented to both agents is an Armchair. The two agents first send $Assert(chair, e_1)$ in the case of A_1 and $Assert(armchair, e_1)$ in the case of A_2. They both discover a disagreement. The sign $armchair \notin S(K_1)$ so A_1 sends $Ask(armchair\ , e_1)$ to A_2. A_2 responds with $Answer(armchair\ \beta_2)$ since $\beta_2 \sqsubset e_1$. Then, A_1 creates the subset $E(C_6) = \{e_i \in E(C_2) | \beta_2 \sqsubseteq e_i\}$. Since $E(C_6) \neq E(C_2)$, A_1 creates the subset $E(C_5) = E(C_2) - E(C_6)$. No contrast set has been created yet, so A_1 creates a new contrast set K_1'. The new concepts $C_5 = \langle chair, I(C_5), E(C_5) \rangle$ and $C_6 = \langle armchair, \beta_2, E(C_6) \cup e_1 \rangle$ are added to K_1' with the concept C_1. Then, A_1 performs an induction on the new $E(K_1')$ for the sign *chair* that results to the generalization α_3 which is added to $I(C_5)$. Finally, A_1 sends an $Accept(armchair)$.

The second example presented, e_2, is a Chair. The agents send to each other $Assert(chair, e_2)$. Since both agents agree on the use of *chair* as a sign to describe a Chair, they just send to each other two messages $Accept(chair, e_2)$.

The last example e_3 presented to the agents is a Stool. As with e_1, they both notice the disagreement over *stool* and *chair*, but this time $stool \notin K_2$. It leads A_2 to send $Ask(stool, e_3)$ to A_1. Since $\alpha_1 \sqsubset e_3$, A_1 sends back $Answer(stool, \alpha_1)$. Now it is A_2's turn to create a subset $E(C_7) = \{e_i \in E(C_3) | \alpha_1 \sqsubseteq e_i\}$,

Table 1. Initial contrast sets of agents A_1 and A_2

C. set	**Agent 1 contrast set K_1**	
Concept	C_1	C_2
Sign	*stool*	*chair*
$I(C)$	α_1: *no.arm, no.back*	α_2: *with.back*

C. set	**Agent 2 contrast set K_2**	
Concept	C_3	C_4
Sign	*chair*	*armchair*
$I(C)$	β_1: *no.arm*	β_2: *with.arm, with.back*

Table 2. Final contrast sets of A_1 and A_2

C. set	**Agent 1 contrast set K'_1**		
Concept	C_1	C_5	C_6
Sign	*stool*	*chair*	*armchair*
$I(C)$	α_1: *no.arm, no.back*	α_3: *no.arm, with.back*	β_2: *with.arm, with.back*

C. set	**Agent 2 contrast set K'_2**		
Concept	C_7	C_8	C_4
Sign	*stool*	*chair*	*armchair*
$I(C)$	α_1: *no.arm, no.back*	β_4: *no.arm, with.back*	β_2: *with.arm, with.back*

and since $E(C_7) \neq E(C_3)$, A_2 creates the subset $E(C_8) = E(C_3) - E(C_7)$. No new contrast set has been created by A_2, so it creates K'_2. The new concepts $C_7 = \langle stool, \alpha_1, E(C_7) \cup e_3 \rangle$ and $C_8 = \langle chair, I(C_8), E(C_8) \rangle$ are added to K'_2 with the concept C_4. A_2 performs an induction on the new $E(K'_2)$ for the sign *chair*. The resulting generalization β_4 is added to $I(C_8)$. Finally, A_2 sends an *Accept*(*stool*, e_3) to A_1. The contrast sets are now as shown in Table 2. We can now see that K'_1 and K'_2 are mutually intelligible.

3.2. Concept Synonymy

In the second scenario the two agents have initially their contrast sets K_1 and K_2 are as shown in Table 3. The only example e_1 presented to both agents is an Armchair. A_1 sends *Assert*(*armchair*, e_1) to A_2 and A_2 sends *Assert*(*recliner*, e_1) to A_1. It leads to a disagreement from both of A_1 and A_2. Since *armchair* $\notin K_2$ and *recliner* $\notin A_1$ neither, both agents can send an *Ask* message. Let's say that A_1 receives the *Ask* message first; A_1 will respond with *Answer*(*armchair*,

Table 3. A_1 and A_2 contrast sets

C. set	**Agent 1 contrast set K_1**		
Concept	C_1	C_2	C_3
Sign	*stool*	*chair*	*armchair*
$I(C)$	α_1: *no.arm, no.back*	α_2: *no.arm, with.back*	α_3: *with.arm, with.back*

C. set	**Agent 2 contrast set K_2**		
Concept	C_4	C_5	C_6
Sign	*stool*	*chair*	*recliner*
$I(C)$	β_1: *no.arm, no.back*	β_2: *no.arm, with.back*	β_3: *with.arm, with.back*

α_3), where α_3 is the generalization that was used by A_1 to categorize e_1. A_2 creates a new set of examples $E(C_7) = \{e_i : e_i \in E(C_6)|\alpha_3 \sqsubseteq e_i\}$. No contrast set has been created before so A_2 creates K'_2. Since $E(C_7) = E(C_6)$, a new concept $C_7 = \langle armchair,\ I(C_6), E(C_6) \cup e_1\rangle$ is created and added to K'_2 along with C_4 and C_5. *Accept*(*armchair*,e_1) is sent to A_1 by A_2. We notice that if A_1 had been faster than A_2 to send its *Ask* message, it is *recliner* that would have been used to designate an Armchair by both agents. This would not have affect the reach of mutual intelligibility.

3.3. Concept Teaching

This time K_1 is still as it was in Table 3 but K_2 is modified as shown in Table 4. The first example e_1 presented to the agents is a Stool. A_1 sends *Assert*(*stool*, e_1) to A_2 and A_2 *Assert*(*seat*, e_1) to A_1. Since *seat* $\notin S(K_1)$ and *stool* $\notin S(K_2)$, each agent can send an *Ask* message to the other. Let's say that A_1 is the fastest to send its *Ask*(*seat* message, e_1), A_2 sends *Answer*(*seat*, e_1).*any* $\sqsubset \alpha_1, \alpha_2$ and α_3: A_1 sends *Refuse*(*seat,* e_1) to A_2. Now A_2 sends *Ask*(*stool*, e_1) to A_1. A_1 sends back *Answer*(*stool*, α_1). Now A_2 creates the subset $E(C_5) = \{e_i : e_i \in E(C_4)|\alpha_1 \sqsubseteq e_i\}$, and since $E(C_5) \neq E(C_4)$, A_2 also creates the subset $E(C_6) = E(C_4) \setminus E(C_5)$. No contrast set has been created yet so A_2 creates K'_2.The new concepts $C_5 = \langle stool\ , \alpha_1, E(C_5) \cup e_1\rangle$ and $C_6 = \langle seat, I(C_6), E(C_6)\rangle$ are added to K'_2. New generalizations for *seat*, $\beta_3 = with.back$ and $\beta_4 = with.arm$, are learned by induction from $E(K'_2)$ and added to $I(C_6)$.

The second example presented e_2 is a Chair. A_1 sends *Assert*(*chair*, e_2) to A_2 and A_2 *Assert*(*seat*, e_2) to A_1. Again, *seat* $\notin S(K_1)$ and *chair* $\notin S(K'_2)$ so each agent can send an *Ask* message to the other. Let's say that this time A_2 is faster and sends *Ask*(*chair*, e_2) to A_1. A_1 sends back *Answer*(*chair*, α_2) since $\alpha_2 \sqsubset e_2$. A_2 creates a new set $E(C_7) = \{\forall e_i : e_i \in E(C_6)|\alpha_2 \sqsubseteq e_i\}$, and since $E(C_7) \neq E(C_6)$, A_2 also creates the subset $E(C_8) = E(C_6) \setminus E(C_7)$. The new concepts $C_7 = \langle chair\ , \alpha_2, E(C_7) \cup e_2\rangle$ and $C_8 = \langle seat\ , I(C_8), E(C_8)\rangle$ are added to K'_2. The concept C_6 is removed from K'_2. A generalization for *seat*, β_6, is learned by induction from $E(K'_2)$ and put into $I(C_8)$. A_2 sends *Accept*(*chair*, e_2) to A_1.

The last example presented e_3 is an Armchair. A_1 sends *Asset*(*armchair*, e_3) to A_2. Meanwhile A_2 sends *Assert*(*seat*, $_3$) to A_1. Since *seat* $\notin S(K_1)$ and *armchair* $\notin S(K'_2)$, both agents can send an *Ask* and let's say that this time again A_2 is quicker and sends *Ask*(*armchair*, e_3) to A_2. Since $\alpha_3 \sqsubset e_3$, A_1 sends

Table 4. A_2's contrast sets before teaching

C. set	**Agent 2 contrast set** K_2
Concept	C_4
Sign	*seat*
$I(C)$	β_1 : *any*

Table 5. A_1 and A_2 Contrast sets after the last concept learning

C. set	**Agent 2 contrast set** K'_2		
Concept	C_5	C_7	C_9
Sign	*stool*	*chair*	*armchair*
$I(C)$	β_2: *no.arm, no.back*	α_2: *no.arm, with.back*	β_6: *with.arm, with.back*

back *Answer*(*armchair*, α_3). After receiving the answer, A_2 creates a new set of examples $E(C_9) = \{\forall e_i : e_i \in E(C_8) | \alpha_3 \sqsubseteq e_i\}$. Since $E(C_9) = E(C_8)$, a new concept $C_9 = \langle armchair, I(C_8), E(C_8) \cup e_3 \rangle$ is created and added to K_2' while C_8 is removed. An *Accept*(*armchair*,e_3) is sent to A_1. Table 5 shows the new K_2'.

Discussion and Future Work

We have put together for the first time in a computational model the notions of semiotic triangle and contrast sets, coming from very different fields of study, namely semiotics and ethnographic studies. We have shown how these notions can be given a computational model to represent concepts and the adaptation of concept meaning in particular contexts. We have also shown that message passing communication among agents can be understood as arguments exchanged between the agents that trigger the necessary changes for adaptation. However, we made certain assumptions to simplify the types of disagreement that may arise. For this reason, the communication protocol only considers a limited number of disagreements can arise, as shown in the "simple" scenarios presented. Nevertheless, the experiments show that a range of common scenarios in contextual meaning adaptation are within the scope of the current approach (concept refinement, synonymy detection).

There are three lines of future research that extend beyond the current assumptions. The first one is that the two contrast sets may have overlapping extensional definitions of concepts, a situation we assumed did not happen in our simple scenarios. This would allow a more complex argumentation model, where counter-arguments and counter-examples of one agent can attack the arguments of the other agent. A second line of research is having several levels of contrast set with different granularities (i.e. a taxonomical terminology). The third line of research is a recursive approach, in which specific predicates in $\mathcal{L}$ may also be unknown or not agreed-upon, e.g. they disagree on what constitutes of not an *arm* of seat, and then agents may initiate a new a dialogue to achieve an agreement over meaning. After this agreement is reached, the agents can return to the higher level dialogue.

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