Creating Human-Machine Synergy in Negotiation Support Systems: Towards the Pocket Negotiator

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ABSTRACT

Negotiation is a complex emotional decision-making process aiming to reach an agreement to exchange goods or services. Although a daily activity, few people are effective negotiators. Existing support systems make a significant improvement if the negotiation space is well-understood, because computers can better cope with the computational complexity. However, the negotiation space can only be properly developed if the human parties jointly explore their interests. The inherent semantic problem and the emotional issues involved make that negotiation cannot be handled by artificial intelligence alone, and a human-machine collaborative system is required. This interest paper presents research goals, ideas, challenges and an approach towards creating the next generation of negotiation support systems.

Keywords

Negotiation, artificial intelligence, human computer interaction, situated cognitive engineering.

INTRODUCTION

Everyone is an experienced negotiator and everyone has an opinion about their negotiation skills. However, even professional negotiators can still improve their skills considerably. "*Most people are ineffective negotiators … Fewer than 4 percent of managers reach win-win outcomes when put to the test … Even on issues for which people were in perfect agreement, they fail to realize it 50 percent of the time*," writes Thompson (2005).

Negotiation is a prime example of a task for which the human mind is but partially equipped, and for which artificial intelligence can only provide partial assistance. Computational power, data storage, search techniques, computational heuristics to tackle exponential problem spaces, are among the good products of AI. However, AI has not solved the problem of the huge amount of knowledge necessary to cope with, and understand arbitrary conversations and problems. The complexity and the variability of the problems humans wish to address are just too much to handle. We, therefore, propose to develop a new type of human-machine collaboration in which the human weaknesses are covered by the strengths of the machine, and the weaknesses of the machine are covered by the strengths of the human.

Humans and computers have to some extent complimentary capabilities for negotiation. In our opinion this implies that tasks should be divided over humans and machines in a way that respects those capabilities. Humans are better equipped to understand the context and the emotional fluctuations in human-human interaction, they are capable of finding new relations between concepts, and they have the necessary background knowledge to interpret the domain of negotiation with respect to their own preferences. On the other hand, humans can be troubled by emotions, and have difficulty with handling the complexity of negotiation spaces. For computers it is almost the other way around, even though the computer can be provided with extensive knowledge on specific topics, and are capable of searching through huge amounts of data.

To allow human and support system to cooperate at the required level of competence, they need to share an abstract model of the task at hand (negotiation), and they need to share detailed models of the domain of negotiation (e.g., real estate), the user model, and the opponent model; together called the DUO-models. Such models can only be shared if they reflect the cognitive models of humans. Research has shown that quantitative models do not reflect the cognitive models. Cognitive models are much more qualitative of nature (Newell, 1990). Therefore, we need to develop models that properly reflect the cognitive models, and can be shared with the user.

In the same sense we need to develop the technology to share a generic task model of negotiation with the user. This generic task model describes negotiation along the lines of the next sections in this paper, and in particular the idea and use of the DUO-models. Once the generic task model of negotiation is shared, system and user share the responsibility to create, and update shared

DUO models of the negotiation at hand. Maintenance of the DUO-models is important, as such models typically change over time.

In our opinion this requires a system development method that combines situated cognitive engineering (Neerincx and Lindenberg, 2008) with artificial intelligence and negotiation as the main disciplines. We deem the development of shared task models (Brazier, 2000) qualitative content models, and the support of humans in coping with emotions due to human-human interaction fundamental for success. These models together properly reflect the way that humans represent problems and reason about them. The shared task models are essential for team work and serve as the backbone of the system; they form the basis of the explanation facilities and task division over user and system, and steer the content modelling process.

This multi-disciplinary approach opens up a new line in intelligent support systems in which human weaknesses are covered by machine strengths and vice versa. In particular, this paper presents the underlying hypotheses and research & development approach for creating a Pocket Negotiator (PN) that can function on a handheld device or laptop to support human laymen negotiators.

Our vision is to create the Pocket Negotiator for integrative bargaining (Walton, 1965) that enhances the negotiation skills and performance of the user by increasing the user's capacity for exploration of the negotiation space, reducing the cognitive task load, preventing mental errors, and improving win-win outcomes. We intend to devise a negotiation model that matches human cognitive representations of negotiation, and develop methods and tools to support humans in coping with emotions.

The rest of the paper is organized as follows. We first briefly summarize the negotiation process in the next section and discuss some of the problems humans face in negotiation thereafter. We then proceed by introducing an outline of an architecture for a negotiation support system aimed at supporting humans in resolving these problems. The main challenges that need to be addressed to implement this architecture are discussed, and an approach to do so is briefly sketched.

NEGOTIATION IN PHASES

Fisher and Ury (1981, 2003), Raiffa (2002), Thompson (2005) and others emphasize that negotiation is not just about money, but also about good relationships, awareness of all issues (domain model), personal preferences (user and opponent model), knowledge of your alternatives (if no deal is reached), and reflection on your performance.

In integrative negotiation four major stages can be discerned: private preparation, joint exploration, bidding, and closing (see Fig.1).

Private preparation

Private preparation is predominantly a stage of information gathering and reflection done before meeting the other party. The negotiator learns as much as possible about the negotiation domain (issues under negotiation, and hidden interests), the coming process, about his profile and about the opponent. Hidden interests are aspects that might not be mentioned, but that do have an impact, e.g., is one of the parties under time pressure?

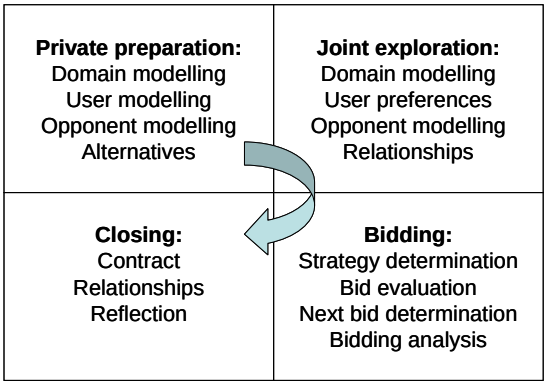

Fig. 1 Negotiation Stages

In all phases other than private preparation, the negotiator is in communication with the negotiation partner. Perhaps due to the need to protect one's interests, negotiation inherently has an aspect of conflict management (Fisher, 2003; Thomas, 1992). Having insight in their conflict-handling style and that of their opponent can help negotiators to predict possible sources of conflict, and ways to avoid or alleviate conflict. Research that can help in this issue, is that surround the well-known Dual Concern Model of Pruitt (1986), see Fig. 2.

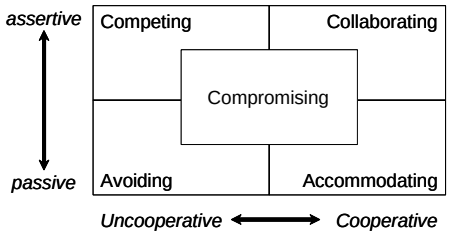

Fig. 2 Dual Concern Model

Joint exploration

In this stage the negotiating parties talk to each other, but don't place bids on the table. The aim of this stage is to check the information they gathered so far, to create a good atmosphere for the bidding that will follow, to make the negotiation space as big as possible, and to agree upon a protocol for the bidding, e.g., turn-taking by phone.

Bidding

During this stage both negotiators exchange bids according to some protocol, typically a turn-taking protocol. For each incoming bid the negotiator has to decide, whether to accept (if he expects no more improvements can be made), to make a counteroffer (if he thinks he can do better), or to stop (if he thinks he has a better alternative elsewhere). The bidding ends when a party accepts a bid or stops.

Closing

During the closing stage the outcome of the bidding stage is formalized and confirmed by both parties. If confirmation turns out impossible, the negotiation returns to one of the previous stages.

Overall, negotiating is an emotional process, certainly for the novice negotiator (Fisher and Shapiro, 2005). The more that depends on the outcome of the negotiation, the more intense the emotions. For example, buying a house for the first time, or negotiating about a job contract, can be intense. This is partly caused by not feeling in control of the situation, not knowing what to expect, and fearing not to perform well enough (Lazarus, 1984; Ursin, 2004).

HUMAN PROBLEMS WITH NEGOTIATION

In this section we address the most important problems from two perspectives: an outcome perspective, and a process perspective. Some of the remedies proposed in the literature are presented to determine the type of support a Pocket Negotiator needs to offer. The outcome related pitfalls in negotiation discussed here are based on Thompson (2005) and Harvard (2003):

- *Leaving money on the table*: when negotiators fail to recognize and exploit win-win potential. This means that a potential outcome exists that would be better for both parties.
- *Settling for too little*: a negotiator may make too large concessions thereby agreeing to a too-small share of the bargaining pie.
- *Rejecting a better offer than any other available option*: this happens when a negotiator ends a negotiation even though the offer provided by the opponent is better than other options available to the negotiator when no agreement is reached, and
- *Settling for terms worse than alternative options*: this happens when negotiators feel obliged to agree to an offer that is worse than other alternatives.

The pitfalls from the outcome perspective are caused by problems occurring during the negotiation process. In the literature, the following aspects are recognized:

- *Lack of training*

Humans have difficulty in structuring negotiation problems and thinking creatively about such problems. Moreover, just negotiating in practice does not alleviate these problems due to faulty feedback and self-reinforcing incompetence. Faulty feedback refers to the problem of not getting accurate, immediate, and specific feedback, which can only be solved through regular training. Self-reinforcing incompetence means not being aware of ones limitations, thus not seeing the need to improve ones skills.

- *Lack of preparation*

Preparation is insufficient when it leaves the negotiator unaware of an important part of the bargaining pie and/or the preferences and circumstances of the parties involved (including himself).

- *Structural barriers to agreement*

This refers to such problems as: die-hard bargainers, a bad atmosphere, power imbalance, cultural and gender differences, disruptive people or incommunicative people at the table, and a lack of information. The last point can be caused by insufficient preparation, but also by communication problems.

- *Mental errors*

Parties commit mental errors such as the escalation error, biased perception, irrational expectations, overconfidence, and unchecked emotions. The escalation error is the continuation of a previously selected course of action beyond the point where it continues to make sense. Biased perception is the problem of perceiving the world with a bias in your own favour.

- *Satisficing*

Due to uncertainty of the future, the costs of acquiring information, and the limitations of their computational capacities people have only bounded rationality, forcing them to make decisions by satisficing, not by maximization.

According to the literature, except for the satisficing problem, these problems are reduced by proper preparation, an effective negotiation style, a good dialogue with the opponent, timely interventions (such as introducing a break), and training. The vision we promote here is that a human-machine collaborative system, the Pocket Negotiator, that supports the user in all stages of negotiation, may reduce the effects of these problems. We intend the Pocket Negotiator to work together with the user to create the content models, to prepare the user for the interaction with the opponent, to offer assistance if problems arise in the user-opponent interaction, and to offer bidding advice.

NEGOTIATION FROM A TECHNICAL PERSPECTIVE

Two areas of research related to negotiation software can be distinguished: negotiation support systems (NSS) and automated negotiating agents (ANA). Whereas the focus of the former type of software is on enabling a user to negotiate by means of structuring the process and possibly by offering analysis support, the latter type of software is aimed at automating (parts of a) negotiation completely. We believe that in order to resolve some of the fundamental problems faced by

humans in negotiation it is beneficial to integrate both types of research in a PN, and we briefly discuss each. We conclude with a high-level proposal for a software architecture that is capable of supporting a human in negotiation and resolving some of the problems faced. In the next Section, we present a number of key challenges that need to be addressed in order to realize this PN architecture.

Inspire (http://interneg.carleton.ca/inspire/) is a Web-based negotiation support system. It contains a facility for specification of preferences and assessment of offers, an internal messaging system, graphical displays of the negotiation's progress, and other capabilities. It has been used to support humans in negotiation as well as to collect data about such negotiations for research purposes. One of the main benefits of Inspire is its ability to offer the user a structured approach to prepare and engage in a negotiation, and its use as a training tool. Another NSS example is provided by *Athena* (www.athenasoft.org) that has been primarily used in education. As is the case for *Inspire*, users of *Athena* have to build content models themselves. That is, preferences are elicited from the user which has to provide the domain structure as well. The provided support does not include predefined repositories of content models, interaction support, or assistance in selecting a bidding strategy. As a final example, *Smartsettle* (http://www.smartsettle.com) is a commercial negotiation support system that also provides bidding support. Interestingly, while other systems keep offers and demands hidden, *Smartsettle* displays proposals and suggestions to all parties.

The past decade various models for automated negotiating agents have been proposed and many results on the performance of such agents have been published (Jonker, 2001; Meyer et al, 2004; Rahwan et al, 2005; Büttner, 2006; Hindriks et al, 2007). The research has mainly focussed on devising strategies, protocols, and negotiation languages, i.e. languages to represent negotiation domains (Rosenschein and Zlotkin, 1994; Kraus, 2001; Tamma et al., 2005). Among others, it has been demonstrated and replicated that automated negotiating agents may obtain significant improvements over the outcomes obtained by humans (see e.g., Bosse, 2005). Additionally, learning techniques have been developed to learn the preferences or the strategy of the other party (see e.g. Olivier, 2005). Such techniques may also be useful for eliciting preferences.

The vision outlined here is that by combining the results of both research areas in a PN the support offered to a negotiator can be significantly improved. Human negotiator and machine need to team up to achieve this. We therefore propose to make a task division between the user and the machine that is based on the strengths and weaknesses of both. Whereas humans have general world knowledge, and prowess in communicating with other humans, a system can be provided with a wealth of general knowledge about negotiation, about some specific domains, and may help in improving the utility of an agreement (and as such may assist to avoid the satisficing problem). A complete automation of human capabilities is clearly impossible, as, for example, the general world knowledge involved is too complex. To ensure optimal team work, user and system need to share a generic model of negotiation consisting of a task model and a meta-model of the content models. In the approach proposed, the content models consist of a *D*omain-, *U*ser-, and *O*pponent-model (DUO-models). It is assumed that the negotiation space is determined by the domain model, which both negotiating parties need to jointly explore to reach an agreement.

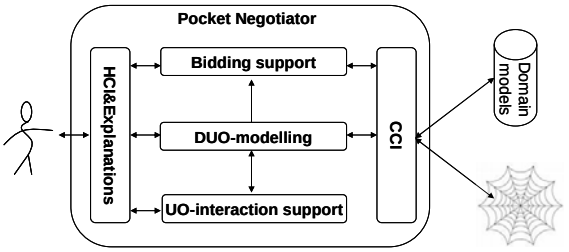

Fig. 3 Pocket Negotiator Architecture

An architecture, based on Jonker (2001), for the PN is outlined in Fig.3. It consists of five components. During all negotiation stages the *DUO-modelling component* is responsible for maintaining adequate and up to date DUO-models. The DUO-models can be inspected and adapted at all times. The history of these models, including the history of bidding is maintained as well.

The *UO-interaction support component* assists the user in his interaction with the opponent, providing support to e.g. cope with emotions of user and opponent, and offering suggestions for questions and remarks to prepare for this interaction.

The *bidding support component* provides support during the bidding phase: advising on bidding strategies, providing bid proposals, evaluating bids made by the opponent, and presenting an overview of the bidding history to get more insight in the progress (or lack thereof) of the negotiation.

Multi-modal interaction with the user for the benefit of all functionality of the PN is handled by the *HCI&Explanations component* according to his specific user requirements. Functionality should be provided here to elicit the preferences and hidden interests of the user. This component is also made responsible for offering a sophisticated explanation environment to explain the negotiation process and pitfalls, and the functionality of the PN. It also provides explanations to the user about negotiation- and conflict-handling styles, thus making the user aware of his conflict-handling style (Thomas, 1992), his mental model of negotiation (Boven, 2003), and what effects such styles can have on the other party.

Finally, interaction with other software, e.g., PNs, shared repositories of domain models, and other sources of domain information, e.g., Wikipedia, is handled by the *CCI (computer-computer interaction) component*.

CHALLENGES

The long term challenge is to research and develop human-machine collaborative systems to increase overall performance in which human weaknesses are covered by machine strengths, and vice versa. The main challenge for NSS thus can be formulated as:

The research and development of human-machine collaborative systems in which the strengths of user and machine are combined, the weaknesses reduced, and the overall performance is improved. For this purpose, we envisage the need to develop new concepts and techniques to be integrated in a negotiation support system (such as the PN) that teams up with the user to enhance his negotiation performance.

We have derived four more specific research challenges from this challenge: the development of (i) a shared generic model of negotiation, (ii) user-opponent interaction support, (iii) elicitation of DUO-models and explanation, and, (iv) bidding support. The shared generic model is to underlie the overall architecture and functioning, the other challenges correspond to specific components.

Shared Generic Model of Negotiation

The first challenge is to develop a generic model of negotiation that is shared by professional negotiators in the sense that it contains descriptions of the negotiation process, and generic descriptions of DUO-models that correspond to human cognitive representations. We need to find techniques to construct such models by the cooperation of user and PN. Furthermore, the PN must be able to reason with qualitative specifications of the negotiation domain and preferences.

Existing negotiation support systems are based almost exclusively on quantitative models. Such models do not match human cognitive representations and are difficult to present to the user. The research and development of a shared generic model that is a meta-model of negotiation is expected to provide a major improvement in this regard (Brazier, 2000; Kersten, 1996). Protocols of negotiation will also have to be included in the generic model.

Existing negotiation languages and ontologies do not provide the required expressivity (Kersten, 1996; Tamma, 2005) and research on languages that combine qualitative and quantitative expressions needs to be continued. Furthermore, work like (Boutilier, 2004) must be improved by allowing the user to determine the complete structure of the DUO-models: adding, changing, deleting parts of the qualitative and quantitative information structure, while still respecting the backbone specified by the meta-model. Finally, the reasoning involved in bidding heuristics has to be able to cope with incomplete information of quantitative and qualitative form (Meyer, 2004; Kraus, 2001).

User-Opponent Interaction Support for Negotiation

The second challenge is to develop a knowledge-based system as part of the PN to support the user in his interaction with the opponent. The challenge is to develop a system that can assist the user in his interactions with the opponent: assessing the situation, regulating emotions, and coping with negative consequences of emotions. To meet this challenge a number of problems must be solved: user awareness of the role of emotions and conflict handling styles in negotiations, emotion elicitation, determination of conflict handling styles, and linking emotions to core concerns, and conflict-handling styles to produce advice. It is more difficult to offer support here as so far humans must do most of the interpretation in context; however, at the same time due to emotions, humans may find it difficult to cope whereas a machine will not be similarly affected. We believe that by using a cognitive engineering approach (see below) some of these difficulties can be resolved.

Negotiators should be aware of the role emotions, moods, and interaction play in negotiation (Fisher, 2003; Thompson, 2005). The challenge is to devise a system that successfully makes users aware of this role. The system needs to incorporate general knowledge about emotions, coping styles and mental models. Emotions or moods, for example, are triggered by a conglomerate of factors such as situation, context, interaction with other people, and physical state, see, e.g., (Ursin, 2004). Successful behavioural responses grow into coping styles (Lazarus, 1984) of that individual. The way people interact with each other and cope with emotions in a negotiation context depends on their mental model of negotiation, and their coping- or conflict-handling style. Regarding *mental* models (Johnson-Laird, 1983) of negotiation, five distinct styles have been found that directly affect negotiation performance (Boven, 2003). Having one system in which all such knowledge resides, would already support the user in his corrective processes (Kahneman, 2003), thus preventing mental errors.

Another challenge is that the system needs to be able to elicit information from the user on the emotional state of both the user and the opponent. State of the art techniques in extracting emotion from visual images or spoken dialogue (Chen, 2000) should be tested on their technical and ethical applicability for real negotiations, and for training situations. Tools and techniques need to be devised to elicit information from the user on the conflict-handlings styles of both parties (Thomas, 1992), and on the mental model of negotiation of the user (Boven, 2003).

Finally, negotiation support systems need to link emotions of the user and the opponent to core concerns (appreciation, affiliation, autonomy, status, and role), following Fisher and Shapiro (2005). This knowledge is to form the basis of a tool that provides general coping advice that fits the profile of the user and is relevant for the situation the user is in.

DUO-modelling and Explanation for Negotiation

The third main challenge is the development of human-computer interaction tools and techniques to elicit the DUO-models of negotiation. Furthermore, a method

needs to be researched and deployed to explain the negotiation process and the functionality offered. Taking the frame of reference theory into account, DUO-models need to contain descriptions from different perspectives, see e.g., (Albers, 2004). It may be useful to use recommender technology here to present examples of models to the user that might already be close to his ideas, see e.g. Schafer (2001).

Existing literature on explanation systems and shared task models (Brazier, 2000) provides guidelines and methods to develop an explanation component. The challenge is to integrate in one explanation component all aspects of negotiation, for example, also the elements developed to meet the challenge related to user-opponent interaction and bidding support. An associated research question is: Does the use of an animated character to do the explanations induce trust in the PN more than other techniques?

Bidding Support

To properly assist the user, the PN has to be able to give runtime advice on bidding strategies, on the quality of bids received from the opponent, on possible counteroffers that the user can make, on whether to accept an offer, to walk away, or to continue with the negotiation. Essential in this process is giving the user insight in the bidding history and a prognosis of future developments, see e.g., (Kersten, 1996). An idea for bidding support is illustrated in Figure 4, where the user is presented with the space of possible bids plotted on the basis of the utility of the user and the estimated utility of the negotiation partner. By pointing to a bid in the space, the interface presents the details of that bid on screen. Fundamental questions underlying these issues refer to the research into computationally efficient bidding strategies that lead to win-win outcomes and cannot be exploited by the opponent (see e.g., Jonker 2001; Ludwig, 2006), the research in this area is ongoing. Also techniques must be improved to reduce the complexity of the negotiation space while maintaining accuracy in bidding (Hindriks, 2006). Heuristics must be developed for runtime estimation of the Pareto-efficient frontier and efficient outcomes, such as Nash, Kalai-Smorodinski (Raiffa, 2002). So far, the computational complexity of these questions has not been tackled. Research and development of evaluation tools and techniques for the analysis of the dynamics of negotiations must continue (Bosse, 2005; Hindriks, 2007; Jonker, 2001; Kersten, 1996). Through on screen visualisation the PN enhances the user's awareness of the negotiation space, potential strategies, and the interests of the opponent (Spence, 2007). Many questions remain in this area especially the relation between the bidding process and the negotiation outcome, still remains unclear. Tools and techniques must be created to assist the professional user in selecting an appropriate bidding heuristic and to fine-tune that heuristic to his liking.

We believe it is particularly interesting to develop support that can work with *incomplete* and *qualitative* information. Research is needed to clarify the relation between qualitative representations of the preferences and other information about the domain being negotiated, i.e. the belief state of a negotiator. This is an important area of research as it may help clarify when to make what type of negotiation move, i.e. when to provide an offer, to ask a question, or provide information to an opponent.

APPROACH

The approach to develop the next generation negotiation support systems will necessarily need to follow an iterative process of research in which each of the various components is specified in ever increasing level of detail and refined after experimenting. It is however important, we believe, that the different challenges are addressed in conjunction to achieve a sophisticated level of intelligent interaction of a user with an NSS.

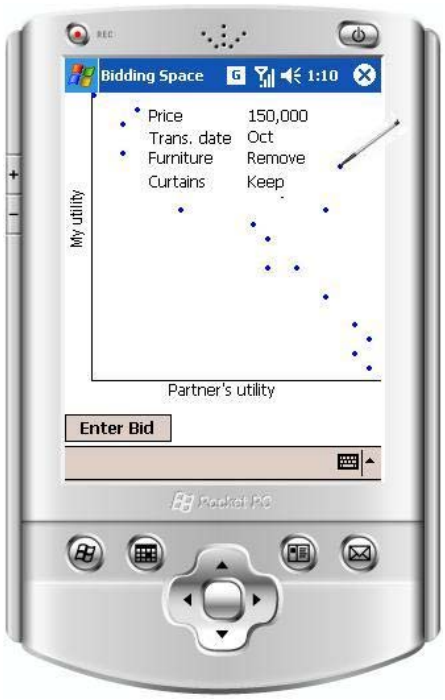

Fig. 4 Pocket Negotiator: bidding support

As we believe that the user needs to be central in the development, we think that the basis of an approach for developing negotiation support systems should be provided by work aimed at improving computer-supported task performance. In particular, the work of Rasmussen (1986) that is based on increasing the insight in the cognitive factors of human-computer interaction is relevant here. In addition, as both the human and machine behaviour in human-machine collaborative systems is adaptive in nature, it is difficult to provide generic and detailed predictions on the overall human-machine performance. To handle this, Neerincx and Lindenberg (2008) developed a situated cognitive engineering method that adds a technological perspective to the classical human perspective in user-centred design (Maguire, 2001). First, the technological

perspective sets a focus in the process of specification and generation of feasible collaboration concepts. Second, the reciprocal effects of technology and human factors are made explicit and are integrated in the development process. Scenario-based design and test methods are being used to address actor's goals and the context of operation (Carroll, 2000). With Wizard-of-Oz techniques (in which a human "simulates" some machine functions), human-in-the-loop evaluations can be used to study design concepts in an early phase and to incrementally implement support functions in a cost-effective way. Game-based evaluation techniques can be used to immerse such users in a realistic usage context.

We believe it is very important to develop and evaluate negotiation support systems in the context of case studies, as has been done in past research. It may also be useful to consult experts, both for knowledge elicitation, and validation purposes.

Finally, strong emphasis should be placed on user empowerment by providing intuitive user interfaces, e.g. based on a direct manipulation interaction style following as natural design metaphor the stages of Fig. 1, see e.g., Spence (2007). An interesting idea here is to use avatar technology to guide novice negotiators (Dehn, 2000).

CONCLUSIONS

In this paper we outlined research goals, ideas, challenges and an approach towards creating the next generation of negotiation support systems. The vision we have behind this next generation is to exploit the strengths of human and machine to overcome the weaknesses of both. The aim is not to supplant the human in negotiation, but to create an intelligent artificial partner, called the Pocket Negotiator.

The Pocket Negotiator is to provide focus and structured support which will increase the user's capacity for structuring and exploring the negotiation space and to reduce the cognitive task load while doing so. By the synergy between the human negotiator and the Pocket Negotiator typical mental errors may be prevented, as the collaborative approach envisaged will support corrective processes.

The key to the development of the next generation negotiation support systems, we believe, will be based on an approach that combines the lessons learned from negotiation research, the methodology of situated cognitive engineering and the techniques developed in artificial intelligence. More specifically, we deem the development of shared task models, qualitative content models, and the support of humans in coping with emotions due to human-human interaction fundamental for success.

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