Attitudes for Achieving User Acceptance
Explaining, Arguing, Critiquing

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Abstract

Far from entrusting decision to advisory systems that have been developed and deployed in industrial, commercial, administrative and military sectors, decision makers do not use these systems efficiently because of a lack of confidence in their recommendations. The user, who is responsible for her decisions, needs to understand how and why certain conclusions have been reached and in what respect these conclusions are better than her own. Hence, in order to achieve user acceptance, a system must be able to convince its user that its recommendation is relevant, justified and useful. Explanatory or argumentative discourse has been shown to be the most effective means to achieve user acceptance. We will discuss the use of explanation and argumentation in decision support systems in relation with their triggering contexts, general dynamics and expected outcomes. Furthermore, the paper will compare these mechanisms with the one used in critiquing systems, which help users assess and refine their own solutions.

1. Introduction

During the past twenty years, knowledge-based systems (KBS) have been developed in various application domains to perform different tasks (such as control, diagnosis, advice giving, configuration and design) in administrative, industrial, commercial and military sectors. Because of the need to improve the decision making process and the quality of decisions, knowledge-based decision support systems have increased in importance in companies and governmental agencies during the past decade. In the military context, these systems are intended to help decision makers deal with complex tasks such as analysis of complex situations, elaboration of action plans, and evaluation and selection of courses of actions. Yet, although several decision support systems have been developed and deployed to support decision makers for performing these tasks, they are usually not used efficiently.

This reluctance can be explained by several factors. For instance, the user, knowing that she will be held responsible for her decision, may tend to discard recommendations that she does not fully understand [Hollnagel, 1987]. But the lack of confidence can also be explained by the fact that a system's recommendation, although technically credible, may be unacceptable for the user because different from the possible alternatives that she had foreseen [Guida *et al.*, 1997]. Jiang *et al.* [Jiang *et al.*, 2000] argue that the user is refrained because the system's recommendations are based on a decision making process which is different from that of human decision makers. Hence, in order to achieve user acceptance, a system must be able to convince its user that its recommendation is relevant, justified and useful.

There are different attitudes a system can display in order to make the user accept or adopt its point of view. Basically, the system can explain its reasoning and behaviour to the user, argue in favour of its claims or advise the user by critiquing her point of view. Research on the integration of such discursive means in knowledge-based systems was initially focused on explanations. Achieving user acceptance very soon became the preoccupation of many KBS designers and research on *explanation facilities* began in the late '70s with the first medical support systems (MYCIN) [Shortliffe, 1976]. Explanations provide insight into the system's knowledge and capabilities and can therefore help the user understand the system's behaviour. More recently, researchers have shifted their attention to argumentation systems, which not only provide visibility into the system's reasoning, but also exhibit persuasive skills. Parallel to these investigations, researchers continue to explore the potential of critiquing systems that help the users assess and refine their own solutions.

This paper will discuss the use of explanation, argumentation and critiquing systems in relation with their triggering contexts, general dynamics and expected outcomes. Through this brief review, we will try to show the different approaches to user acceptance, which range from models in which the system provides and possibly explains a solution to models in which the system and the user negotiate a solution by exchanging information and sharing expertise.

2. **Knowledge-based systems explanations**

During their interactions with knowledge-based systems, users may need explanations in various situations: when they perceive an anomaly in the advice provided, when they need a specific piece of knowledge to participate properly in problem-solving, or when they want to learn more about the domain or about the reasoning approach of a KBS [Mao and Benbasat, 2001]. It is commonly accepted that responding to these explanations needs, can enhance the users' perception of the system, a perception that can be measured in terms of trust, satisfaction, perception of ease of use and belief in the usefulness of the system.

Generalizing from previous work on the role of explanations [Hayes and Reddy, 1983; Southwick, 1991; Giboin, 1995] and going further than the domain of reasoning explanations, one could say that explanations can be used to: (i) assure the user (or ultimately convince her) that the system's reasoning is logical and its conclusions sound, relevant and useful; (ii) provide visibility into the system's states, actions and intentions and guide the user in performing her problem-solving tasks (iii) teach or give the user the possibility to learn by exposing the system's domain knowledge and reasoning techniques.

From a design perspective, providing explanations covers two closely related problems, one which concerns the representation of the knowledge needed to support explanations and one which concerns the techniques relative to explanation generation [Swartout and Moore, 1993]. Our objective in this paper, however, is to look at explanations, not as an object to be designed, but as a communicative goal to be achieved in relation with an individual. As a medium, an explanation can be characterized with respect to its content, its presentation format and its provision mode [Gregor and Benbasat, 1999]. We will briefly discuss these three aspects relatively to their impact on user acceptance.

2.1 ***Explanations: content and depth***

The content of an explanation may concern three aspects: (a) the domain for which the system has been designed, (b) the general features and functionalities of the system, or (c) the system's reasoning mechanisms.

Domain knowledge is static, time-independent and software-independent [Hermann *et al.*, 1998]. For example the principles of Command and Control can be explained independently of the software applications that support them. This knowledge can be presented on its own, for example, as a set of concepts and relationships. But it can also support system or reasoning explanations (types b and c), thus helping the user to understand how the system has been integrated into the domain and/or what are the principles that underlie its reasoning and task performance.

System-related explanations consist of facts about the system. Many aspects of a system may require explanations, including, at the macro-level, the global dynamics of the system, its overall goals and the way these are implemented in the problem-solving sequence; and at the micro-level, the functionalities provided by each individual module, its integration into the system as a whole and its relation to the system's higher-level goals and strategies. The user needs to be able to build a mental picture of the system, find out what are her possibilities at each point and how she can use them efficiently.

Reasoning explanations concern the problem-solving knowledge of the system. This knowledge can be represented as plans and methods that consist of a sequence of steps to accomplish a goal [Swartout and Smoliar, 1987]. This sequence can be explained in more or less detailed manner. Consequently, reasoning explanations have been classified relatively to the amount of knowledge contained in the explanation or the 'depth' of an explanation. This classification comprises three types of explanations: *trace explanations*, *strategic explanations* and *deep explanations* [Chandrasekaran *et al.*, 1989; Southwick, 1991].

Trace explanations provide a trace of the inference rules that lead to a given conclusion. These explanations, the first to be offered by expert systems, can be difficult to interpret and do not provide any information on the system's general goals and resolution strategy. With second-generation expert systems, researchers tried to abstract from rule representations and provide explanations that placed a system's specific actions in context [Swartout and Moore, 1993]. With strategic explanations, the system's higher-level control and planning information are made explicit. These explanations display the system's problem-solving strategy, that is, they indicate why information is gathered in a certain order, why one knowledge piece is invoked before others and how reasoning steps contribute to high-level goals.

While reasoning trace explanations and strategic explanations respond to the user's 'how?' question by showing how final and intermediate results have been achieved, deep explanations can answer to the 'why?' question by linking the problem-solving knowledge to other domain knowledge. Deep explanations relate the data to a deep or causal model of the domain, elaborating on key concepts and their relationships. These explanations are also referred to as justifications since they do not show the steps performed for obtaining a solution but demonstrate why the obtained solution solves the problem. Anchored in the principles of the domain, justification type explanations can be an excellent source of learning for novice users.

Southwick [Southwick, 1991] illustrates this taxonomy with the following example in which a diagnostic system for car maintenance reports its conclusion using these three types of explanations:

> - *Reasoning trace*: You told me that the engine spluttered, and I know that if the engine coughs, then the filter may be at fault.
> - *Strategic*: There are three engine subsystems to check. I checked the fuel system first, because the symptoms indicated the likelihood of a fuel system problem.
> - *Deep*: A clogged fuel filter prevents petrol from reaching the carburator, thus causing engine failure.

Ye and Johnson's [Ye and Johnson, 1995] empirical studies on the impact of alternative types of explanations on user acceptance show that deep or justification-type explanations seem to be the most effective type of explanation to bring about changes in users' attitudes towards the system. Only such deep explanations in which the data are supported by an underlying rationale can demonstrate that the system's conclusions are based on sound reasoning [Ye, 1995]. Also, explanations that make the concepts and procedures that underlie the KBS output explicit, induce better learning and better recall [Pressley *et al.*, 1987], giving this knowledge a better chance to be later applied.

2.2 ***Format and provision***

The other parameters that are taken into consideration for defining a taxonomy of explanation types are presentation format and provision mechanism. Most explanations are text-based. This can be a 'canned' text or a text generated in natural language. A great deal of work on explanations has been dedicated to the quality of the explanation text, in order to make it coherent, meaningful and relevant [McKeown, 1988; Paris 1991]. The explanatory text can be accompanied by graphics or animation, in which case the explanation is said to be multimodal or multimedia [Daniels *et al.*, 1999].

The provision mechanism concerns the way explanations are provided to the user. *On-demand explanations* are provided at the request of the user. These can be accessed through menu options, commands or hypertext links. *Automatic* or *embedded explanations* are presented independently of the user's will. They can be presented in the beginning of a session in a feedforward manner or at different points depending on the choice of the designers. *Intelligent explanations*, contrary to automatic explanations, are provided only when judged necessary or useful. Yet, it has been observed [Hook, 2000] that proactive help, because of its unpredictable character is not very appreciated by users. Mao and Benbasat's [Mao and Benbasat, 2001] empirical study on the use of explanations shows that user-invoked explanations that give immediate access to relevant knowledge within the problem-solving context, referred to as *contextualized access* (and best handled by hypertext links) lead to an increase in the number of explanation requests and result in a greater congruence between users' judgement and the knowledge base system. Contextualized access to knowledge reduces the cost of learning and influences the effort-accuracy trade-off involved in accessing domain knowledge.

The role of proactive explanations has been emphasized in cooperative problem solving contexts [Karsenty and Brézillon, 1995], which must be distinguished from human-computer settings in which the system has a prescriptive role. In a human-computer setting where the system makes recommendations, advises the user or simply assists her in performing her task, the purpose of system-generated explanations is above all to achieve user acceptance and thereby enhance the quality of the user's decision. Even in this context, the system must display a cooperative attitude by adapting the form and content of its explanations to the user's goals, level of knowledge and preferences. The needed information about the user can be gathered in a user model or be inferred from the user's feedback.

In the human-human setting or in a cooperative setting involving human and/or software agents that participate together in a problem-solving task, explanations are essentially used by different parties to find a compatible interpretation of a problem [Karsenty and Brézillon, 1995], negotiate a common understanding [Baker, 1992] and finally reach an agreement. As Baker emphasizes: "[In this context] explanations are not knowledge structures to be translated into communicative acts, adapted to users and transmitted to them, but qualitatively new structures, to which both participants in the explanation dialogue may contribute." This is why such explanations are provided spontaneously.

For Cawsey [Cawsey, 1995], the analysis of human explanations is unlikely to be adequate to fully determine the explanation needs of a particular application and class of users because human-system interaction context is quite different from the human-human context in terms of its requirements and possibilities. However, Gregor's recent empirical study [Gregor, 2001] shows that even in the human-computer framework, cooperative problem solving induces a higher frequency of explanation use and a greater interest on the part of the users.

As Dhaliwal and Benbasat [Dhaliwal and Benbasat, 1996] remark, explanation facilities can affect the user's understanding of the system's output and help her to learn. This affects both the decisional performance of users as well as their perception of the system's value. However, the question of whether such learning or understanding translates directly into improved decision making remains as yet unanswered.

3. **Argumentation systems**

Like collaborative explanations, informal argumentation is also meant for contexts in which the participants have a peer-to-peer relationship. This is the case of advice giving where the two parties, expert in different areas, intend to help each other with respect to some issue. Argumentation becomes useful when the advice giver faces situations in which the advisee is not receptive to advice and the advisor has to overcome scepticism and similar barriers [Grasso *et al.*, 2000].

Indeed the main difference between explanation and argumentation is not the reasoning employed in each case, which is basically the same, but the purpose of the dialogue. The goal of an argument is to use reasoning to get the partner in dialogue to become committed to a proposition to which he was not committed at the beginning of the dialogue, while, the purpose of an explanation is to take something unfamiliar to him and make it make sense to him by relating it to something that makes some sense to him already [Walton, 1996]. Hughes [Hughes, 1992] defines the context of use of these two different discourses as follows: "Explanations are appropriate when the event in question is taken for granted, and we are seeking to understand why it occurred. Arguments are appropriate when we want to show that something is true, usually when there is some possibility of disagreement about its correctness".

A well-known argument structure is Toulmin's model [Toulmin, 1958] in which a *claim* is supported by *data* that can be justified by a *warrant* that can itself be accounted for by a *backing*. Such deductive models have been used as a basis for knowledge representation within artificial intelligence because arguments capture many types of inference mechanisms, account for plausible reasoning and combine to form chains of reasoning. A survey of the application of argument structure to intelligent decision support can be found in Stranieri and Zeleznikow [Stranieri and Zeleznikow, 1999].

Let us mention here that arguments are also tightly linked with explanations. First, theoretically, an argument and an explanation can be viewed as two ways of presenting the same set of propositions [Little *et al.*, 1989], depending on whether one moves from the premises to the conclusion or the other way round. Secondly, practically speaking, those components of an argument structure that are intended to support or counter claims are in fact explanations. During argument exchange, and generally in all contexts where the participants have shared goals, explanations *emerge* [Baker, 1992] as the participants try to reach a mutual agreement. The claims as well as the explanations that support or counter them can later be used as a valuable knowledge source. Thirdly, the depth of an explanation can be measured by means of an argument structure. For Ye [Ye, 1995], Toulmin's model highlights the discrete response steps that an expert system explanation facility should follow in order to answer user's queries in a convincing way. For example, justification type explanations can be viewed as warranted data that, if challenged, can be further supported by a backing.

Although the *demonstrative* power of arguments has been widely used in different applications to help communicating agents to exchange information, debate and resolve conflicts [Kraus *et al.*, 1998; Jung *et al.*, 2001], it is the informal method of *dialectical* argumentation, more concerned with practical reasoning, that can be useful for the support of human users. Analytic reasoning, studied in modern logic, is concerned with the application of sound inference rules to axioms. In contrast, dialectic reasoning, based on empirical evidence, is concerned with opinions that are adhered to with variable intensity. The objective of dialectic proof is to convince or persuade an audience to accept the claims advocated.

The work of Perelman and Olbrechts-Tyteca [Perelman and Olbrechts-Tyteca, 1969] focuses on the way people naturally argue, by appealing to the values and opinions of their addressees. They distinguish different schemas (eg. *transitivity*, *analogy*, etc.) that are used by arguers to connect premises and conclusions. Another branch of theoretical work on argumentation [Anscombre and Ducrot, 1983] focuses on how the argumentative orientation of a discourse is linguistically realized through lexical choice or syntactic constructions (e.g. AI can be *difficult* BECAUSE it requires a lot of work BUT it is a very *interesting* course.) [Elhadad, 1995]. The use of argumentation as a rhetoric device can be seen in work on qualitative explanations [Quillici, 1991; Raccah, 1996] and advisory support systems based on users' preferences [Carenini and Moore, 1999; Grasso *et al.*, 2000].

4. **Critiquing systems**

Critiquing systems are different from expert systems in that they do not act as if they detained the solution to the user's problem. In fact, instead of proposing a solution they examine the user's proposal and make suggestions so that she can improve her solution or performance. Critiquing systems use two inputs: (1) the problem description provided by the user or displayed by the computer, and (2) the user's solution to the problem (diagnosis, design, document). This second entry is the distinctive feature of a critiquing system. Once the solution has been examined, the critic provides feed-back which is specific to the user's solution.

Rather than deciding upon a system-generated solution or advice, many competent users may prefer to interact with a critiquing system that can give them a second opinion on their own solution. There is evidence that experts make early judgements about a problem, rapidly generate partial solutions [Woods *et al.*, 1990], and anticipate the consequences of their solutions and the constraints they must satisfy [Pollack *et al.*, 1982]. It has also been pointed out [Muir, 1987] that advice-giving systems place the user in the paradoxical and extremely difficult role of monitoring, and overruling when appropriate, the recommendations of a machine whose competence is presumed to exceed that of the user. The critiquing system can be an interesting alternative in that rather than placing the user in the position of evaluating the quality of a recommendation she did not elaborate, it engages and challenges her positions and assumptions, thus enhancing her decision quality.

The use of critique and advisory support in decision support systems can be seen in Mili's [Mili, 1988] DECAD (*decision critique and advisor*) system as a facility that watches for errors and advises the user with regard to further actions. Fischer and Mastaglio [Fischer and Mastaglio, 1991] developed a general architecture for knowledge-based critics that fully support cooperative problem solving. In their conceptual design, the user's solution is analyzed by the critic, and suggestions to improve it are made until the user is satisfied.

Critiquing systems can have as many critics as there are issues to be addressed. Like explanation and argumentation systems, critiquing systems can rely on the user to specify the type of critic needed or attempt to infer this information by plan recognition techniques and/or user models. Critics can be classified along the following dimensions [Fischer, 1989]: active vs. passive (to be compared with proactive and on-request explanations); reactive vs. proactive (reactive critics critique accomplished work while proactive critics try to guide the user before a specific decision has been taken); positive vs. negative (praise and criticism); and local vs. global (analyse specific elements or their interactions).

Critics' feedback is delivered in the context of decision-making, before the decision maker switches to a new mental state. Indeed, while shifting to a new task, the user's short memory fades, losing information that will be hard to recall. As we already mentioned for contextualized explanations, availability of knowledge is not sufficient, the user must be given access to relevant knowledge in a timely manner [Schwartz and Te'eni, 2000].

Critiquing systems can also be distinguished by the critiquing strategy they use. Systems using *analytic critiquing* provide support by detecting error occurrences that they turn into assistance opportunities. Systems using *comparative critiquing* point out differences between the user-proposed and a computer-generated result. As Robbins [Robbins, 2002] points out, comparative critiques can be confusing when multiple good solutions exist that are very different from each other. Also, these can help the user reflect upon her own work, yet, in certain contexts, they can also lead the user to make her work more like the one proposed by the system. Analytic critiques, in contrast, "guide the users away from recognized problems rather than guiding them to known solutions".

Nevertheless, it is likely that this will not be the case if the system both critiques and praises the user's result. Vahidov and Elrod [Vahidov and Elrod, 1999] propose a framework in which a decision support system has both negative and positive critiquing agents. In their system, two antagonist critics, called 'devil' and 'angel', act as the opponent and the proponent of the user-suggested proposition. Their ongoing conflict enables the decision maker to assess her solution in terms of advantages and disadvantages and thus gain confidence in her decision quality.

While explanation and justification systems try to show the correctness and usefulness of system recommendations, a critiquing system tests the credibility of a user's solution by examining the knowledge and judgement that she used to reach the solution. As Silverman points out, the critic's role is not to teach but to remind an expert of a skill he or she neglected to apply. The critic tests the clarity, coherence, correspondence (agreement with reality) and workability of the knowledge used by the user and helps her to acquire knowledge through the iterative interactions of the criticism dialogs [Silverman, 1992].

5. **Conclusion**

In this paper, we discussed the role of explanation, argumentation and critiquing in knowledge-based systems. Globally, all three methods aim at making the user understand and accept the system's view. However, they differ by the attitude they adopt towards the user. In fact, a system will explain when it assumes that it is providing expert knowledge that might not be fully understood; it arguments when it presumes that there is a problematic issue and that it has to follow a certain discursive strategy to promote its point of view; and finally it critiques when it acts as more experienced partner which can make suggestions for improvement.

All of these techniques have proven to be useful in cooperative or collaborative settings where the machine provides cognitive support to the user so that both parties, the human and the machine, can jointly participate in performing a task. As De Greef and Neerincx [De Greef and Neerincx, 1995] put it: “the purpose is to design cognitive support which enhances and amplifies human cognition or, more specifically, to improve human involvement by designing system functions which supplement joint human-machine task performance. The effect of cognitive support should be a better joint human-machine task performance.”

6. **References**

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