NOTES ON ASSUMPTIONS OF USER MODELLING

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Abstract

Conversation, co-operation and mutual understanding are considered in human discourse valuable and important. It is desirable for the flexible, interactive computer dialogue system to exhibit these various features of human discourse. For this, it is crucial that the system contains a user modelling component. Such a component will be used to collect and represent relevant aspects of knowledge about the user. This knowledge normally consists of goals, plans, beliefs and background understanding.

In this paper basic assumptions of goals, plans and beliefs are presented and evaluated. It seems that the system collecting a user's goals, plans and beliefs considers a user as a regularly behaving unit like a machine. Our contribution is to present some alternative views on human being. They may provide a more adequate model of a user. In the same context some means for collecting knowledge of a user are considered to be ethically questionable. Similarly, some warnings to use user models are also presented.

Introduction

User models have been studied in the field of artificial intelligence dialogue systems. According to Kobsa (1991) the need for computer systems that automatically adapt to their current users is generally acknowledged, and it has become evident that they can acquire such an ability on a large scale only if they possess models of their current users that contain assumptions about the users' *background knowledge*, their *goals* and *plans* in consulting the system, and their preferences, misconceptions and attitudes. The assumptions are tried to create automatically during an "on-line" interaction with the user.

As was pointed out by Rich (1983), user modelling is especially important if the dialogue system is used by a heterogeneous group of users and if the system shows some flexibility in what it tells the user. A special case of exploitation of a user model is its use in various forms of anticipation feedback loops. Anticipation feedback loops involve the use of the system's language analysis and interpretation components to simulate the user's interpretation of an utterance which the system plans to verbalize.

The goal of a co-operative information system is to help the user solve his/her problem. It must dynamically construct a model of the user from an ongoing dialogue, reason intelligently about what the user wants to do and how he plans to accomplish it, and use this acquired knowledge to produce co-operative, helpful responses (Eller and Carberry 1992). The plan recognition was also used to understand sentence fragments and indirect speech acts, to track a speaker's flow through a discourse and to deal with correctness and completeness discrepancies between the knowledge of users and systems (Goodman and Litman 1992).

The first international workshop on user modelling (UM86) was organized in Maria Laach (D) in 1986 (Kobsa and Wahlster 1989). The editors of the workshop book told that during the 1970s many special-purpose natural-language (NL) interfaces were developed and they mechanically responded to the user's questions. To achieve a real conversation between the user and the system, the system needs an explicit model of the user's beliefs, goals and plans. Kobsa (1991) tells that the series of workshops continued in Honolulu (1990), and he also refers to some bibliographies of the field: Van Arragon (1987) and Kobsa (1988). Shifroni and Shanon (1992) emphasized interactive user modelling and proposed an integration of explicit and implicit approaches. They gave reasons for their proposal by presenting historical roots of approaches.

The reasoning above caused some questions: Which fundamental assumptions are in user modelling? Are the user's beliefs stable or dynamic, and are they objective or subjective? How "natural" are the input and output languages in a conversation? Are assumptions concerning users ethically sound? Does a use of user models cause any risks?

We shall in this paper analyze the questions above, show some promising alternatives and give some warnings concerning the uncontrolled use of user models.

On definitions of user model and user modelling

There are many definitions for both basic concepts, a user model and a user modelling. Wahlster and Kobsa (1989) state them as follows:

A *user model* is a knowledge source in a natural-language dialogue system which contains explicit assumptions on all aspects of the user that may be relevant to the dialogue behaviour of the system. These assumptions must be separable by the system from the rest of the system's knowledge.

A *user modelling component* is that part of a dialogue system whose function is to incrementally construct a user model; to store, update and delete entries; to maintain consistency of the model; and to supply other components of the system with assumptions about the user.

For user modelling the system can evaluate the observed behaviour of its dialogue partner (Wahlster and Kobsa 1989). Some researchers then believe on behaviourist theory developed by Skinner (1938). He viewed man much like a machine, simply responding in a deterministic way to external stimuli. Very much a proponent of experimental methods used in the natural sciences, Skinner disregarded subjective states of mind (Hirschheim 1985).

Norman and Draper (1986) mentioned in glossary that there are three different types of user models: 1. The individual user's own personal, idiosyncratic model, 2. the generalized 'typical user' model that the designer develops to help in the formulation of the design model, and 3. the model that an intelligent program constructs of the person with which it is interacting.

A user model does not only concern dialogue but also other component of the software. In intelligent tutoring systems there are the user dialogue module and two other modules containing knowledge about a user, the student model module and the tutoring module (Nwana 1991). The student model module refers to the dynamic representation of the emerging knowledge and skill of the student. The tutoring module designs and regulates instructional interactions with the student, hence it can be called the teaching strategy and the pedagogic module.

Sarner and Carberry (1992) added a new aspect, *receptivity* to different kinds of information, to the user model. They demonstrated receptivity concept by giving different definitions in different contexts. The system may provide a definition as a part of correcting a user misconception or may generate definitions spontaneously. Some people respond well to definitions when they are examples, whereas others learn better from explanations of how things work.

Coutaz (1992) stated after discussion in a group of researchers that "we are aware of two areas of research interest within user modelling: user models developed in cognitive psychology and embedded user models. Within cognitive psychology, two types of user models can be found: predictive and explanatory models. In the life cycle of interactive systems, predictive models should be considered in the design phase; whereas explanatory models are useful during the evaluation stage. Embedded user models are used to increase the automatic adaptability of the system to users' behaviour and characteristics. An embedded user model is defined to be an explicit and dynamic representation of all aspects of the user that are relevant to the system adaptive behaviour toward the user.

The working group chaired by Coutaz (1992) collected a list of user characteristics contained in the user model. Their usage is considered at three levels: task (T), dialogue (D) and physical (F) levels. The characteristics themselves are divided to the static and dynamic ones. The static characteristics are: Psycho-motor skills (keying, mouse-movement, head-movement) (F); Memory (retrieval from long-term memory, overload of short-term memory) (T, D); Cognitive abilities (executing task steps, choosing among methods, parallelism) (T, D); Learning abilities (procedural rules, transfer of learning) (T); Perception abilities (saccade, recognition) (F); Knowledge (skill-based, rule-based, knowledge-based, situated knowledge) (T, D, F). The dynamic characteristics are: Beliefs (T); Goals (T); Focus of attention (D, F); Plan (the user's task model) (T); Perceptual state (F); Interpretation of system output (T, D) and Evaluation (T, D).

Moore and Paris (1992) noted that the efforts have largely been devoted to investigating how a user model could be exploited to produce better responses, systems employing them typically assumed that a detailed and correct model of the user was available *a priori*, and that the information needed to generate appropriate responses was included in that model. However, in practice, the completeness and accuracy of a user model cannot be guaranteed. Thus, unless systems can compensate for incorrect or incomplete user models, the impracticality of building user models will prevent much of the work on tailoring from being successfully applied in real systems. To this end, Moore and Paris (1992) argued that one way for a system to compensate for an unreliable user model is to be able to react to feedback from users about suitability of the texts it produces.

A priori knowledge

Many user modelling researchers (Wahlster and Kobsa 1989) demand that the user model must contain the user's prior knowledge about a domain. The system must detect false conceptions a user may have concerning the domain. - But how does the system create the first guess of a priori knowledge. There are two methods to generate such hypotheses of the beliefs. One method is to have stereotypes (Rich 1983) and to ask a user to select the nearest one. (A *stereotype* represents a collection of attributes that often co-occur in people.) The second method is to take the system's beliefs as a basis, and perturb them. When the latter is applied, we have the problem: How to change a priori beliefs to a posteriori ones? Ballim and Wilks (1991) propose an ascription algorithm for that purpose, but it seems to be rather crude compared with Aulin's theory below.

Aulin (1989, p.261-) considers human consciousness by using the theory of subjective probability and its Filter Theorem. Let us assume that we have given a measure of probability P that stands for the *cognitive beliefs* of a conscious actor. In other words, P(A), for any subset A of X, gives the probability of the truth of the state of affairs A, as judged by the actor. It is called the *subjective probability* of A for the actor in question.

It is the basic idea of the theory of subjective probability that the knowledge of each fact E changes the cognitive beliefs of that actor in a lawful way. To find out the law two axioms are set forth:

(i) The actor already has, prior to any observed facts being in his possession, a pattern of *a priori beliefs* represented by a measure of probability P standing for his *a priori subjective probabilities*.
(ii) The observation of the fact E changes his cognitive beliefs in a way, say
$P(A) \rightarrow P(A/E)$, that makes the state of affairs E 'a posteriori' true, i.e.
$(P(E/E) = 1$.

The changed cognitive beliefs of the actor are called his *a posteriori beliefs*, and they are mathematically represented by his *a posteriori subjective probabilities* P(A/E).

The "Filter Theorem" says that the a posteriori subjective probability $P(A/E_1E_2...E_n)$ of a true state of affairs A grows with a sufficient accumulation of the empirical knowledge $E_1E_2...E_n$ how close to sureness, provided that

(1) $P(z/A) \neq P(z/(\bar{A}))$ at least for some $z \in R$, and
(2) $P(A) > 0$.

If the a priori probability P(A) is zero, the a posteriori probability too remains zero, how large the accumulated empirical knowledge contrary to such a judgement. - The application of the Filter Theorem to the human life means that our world view will become closer and closer to the real one, if we do not have any mental "ossification", i.e. any a priori belief with probability zero or 1.

Rich (1989) recommended to use a stereotype as the first trial of beliefs, and she also proposed that a certainty value should be connected with a certain stereotype during the use process. It seems to that Rich is here thinking parallel with Aulin and with his a priori / a posteriori beliefs.

On term "belief"

Kobsa (1989) proposed a taxonomy of beliefs. He defined that *basic* beliefs of an agent are beliefs which are *not* about goals or beliefs of the same or some other agent, but about facts in a certain domain (the so-called *situation*). Beliefs which *are* about other beliefs and goals will be called *complex* . - Situational facts may be individual or general. Individual facts comprise single events in the past, present or future. General facts concern general properties of objects in the situation, general relations between objects, general rules etc. Kobsa's fact does not contain any probability nor nay subjectivity. It would be interesting to perform a comparative philosophical analysis between Kobsa's ands Aulin's "belief" concepts .

As a continuation of discussion about a priori and a posteriori beliefs in the former section we refer to Aulin (1989) who separated two layers of knowledge: the layer of *a priori* knowledge and the layer of a posteriori knowledge. The former is the consciousness steered from outside. The actor himself does not control the formation of his *a priori* knowledge. *A priori* knowledge, by its very definition, is already there, in the consciousness of the actor, when he starts consciously to check his beliefs. The layer of *a posteriori* knowledge is the self-steering consciousness, because in the formation of this kind of knowledge the actor himself chooses the objects of his thinking, makes generalizations concerning them and checks the results by acquiring empirical knowledge: the actor is himself in control of his knowledge, as far as *a posteriori* knowledge is in question.

Beliefs about physical and social reality

Ontological beliefs (Orlikowski and Baroudi 1991) have to do with the essence of phenomena under consideration; that is, whether the empirical world is assumed to be objective and hence independent of human, or subjective and hence having existence only through the action of humans in creating and recreating it. Then there are beliefs about human rationality, which deal with the intentions ascribed by various designer to the human they describe. Finally, there are beliefs about social relations, about how people interact in organizations, groups and society. For example, designers may believe social interactions to be stable and orderly in general, or they may believe them to be primarily dynamic and conflictive.

User models are regarded as forming some kind of mental model (Gentner and Stevens 1983) which provide predictive and explanatory power for understanding interaction. This conception refers to the positivistic view of reality. The positivist thinks that understanding phenomena is primarily a problem of modelling and measurement, of constructing an appropriate set of constructs and an accurate set of instruments to capture the essence of the phenomenon (Orlikowski and Baroudi 1991). It is believed that as impartial observers, designers or the system can objectively evaluate or predict actions and processes, but that they cannot get involved in moral judgements and subjective opinion.

In a user model a parameter is associated with each individual concept in the system's knowledge base to indicate whether the concept is known or not-known by the user, or whether the system has no-information in that respect (Sleeman 1985). Sleeman clearly assumes that a particular term has only one meaning. But Checkland (1989) very dramatically shows how a certain term may have many interpretations, i.e. "Ask someone how they would regard a prison as a purposeful human activity system and they will usually describe it as 'a rehabilitation system' or 'a punishment system' or 'a system to protect society' or more cynically ' a system to train criminals'.

In addition to many meanings of the same term there is another view which may cause problems. Ballim and Wilks (1991) consider that it is often insufficient for the system to maintain a model of each agent. Rather, what is frequently required is that the system model each of the agents, and each agent's models of the other agents (hierarchy of nested models). Referring to Orlikowski and Baroudi, and to Checkland above we can now ask: Are those nested models done by the system more adequate and more exact when severe reservations must already be connected to the "single" model of the user?

On goals and plans

This far we have mainly dealt with beliefs. In order to consider other categories of action we first refer to Aulin (1989, p. 164). Human acts can be conceived of as tools of interaction between consciousness and the world of objects. Human action is a two-way traffic. On one hand, as a consequence of a certain kind of acts we obtain knowledge about the real world. We process this information and compose our cognitive *beliefs* of what the world is like. On the other hand, man is an active being who chooses is acts in order to push events in the real world in a certain directions he wants, and away from some directions that he finds displeasing; in other words he wants to realize his *values* in the world of action, and not only in his imagination. The rules of choice of acts are called the (actional) *norms* of one's behaviour. We can conceive of them as depending on the values as well as on the cognitive beliefs. - I think that Aulin's values correspond to goals in AI and norms to plans, respectively. Kass (1991) give a special emphasis on the plan by stating that in many cases, a system's only user modelling concern is to discover the user's plan (and corresponding goals) while using the system.

Chin (1991) says that plan recognition as a sub-field of user modelling has emerged as a strong research area. Most studies, however, are conceptual. To this end Chin is waiting for as researchers become more concerned with plan recognition in real world situations where they are faced with incomplete system knowledge, ill-formed input, user misconceptions, multiple users and even antagonistic users, plan recognition algorithms will need to be more robust. For example, how does a plan recognition system know when it lacks information to properly understand a user's plan versus when the user has a misconception about the right plan? Also, how does a system know when users have changed their minds or decided to defer their current plans versus when users have adopted a broken plan? To my mind the questions presented by Chin nicely describe a man as a self-steering actor who may change his goal function.

Kobsa (1989) defined that basic goals are similar to basic beliefs in that they are about situation and not about beliefs and goals of other agents. Unlike beliefs, however they are not about the current situation but about a desired situation. Thus, for an agent to have a goal p means to desire a situation in which p is the case. Kobsa's definition of a goal differs from Aulin's definition that Kobsa's goal concerns one goal only, but Aulin concerns many goals simultaneously and his definition encourage to put the desired states of the world into the priority order.

"Natural language interface"

For constructing a user model the system can utilize records of user's input. For example, the interpretation of modal verbs like 'must, should, need, may' in the user's input makes it possible to infer some of his/her wants and beliefs (Wahlster and Kobsa 1989). Unfortunately, modals are ambiguous in most languages.

In natural-language dialogue systems, for representing knowledge about the world, representational schemes, developed in the field of knowledge representation are employed (e.g. first-order predicate calculus). According to Wahlster and Kobsa (1989) it seems most natural to extend these schemes so that the system's assumptions about the beliefs, goals and plans of the user can be represented. But they must state that a simple extension is not possible, because e.g. 'believe' and 'want' verbs cannot be described. Concerning possibilities to use meta-language for describing beliefs Wahlster and Kobsa (1989) are forced to conclude that for complex constellations of belief representations they become computationally untenable.

Laurel (1990) writes that visionaries seem to have no difficulty imagining a future where we'll be able to talk to software applications - or even computer agents - in plain English. There is pessimism as to whether there will ever be a useful natural language interface technology, particularly among those who advocate direct manipulation and desktop interfaces (Shneiderman 1981). Brennan (1991) writes that there is optimism among computational linguists who have made significant progress in formalizing the structure and semantics of sentences and mapping them onto database query or command languages. But people don't always speak in grammatical sentences. They are often indirect; they don't say what they mean. They rely on the unspoken knowledge and presuppositions they share with their conversational partners (Brennan 1991).

In discussion about help systems Tattersall (1992) refers to the Unix Consultant (UC) project (Wilensky et al. 1988). UC accepts questions in natural language and analyses the query to identify the understanding user goal. The Unix context, although rather complex, may still be restricted in such a way that the questions mentioned above could be analysed in the finite number of steps, because the Unix is a program with the finite number of different states. The text generation in the correct form of English, i.e. in natural language, is possible.

The main reason for problems with so called natural-language dialogue systems, especially in interpreting input given by the user, is that the real natural language is unsolvable (Hopcroft and Ullman 1969, p. 211-) and the real natural language belongs to such a type of languages that are not decidable (cf.

Chomsky's hierarchy of languages, Kurki-Suonio 1971), in other words if the whole variety of the real natural language are allowed, there does not exist any algorithm for deciding whether a particular expression given by the user is acceptable or not. Hence the (artificial) language used in interaction must be a strongly restricted subset of the real natural language. To my mind there are no factual arguments for using term "natural-language".

Ethics

Wahlster and Kobsa (1989) referred to Schuster and Finin (1983) and wrote as follows: "A lot of work in the field of user modelling is devoted to recognizing user misconceptions, i.e. conflicts between system and user beliefs. - I would like to ask: Are you sure that the user had misconceptions, not the system?

In Rich's (1979) GRUNDY system the following request is presented: "I'd like to know what sort of person you think you are. Please, type in a few single words that you think characterize the most important aspects of yourself". - Clearly, there is a danger to loss of privacy and easier surveillance.

Wahlster and Kobsa (1989) found four types of conversational behaviour in the systems with user model: A) question-answering and biased consultation, B) co-operative question-answering, C) co-operative consultation and D) biased consultation pretending objectivity. To my mind it is not ethically sound that the hotel reservation system (type A) always offers the most expensive room, nor the system (type D) mimicking professional salesmanship.

Ballim and Wilks (1991) consider that for representing competency information a way of abstracting belief propositions is needed. They refer to McCarthy and others who proposed that lambda expressions be used to represent knowledge. Each such lambda expression should be provided with restrictions on the capable evaluators. An agent who is neither explicitly nor implicitly mentioned is deemed to not have the requisite competency to have the belief. To my mind this kind of thinking underestimates a very nature of humans.

Wahlster and Kobsa (1989) found social problems in exploiting user models: (a) The user is aware of the user modelling component, (b) s/he has control over the component, and (c) user modelling involves the risk of misunderstandings. According to Wahlster and Kobsa (1989) if the user is *aware* (a) that the system with which s/he is interacting is equipped with a user modelling component, then s/he has the chance to apply all the techniques for hiding his/her beliefs, goals and plans which s/he constantly uses in every-day person-to-person interaction. To my mind the user's reaction is sound and normal. I would like to prefer transparent systems. According to Wahlster and Kobsa (1989) *control* of the user over the user modelling component (b) means that s/he can inspect the model the system has made of him/her in the course of dialogue. One problem, according to Wahlster and Kobsa (1989), is the enormous number of assumptions to be inspected and the other one is that the contents of user models are often very difficult to translate into ordinary English. To solve the former sub problem, I recommend to use computerized tools like a browser for finding interesting assumptions, and for the latter I refer to the natural-language section and ask: How can the system recognize the user's beliefs, goals and plans as input data but cannot represent the same ones as output? Concerning *misunderstandings* (c) Wahlster and Kobsa (1989) were afraid of the user only, for one of the tasks of a user modelling component is to maintain the consistency of the model. The user can get a wrong interpretation of the results, if s/he does not understand a certain command or some technical term, and if the system does not detect it. To my mind Wahlster and Kobsa (1989) believe that the model developed by the system is adequate and corresponds to the part of reality, but this is not always the case. Smith (1985) very nicely shows the limits of correctness of models. To my mind the user is more flexible and faster to correct his/her mental model than the system its model, respectively. In my opinion, the common characteristic in Wahlster and Kobsa's (1989) "social problems" above is the pessimistic, almost negative human image cannot be ethically accepted.

Risks

User modelling may cause a big risk, if some *prediction* is based on the user model. For example, Kobsa and Wahlster (1989) have written that the great advantage of the stereotype technique stems from the fact that predictions concerning the user can be exploited as soon as a limited number of preconditions are fulfilled. But the stereotypical predictions that originally were thought correct may become outdated. Rich (1989) calls this need for the change in the stereotype as adaptation. Aulin (1989, p. 173) considers that conscious actors, capable of making decisions based on their own will, can be represented by self-steering actors, and the total behaviour of self-steering actors is unpredictable and indeterministic, also in a probabilistic sense.

Coutaz (1992) wisely states that the usability of a system heavily depends on the predictability of its interface. This imposes certain limits to the adaptation process and, therefore, to the usage of a user model. Hence the system must be predictable. Gaines (1981) says the same fact in other words: Do not assume that the user is passive static partner to be controlled, modelled and directed by the computer - evaluate all actions of the system in terms of their effect on an actively changing user who is attempting to comprehend the system.

Gaines (1981) also paid attention to the potential instability and risk if either computer or user will alternately (in unpredictable way) dominate interaction. If computer is to dominate, it must be programmed to, and have sufficient information to, model user - if user is to dominate, then computer system must be simple to understand. As shown above user cannot be modelled, and hence user should dominate system.

Kobsa (1989) referred to the systems where the robot is executing a plan and communicating with other co-operating robots. Although they may be equipped with some perceptual capabilities, they may still have a model that does not correspond to a part of reality. There is therefore a big risk that the robot or the group of robots may perform wrong actions with damaging consequences.

Discussion

London (1992) pays attention to differences between on one hand the ideas and models presented and the experimental systems reported in the scientific papers and on the other hand the systems utilized in practice. The latter he describes as follows:
A) *Closed-world assumption*: All relevant plans and actions are known either explicitly or by closure.

B) *User's correctness*: The user has a coherent, well formed plan, with no fatal misconceptions.
C) *Unified goal and plan*: Typically, the user has a single top-level goal, with subgoals in a proper hierarchy. If there are non-hierarchic goals, then they are either resolved into a unified plan or maintained as multiple plans that are nearly independent. Also, users have a somewhat persistent focus.
D) *Co-operative user*: The user is purposely giving information to help the user modeler, or the system can verify and adjust its conclusions by co-operative negotiation with the user.
E) *No real-time requirement*: The system is not required to respond within the time bounds of normal human communication.

Assumptions A) - E) very nicely describe problems with user modelling in practice. Assumption E (No real-time requirement) reflects on a laboratory phase of user modelling engineering. Referring to Moore and Paris (1992) assumption A (Closed-world assumption) is already cancelled by the user modelling community itself. Assumptions B, C and D show that a man is considered to be deterministic and mechanistic. Our analysis above put emphasis on self-steering nature of human being. A user can change his/her goal and plan eventually. Hence, Aulin's theoretical approach referred by us may provide a new basis for theoretical and practical research in user modelling.

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