User interaction with an AI tool:

The RAXEM experience

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Abstract

An effective interaction with the user is a key aspect for the success of technological tools deployed into real world contexts. This paper focuses on an AI based system named RAXEM, developed to support human mission planners in a specific daily task within the MARS EXPRESS program. The interactive environment of RAXEM helps the users analyzing the problem and taking planning decisions as a result of an interactive process. Different aspects have been considered like fostering user’s trust toward the automated algorithms, promoting their deep participation during problem solving and guaranteeing a continuum in their work practice. The paper discusses how the enhancement of both transparency and usability of AI decision-making tools is fundamental for users’ acceptance and discusses the lesson learned during this experience.

Keywords

AI decision support tools, interactive problem solving, user interaction, visualization, user involvement seamless integration.

ACM Classification Keywords

H.5 Information interfaces and presentation

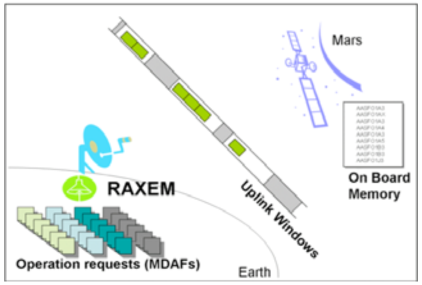

Fig. 1 A sketchy representation of the MEX-UP problem

Introduction

Space missions represent challenging domains for applying Artificial Intelligence (AI) techniques. Nevertheless, several open issues still need to be addressed most of which are related to interaction with the tools as well as to a “correct” subdivision of tasks between humans and machines. To this purpose a promising approach for success stems from collaboration between AI and HCI communities. One major drawback of classical AI-based tools is that users usually tend to be skeptical toward the use of *black-box* systems that provide automated solutions, hardly explaining choices, actions and results. Classical AI system where everything is automated revealed not to be a good choice. On the contrary, an interactive approach, which preserves users’ control and responsibility, seems a more valid option. In addition, the naturally conservative behavior of people in changing their habits makes it difficult the spread of such a supporting technology, especially in those contexts, which are particularly conservative. Users tend not to abandon their traditional way of working and get into new habits. In this paper we present our effort in importing HCI recommendations and experiences into the design of an intelligent interactive AI system, named RAXEM, which supports human planners within a space mission context.

MEX-UP problem: a model-based approach

The Mars-Express[1] spacecraft is not an autonomous system able to plan and execute science operations around Mars in a fully autonomous way. A particular part of the space probe on-board memory, the Master timeline (MTL), is replenished by uploading telecommands (TCs) from the Mission Control Center on the ground. This situation is shown in Fig. 1: a set of *operation* requests stored in the so called MTL Detailed Agenda File (MDAF) has to be sent to the Mars Express probe through a limited transmission channel (*uplink windows*) in order to define the operations that has to be accomplished. Two constraints make this problem hard: the limited bandwidth of the transmission channel and the finite capacity of the on-board memory (MTL) where the commands are stored, waiting for the execution. This problem has been named MEX-UP and the goal is to synthesize a consistent sequence of activities for uploading the set of commands on-board (i.e., the uploading plan). Pursuing an AI approach, the first step in solving the MEX-UP problem was to build a representation (or *model*) of the domain that contains the relevant objects to describe the problem features. This representation phase is fundamental because a good modeling choice not only supports the solving algorithm but also will create a basis for the interaction with the user. In particular we considered the temporal evolution of the two relevant system components, the MTL, which contains the set of telecommands and the Communication Channels, namely the uplink connections to Earth for transmitting data. This choice was not only instrumental for building the model but also to reflect users reasoning process. RAXEM provides an intelligent support for solving the MEX-UP problem [3] fostering collaboration between AI algorithms and human problem solving skills.

RAXEM solution

The design of RAXEM is inspired by our previous work in developing decision support tools [2]. Fig. 2 shows the RAXEM architectural design. A first module is

[1] *http://www.esa.int/SPECIALS/Mars_Express*

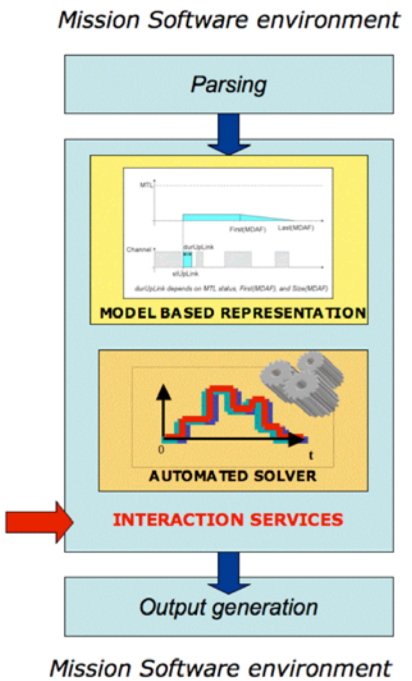

Fig. 2 RAXEM architecture. To make the system usable in the operational environment, the classical AI system composed by the *model based representation* and the *automated solver* has been enriched by additional modules: an *interaction services* layer and two modules for data *post and pre-processing*

responsible for modeling the MEX-UP domain and the dynamic rules according to which it evolves. This module relies on a *model-based representation* of the problem, which is manipulated by the automated algorithms. The second component is the *automated solver,* which is responsible for performing the hard and tedious computations and constraint checking on behalf of the mission planners. These two components alone can be seen as the usual “AI *black-box* systems” that users tend to underestimate and reject. The two basic components of the AI application have been embedded within an *interactive environment* designed to foster users participation and supervision. Following the HCI user-centered approach we built an interactive environment, which provides services to validate and check the automated solutions, as well as to enabling user participation in the incremental management of MEX-UP problems. While designing the interaction with the users we realized that an additional effort was needed to ensure continuity: in particular the first (*Parsing* module) processes the input files and selects the relevant information for the symbolic model used by the solver, while the second (*Output Generation* module) manipulates the results produced by the system and generates the output according to ESA traditional external formats. Indeed, to successfully deploy RAXEM, additional attention has been dedicated, to these two modules in order to guarantee a smooth dialogue with current industrial practice in developing mission planning software.

RAXEM INTERACTION DESIGN

The design of the interaction services has followed a user-centered approach. As for the user requirements elicitation, we used both *direct observation* and *survey studies* [4]. In particular through subsequent visits to the ESA mission control center, we monitored users at work, capturing previous work practice and understanding the everyday context use. In addition we also realized interviews for the users who were invited to report experience, opinion and behavioral motivations. Given the very conservative nature of the ESA environment as well as the fact that we developed the system while the mission was already running, we decided to use a *cooperative design*, involving end users and giving them the possibility of affecting the system design. In this way users had an active role in understanding possible problems and proposing solutions. In addition we used a *system prototyping* approach, developing incremental versions of the system and involving users in formative evaluations of the intermediate versions. We paid particular attention to propose a non-disruptive way of working, so as to minimize the potential risks of producing a non-usable tool, but at the same time we tried to smoothly change their way of working by fostering the potentiality of the interactive AI-based tool. To this purpose, users’ involvement during the design and development phase has been paramount.

INTERACTIVE PROBLEM SOLVING IN RAXEM

The MEX-UP problem can be considered incremental in its definition. MDAFs become dynamically available to users responsible for the uplink plan, making it difficult for mission planners to effortless compute the plan. Additionally, the complexity of the problem solving leads usually to non-optimal solutions. RAXEM relieved users from the hard part of the mission planning task, offering them the possibility of concentrating on the strategic decisions. The tool exploits users’ ability in properly tuning the input and provides services for output checking and validations overall preserving their

Fig. 3 Alternative views for the solutions and *what if* analysis environment.

supervision and control. The main layout of RAXEM is shown in Fig. 3. Users can count on a clear representation of the problem and act on the input values to reflect the particular contingency of the current problem that needs to be solved as well as to specify their preferences and priorities. Once the users have specified the input for the target problem they can ask the solver to compute an uplink plan. Alternative views of solutions are provided for users' inspection. In addition, the interactivity of the tool allows them to change the problem, guided by their knowledge and expertise, and rapidly obtaining different solutions. This allows mission planners also to imagine different scenarios and perform *what-if* analysis. In this light the tool is able to off-load human cognition, giving the user the means to explore alternative solutions during the decision making process and functioning as a learning tool, thus increasing humans problem solving skills.

Discussion

The project is still running and RAXEM is under continuous use and testing by mission planners. However we can draw some interesting conclusions from this experience, some of which represent reinforcement of well-known considerations in HCI. RAXEM showed how in addition to both interface's usability and powerful algorithms, different aspects contribute to make AI tool usable in real context, which are briefly described in the following.

Transparency: The first aspect taken into account in the interaction design has been the implementation of a friendly and comprehensible representation of the problem, the solving process and the solutions, especially important in cases, like RAXEM, in which the automated system supports a user in solving complex problems. Attention has been given to enable users to verify the correctness of the results, and to endow her with the possibility to express her own preferences.

Seamless integration: Usability and transparency alone are non sufficient to make AI tools usable. These tools should allow a continuum in changing users' way of working, by enabling a gradual adaptation to the innovation. The RAXEM experience has shown how the connection with traditional software, which is usually quite neglected, is indeed a strong enabler for success. Operational space environment is quite critical with respect to changes of procedures that have been developed over years so when inserting new technology a non-disruptive approach is paramount.

User in control: Finally the relevance of allowing the user to keep responsibility and maintaining a level of control over critical decisions has turned out to be extremely functional to the acceptance of technology. In this respect the mixed-initiative approach seem to be a valid choice (see also the example of MAPGEN [1]).

References

[1] Ai-Chang, M., Bresina, J., Charest, L., Chase, A., Hsu, J. C., Jonsson, A., Kanefsky, B., Morris, P., Rajan, K., Yglesias, J., Chafin, B. G., Dias, W. C., Maldague, P. F. MAPGEN: Mixed-Initiative Planning and Scheduling for the Mars Exploration Rover Mission. *IEEE Intelligent Systems*, 19(1):8–12, 2004.

[2] Cesta, A., Cortellessa, G., Denis, M., Donati, A., Fratini, S., Oddi, A., Policella, N., Rabenau, E. and Schulster,J. MEXAR2: AI Solves Mission Planner Problems. In IEEE Intelligent Systems, 22(4):12-19, 2007.

[3] Cesta, A., Cortellessa, G., Denis, M., Donati, A., Fratini, S., Oddi, A., Policella, N., Rabenau, E., and Schulster, J. RAXEM, A Support Tool to Plan Uplink Activities for MARS EXPRESS. In i-SAIRAS-08. Proceedings of the 9th Int. Symp.on Artificial Intelligence, Robotics and Automation in Space. JPL, Pasadena, CA, 2008.

[4] Sharp, H., Rogers, Y. and Preece, Jenny (2007): Interaction Design: Beyond Human-Computer Interaction. John Wiley and Sons.