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| RESEARCH ARTICLE

A Model for Viewpoint Control in Requirements Elicitation

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| ABSTRACT
Requirements elicitation from multiple human sources involves uncertainty management. Most requirements analysis methods focus on expressing the requirements and ignore the uncertainty inherent in the process of requirements elicitation. This paper proposed a model for requirements elicitation from multiple viewpoints. The model is based on the idea of building internal models of the viewpoints that record their performance in providing information, assessing information, and resolving conflicts between viewpoints. The paper argues that the proposed approach provides a better mechanism in information validation and conflicts resolution. The paper is part of the work reported by the author in [Messaoudi, 1994].

| KEYWORDS

Requirements Engineering, Viewpoint-based Requirements Engineering, Truth maintenance, Uncertainty management, conflicts resolution.

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1. Introduction

The Viewpoint Control Mechanism is an adaptation of the work reported in [Bokma, 1994]. It is a model for the management of uncertain information, from human viewpoints, through belief revision. The main principle of the Viewpoint Control Mechanism is that human agents tend to build models about other human agents they are acquainted with. These viewpoint models record factors concerning their opinion about the abilities and trustworthiness of individual viewpoints. The viewpoint models are used to evaluate information received from the respective viewpoints. They are then reassessed in the light of feedback from the results of the process of information evaluation and belief formation. A viewpoint model keeps a record of a viewpoint's performance in providing information. It represents the system's opinion about the viewpoint and encapsulates expectations on the viewpoint's behavior. The VCM attempts to learn about the behavior of its environment with the view to preempt and anticipate situations that carry the potential of serious contradictions.

2. Viewpoint Control Mechanism

The Viewpoint Control Mechanism (VCM) operates on an object-level and a control-level. At the object level, pieces of information are processed until a contradiction occurs. The control level attempts to resolve the contradictions and, at the same time, use the contradictions as a signal to trigger an evaluation of the information viewpoints.

The object-level involves:

- Defaults and Classification. Default viewpoint models for new viewpoints are created using a default and classification mechanism. This is based on the observation that human agents frequently have to evaluate information from viewpoints they do not know much about. In the absence of concrete evidence that can be gained from actual experience with the viewpoint or reported by third parties, human agents tend to quickly create a viewpoint model based on some class to which the viewpoint can be associated with and whose properties are known or, as a last resort, use defaults values.

- Importance Analysis. Importance Analysis is Approximating the amount of effort that needs to be invested in the analysis of a piece of information. If there is a problem with a piece of information, Importance Analysis decides how far to go into investigating the problem.

• Information Evaluation. As the information from human viewpoints is large of uncertain nature, human agents have to decide whether, or how much, to believe individual pieces of information. The SCM uses the external features of a piece of information (such as viewpoint, tone, language, consistency, etc.) rather than the content of the information itself.

The control-level mechanism is based on the following:

- Conflict Resolution. Conflict resolution heuristics use information from the viewpoint models to sort out contradictions between information from the same viewpoint and from different viewpoints. For example, the opinion of the most reliable viewpoint prevails.

- The Principle of Enquiry. An enquiry is launched if more information is needed. Information may be required to find out more about a particular viewpoint or for more evidence to support or weaken an existing piece of information.

- Viewpoint re-evaluation. Information about a viewpoint recorded in the viewpoint model needs to be adjusted in the light of new evidence about the viewpoint's ability and trustworthiness that may emerge from the analyses and enquiries. In order to form beliefs about given information, the SCM uses a collection of general heuristics to extract the various parameters from that information and to make a decision about it on the basis of those parameters.

2.1 Uncertainty management

The fundamental principle of the Viewpoint Control Mechanism was born out of the need to manage the uncertainty of the information that one gets from human viewpoints in order to make sense of a particular subject matter. Its strategy is to form beliefs about the information using its view about the viewpoints and then modifies those beliefs in the light of what it has learned about the viewpoints.

Uncertainty in computer applications is certain, and software engineering is an attempt to manage that uncertainty [Lehman 1990]. This is particularly true for requirements elicitation from multiple human sources. Requirements engineering is a people-oriented job. The use of multiple viewpoints in requirements elicitation is akin to a court investigation where different witnesses may have conflicting or corroborating views [Leite, 1988, Fickas, 1988].

2.2 Initial viewpoint models

For each new viewpoint, establish an initial viewpoint model using a default and classification mechanism in the absence of concrete evidence about the actual properties of the viewpoint. A viewpoint model for an engineering configuration manager is represented by the VCM as:

Manager
Ability:
expertise: engineering configuration management.
experience: high
reasoning: high
interests: improve the q u a l i t y of the control construction
manager > analyst
helpfulness: average (default)
trustworthiness: high
analyst > manager
helpfulness: high
trustworthiness: high

The process is to select an initial set of viewpoints that would take part in the viewpoint resolution process using some form of pruning mechanism and then create a viewpoint hierarchy. Examples of heuristics for constructing a valid viewpoint hierarchy were recommended by the CORE method [88]:

If a viewpoint has more than one responsibility or several superiors, it should be re-examined.

Then, establish the initial models of the selected viewpoints using their area of responsibility, area of expertise and experience in the context of requirements elicitation. The 'interests' parameter will be interpreted as goals the viewpoint wants to achieve. Other viewpoints are included as the investigation progresses.

Requirements elicitation requires a context (universe of discourse) to assess the information. For example, Fickas [Fickas,1988] uses domain goals as a universe of discourse to validate specifications. The Universe of discourse in this thesis is composed of the viewpoint models that capture records of the information viewpoints. A viewpoint model will play a crucial role in requirements elicitation:

- It captures a detailed track record for individual agents.
- It ties pieces of information to the universe of discourse.
- It will be used to assess information.
- It will be used in case of negotiation required to resolve conflicts.
- It can be used in other activities of the software development process if the corresponding agent is involved (e.g., during system maintenance).

2.3 Importance analysis

Given a viewpoint model and piece of information, there are three ways in which importance can initially be established:

If one has an interest in the subject of the information, then the information is important.

If the information is strong and there is a connection to existing, important information, then the information is important.

If one's helpfulness towards the viewpoint is high, then the viewpoint is important.
If the viewpoint is trustworthy and competent, then the viewpoint is important.

Other heuristics are concerned with situations where a piece of information has been analyzed already and where the importance analysis has to decide whether there is enough interest in the situation to make further enquiries. For example:

If there is a problem and the information and the viewpoint are of interest, then recommend not to enquire.

If there is a potential problem with the ability and the viewpoint is important to the mechanism, then recommend viewpoint analysis and enquiry.

The initial assessment of relevance could be guided by the following heuristics:
If the information lies directly within the viewpoint's responsibility, knowledge, and. experience then the information is relevant

If the analyst has knowledge of the application domain, then use that knowledge to make the best approximation of relevance

If the viewpoint's representative is important in the organization's hierarchy, then the information is relevant. If the analyst has an interest in the subject of the information, then the information is relevant

The following case illustrates the importance of the assessment of relevance (quoted from [London, 1976]):

> *A user gave a very comprehensive account of one subject which was officially his responsibility, and implied he had knowledge of it. It turned out later, much later, that the man had only been in the job for less than three weeks. His answers were theoretical ones; how he thought logically, it should be done.*

2.4 Information Evaluation

Information evaluation is concerned with assessing the credibility of a piece of information both from its well-formedness standpoint and against the *viewpoint model.* Information evaluation operates both on the properties of the information and the properties of its viewpoint. At the information level, the following parameters are involved:

- The relative strength of the argument
- whether responsibility is accepted
- whether the viewpoint has an interest in including the information.

- At the viewpoint level, the ability and trustworthiness of a viewpoint are considered, namely: expertise - includes subjects that the viewpoint has had particular training in, as well as expertise in general, common knowledge and more practical experience,
- experience - the viewpoint's ability to judge and handle its own, personal experiences correctly,
- reasoning - the viewpoint's ability to correctly follow and handle long chains of reasoning. It is not limited to particular areas of the viewpoint's expertise, interests and beliefs,
- judging information - the viewpoint's ability to handle and evaluate the information it receives from other viewpoints.

Given a viewpoint model, the following is an example of requirements evaluation heuristics:
If the conviction in the information is high, the viewpoint denies responsibility
and the trustworthiness of the viewpoint is low, then record trust problem and reject the information
If the viewpoint is trustworthy, record the ability problem and modify belief according to the ability.

If the conviction in the information is low, the viewpoint denies advantage, and the trustworthiness of the viewpoint is high,
and the ability is high, then record o.k. and accept information as given

Analysts often encounter conflicting interests, some of which may be hostile to the successful operation of the proposed system. An analyst must anticipate views that, accidentally or intentionally, might lead to unacceptable situations. It is necessary, therefore, where possible, that opportunities for those views must be eliminated [John, 1989]. Many authors recognize the role of human factors in requirements analysis, but no one treats those factors explicitly. Fickas et al. [Fickas, 1988] suggest a set of heuristics for defining which system human agents should best perform which actions. Agents are assigned to actions depending on their ability, reliability and motivation. For example, no agent will be responsible for a goal in conflict with its private goal, or if there are several candidate agents to perform an action, an agent is selected so that the values of the ability and reliability are maximized. Mullery [Mullery, 1979] and Finkelstien [Finkelstien, 1988] promote the idea of commitments, that is, to hold people accountable for statements they make or decisions they take, in order to encourage responsible attitudes.

2.5 Conflict Analysis

The VCM considers single viewpoint and multiple viewpoints conflicts. Four types of conflicts are defined:

- Reiteration
- Weakening
- strengthening

The principles of single-viewpoint conflict analysis (i.e. information from the same viewpoint) are the same for multi-viewpoint conflict analysis. As in information evaluation, conflict analysis heuristics use the external features of the information. The VCM does not provide a method for detecting conflicts, except a few heuristics for contradiction analysis. For example, given a piece of information:

If the viewpoint accepts responsibility and the convictions for and against are of the same strength, then there is a contradiction.

In this section, only multi-viewpoint conflict analysis heuristics are considered. Single-viewpoint conflict analysis heuristics follow the same principles with slight variations.

Assuming that a change of environment is not plausible, part of the decision tree looks like this:

In the case of reiteration:
if the old conviction is roughly equal to the new
and the levels of conviction are high
and there is no problem with trust
and there is the problem of ability
then add viewpoint and checkout ability problem.

In the case strengthening:
if the new information is weaker than the old,
and the investigation reveals that there is some substance
then keep the old belief and add viewpoint,
otherwise, keep the old belief and do not add viewpoint.

In the case weakening:
if the new information is weaker than the old, then keep the old belief and add viewpoint; otherwise, keep the old belief and do not add viewpoint
If the new information is stronger than the old, and there is no problem of ability, then reduce belief and add viewpoint.

In the case a contradiction:
if the new information is weaker than the old, then keep the old belief and add viewpoint

if the new information is stronger than the old, then suspend and investigate
if the two positions are equally solid, then keep the relative weight of beliefs, and add a new viewpoint on the opposing side

Conflicts analysis is a crucial part of a multi-viewpoints method and should be treated as an explicit activity. Having adopted the principle of a court investigation as a basis for requirements elicitation, it follows that the four situations: reiteration, weakening, strengthening, and contradiction applies in requirements elicitation. Conflicts are used here as a trigger to uncover further information and to learn more about the problem under investigation. There is no consensus over what a conflict is and what is not. Each author adopts their own definition. In this paper, a 'judicial' approach adopted was adopted as advocated by the Viewpoint Control Mechanism.

2.6 The principle of Enquiry

An enquiry is launched if:

- There is a need for further information necessary to find a solution to a question.
- There is a need for more evidence to support or weaken an existing piece of information.
- There is a need to find out more about a particular viewpoint.

The VCM first decides whether it is worth launching an enquiry by using a different type of importance analysis. For example:
if there is a problem and the information and the viewpoint are not of interest
then recommend not to enquire

if there is a problem and the efforts required to solve it
is greater than the viewpoint or information warrants it, then recommend not to enquire

There are other domain-specific heuristics, for example:
The analyst should encourage viewpoints to volunteer information. The analyst should make maximum use of the information available, e.g. use the properties of the requirements language to infer other information.

Requirements elicitation is an investigative process of exploration and learning. Collecting the maximum information in the minimum of time requires maintaining a balance between interactions with the information viewpoints and making the maximum use of information available.

2.7 Viewpoint Re-evaluation

The VCM revises the indices in the model of an existing viewpoint in the light of new evidence or creates a new model for a new viewpoint based on the available information about that viewpoint. It must change:

- The ability related indices - e.g. expertise, reasoning, etc.
- The trust-related indices - e.g. beliefs, interests, special relationships

An example of a heuristic to change the ability index:

if there is a new case, and there is no connection to other information, and there is no specific evidence, then add the type of case to the accumulated evidence,
else enquire with the viewpoint or viewpoints which would know.

To maintain the belief index:

if there is a regular pattern in the records, and that pattern is about opinions, and the viewpoint keeps reiterating its opinion, and there is direct evidence, then add belief to list

else if there is no direct evidence, then record the possibility of a strong belief

As pointed out by Fickas [Fickas, 1988], we get a radically different criticism of a statement if we vary the universe of discourse (defined by the domain goals in Fickas's case). A domain goal's importance does not remain fixed but changes as the analysis progresses and more knowledge about the domain is acquired. Similarly, the viewpoint models record the results of learning about the viewpoints. They need, therefore, to be updated as the investigation evolves.

3. **Conclusion**

The paper has presented an approach that regards viewpoint resolution as a belief formation exercise of identifying viewpoints, reasoning within a viewpoint, reasoning between different viewpoints, and revising a viewpoint. The approach stresses the role of uncertainty in the information acquisition process and the crucial role that human factors and relations play in dealing with uncertainty, should those factors be made explicit. It is based on the principle that in order to make sense of a domain, one must learn about the information viewpoints.

The principles of the new viewpoint resolution approach stem from the adaptation of the Viewpoint
Control Mechanism to requirements elicitation. It has been shown that the Viewpoint Control Mechanism can be applied successfully to domains where there is a continuous flow of information from human viewpoints, operating in the same domain and where precision is of less importance than establishing evidence about the situation under analysis. The VCM and requirements elicitation share the principles of a court investigation where different witnesses may have conflicting or corroborating views.

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