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ABSTRACT

While there are many purported benefits of agile software development, use of these methods often has a significant impact on project coordination and information management, particularly where large, distributed teams are concerned. Effective coordination requires easily accessible, preferably structured information that is typically unavailable. In this paper we present a comprehensive argument for the need to develop supporting tools for extracting information in agile projects. Such tools may improve the coordination, information management and tracking processes in agile teams with automated highlighting of salient issues arising from project meetings using documentation generated automatically from unstructured information, such as Instant Messaging (IM) history or transcribed audio records of team meetings. We discuss the relevance of our methodology for large-scale, distributed, multi-project agile teams and present guidelines for designing information systems to support such tasks. We present a description and evaluation of the proposed information extraction method using an actual dataset.

Keywords

Agile Development, Information Extraction, Decision Support Systems

INTRODUCTION

The last 10 years or so has seen the emergence of a number of information systems development (ISD) methods, collectively been labelled as agile. According to Tan and Teo (2007), "agile techniques are fast becoming the adopted methodology commercially". A survey of 2,570 participants, shows that more than 22% of the companies have adopted agile processes (Schwaber and Fichera, 2005).

However, in relation to decision making in agile development, we argue that there are a number of weaknesses in current agile method research (Conboy, 2009; Conboy et al., 2009). Firstly because agile development relies on tacit communication with little documentation (Fowler and Highsmith, 2001), capturing task-specific meeting minutes and tracking issues is much more difficult, especially in large teams, and is something that makes traditional data gathering approaches challenging or obsolete. This may be exacerbated in an agile setting where political, cultural and other people issues are heightened (Conboy et al., 2010).

Secondly, in an agile development environment, the project manager's role as a decision-maker is greatly reduced, and is more akin to that of a facilitator or coordinator (Alleman, 2002; Nerur et al., 2005). The development team makes most of the decisions, creating a "pluralist decision-making environment" (Nerur et al., 2005) due to the diverse backgrounds, attitudes, goals, and cognitive dispositions of the team members (Chin, 2004; Cockburn and Highsmith, 2001; Highsmith, 2004). This may give rise to additional complexities and decision-making may not be as well structured and recorded. This is even more important to the individuals on the project given that the team shares accountability.

Thirdly, in agile projects the organisation or team structure is “organic and flexible”, as opposed to traditional structures which are “mechanistic, bureaucratic and formalized” (Nerur et al., 2005). Further, developers are not confined to a specific specialised role and are encouraged to self-organise, interchanging and blending roles (Nerur et al., 2005) and involved in decisions that may fall outside their traditional skill areas. While this fluidity brings many benefits, the decision-making process may also have to be more flexible and less structured, increasing the need for appropriate support.

Fourthly, while small teams are typically suited to co-location, face-to-face team meetings and verbal project updates, this becomes increasingly difficult to coordinate with large teams (Boehm, 2002; Bowers et al., 2002). Additionally, using agile methods with distributed teams and/or multi-project agile teams increases the coordination issues of meetings and tracking and reporting tools (Sutherland et al., 2007). As the scalability of agile methods to large-scale, distributed and multi-project teams is increasing due to the business value of distribution (Woodward et al., 2009), it is necessary to develop new decision aids to capture and track information to coordinate such teams. Distributed teams also often have cultural and language barriers to overcome (Sutherland et al., 2009; Sutherland et al., 2007). However, for teams that have members speaking multiple languages, a decision aid that tracks meeting summaries and issues can clarify project updates and issues after meetings when team members can read meeting summaries. Finally, the use of agile methods has been questioned in critical systems development where an auditable trail of documentation for decisions is required (Drobka et al., 2004).

To improve the coordination for decision-making in larger agile teams, we propose developing a decision aid tool that can a) document meetings, b) track information over time for agile teams, and c) extract context-specific items of importance discussed at meetings and requiring action. Ultimately, a tool that tracks meeting minutes and customer user stories would be beneficial to drill down to the tasks required for each user story, including the developer and time to complete the task. Samples of code that have been used for similar customer stories and customer prioritization votes could also be tracked. Ideally, a tool that scans all meeting minutes to include audio and/or video segments of team discussion for each customer story would have immense value for agile development teams.

As a first step to building such a tool, we propose the development of a system capable of intelligently extracting and highlighting topical items talked about at meetings. The system would examine unstructured records of agile team meetings (e.g. meeting notes or IM history) to support agile processes. In time, we see this tool as a project management system that can track various project data and collate selected facts into management reports to improve the tracking of agile teams while still maintaining limited project documentation.

This work in progress paper presents a methodology for supporting meeting coordination and issue tracking in agile project teams using information extracted from various types of recordings of team meetings. We discuss an approach for documenting project meetings using information extraction techniques applied to unstructured content (e.g. Instant Messaging (IM) history or transcripts of audio streams recorded during team meeting) in planning, stand-up and retrospective meeting contexts. While this methodology can be applied to any type of software development team, we focus on agile teams because these teams specifically value software over documentation (Fowler and Highsmith, 2001) which was traditionally used as a vital decision aid. Our approach can minimise the effort necessary for documenting project progress, and enable agile team members to summarise team meetings and track tasks and recurring issues over time using structured information. However, in this paper we also focus on how this approach can facilitate decision-making in agile teams, by extracting salient issues requiring addressing and decision using intelligent analysis of automated meeting transcripts.

First we present the motivation of our study. We then describe the theoretical background for large-scale team meeting coordination in agile IS projects, explain the research approach and discuss the empirical cases of our study.

DOCUMENTING MEETING ACTIVITIES

Meetings are a common medium for teams to coordinate and to share understanding about their work (Minneman et al., 1995). They involve various team activities oriented on exchanging information (e.g. discussions, presentations). As such, they undoubtedly are a rich source of information in a variety of forms (notes, audio/video records, sensor data) that, when properly organized, facilitates project management (Geyer et al., 2005). Best practices highlight the importance of meeting records that capture the agenda, the decision made during the meeting, the action items assigned and the issues that need to be solved later, with a variety of forms (see Figure 1). Such records may improve meeting efficiency by decreasing the effort necessary to revisit the conclusions and provide better understanding of the decisions made.

The importance of meeting documentation is acknowledged (Khan, 1992; Whittaker et al., 1994) showing that at least 33% of team members review their notes regularly, but 70% reported that “there had been occasions when they wished they had written better notes" (Geyer et al., 2005). Finally, documenting meetings (e.g. note taking) not only requires additional effort from participants but also may become a distraction (Geyer et al., 2005).

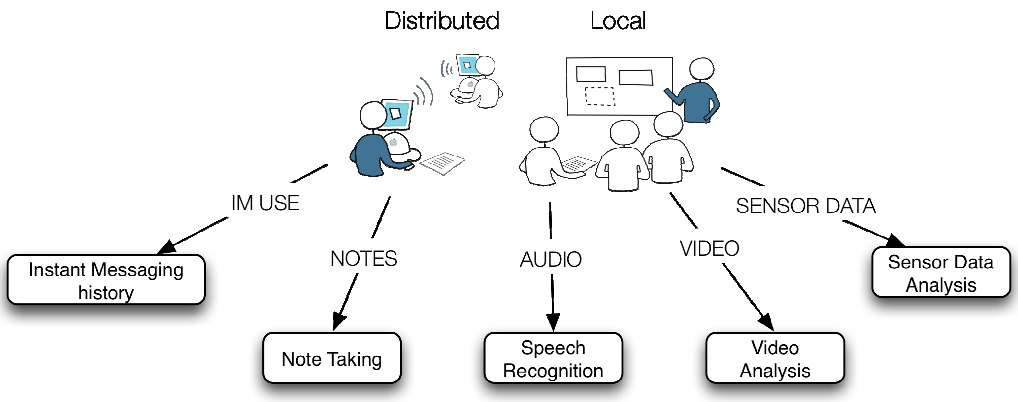

Figure 1. Generic types of meeting documentation

Although multi-modal (e.g. integrating notes and audio) meeting support systems are emerging (Belkhatir, 2010; Chiu et al., 2000), due to information richness, maturity of existing speech-to-text solutions (Belkhatir, 2010), and minimum technical requirements for recording (Yu and Nakamura, 2010) - in this work we concentrate on audio records.

From Meeting Records to a Decision Aid

Although there is significant value in a system capable of automatically generating documentation from project meetings, its value may centrally rest in facilitating the tracking and history of decisions and developments through the course of the project. Of more *instant* value to teams may be a system not only capable of capturing audio speech as text, but capable of analysing that text to identify the main issues (or topics) discussed by the team, assess whether discussion on such items identified them as requiring action, and displayed this analysis to the team in a manner that visually ranked items discussed more frequently or with more emphasis as those possibly needing immediate attention. Such a system would provide a valuable decision aid for the agile development team, and one that could be useful at each meeting.

Decision aids are support systems designed to enhance decision making (Thomassin Singh, 1998). They encompass the application of "available and computer-based technology to help improve the effectiveness" of decision making (Keen and Scott Morton, 1978). The decision effort expended or required to be expended in decision-making is a central and important factor influencing decision behaviour (Payne, 1982; Todd and Benbasat, 1991; Todd and Benbasat, 1993). Much of the literature on decision support systems (DSS) suggests that decision aids, which minimise decision effort, are of particular value (Todd and Benbasat, 1991; Todd and Benbasat, 1993). Todd and Benbasat (1993) argue that a DSS can be used as a replacement for decision maker effort rather, allowing a decision maker to "complete the decision task with less effort". Indeed, decision makers "typically trade off the amount of effort to be spent in making a decision and the benefits they expect as a consequence of effort expenditure" (Todd and Benbasat, 1992).

Automation of salient item extraction from meetings and the highlighting of those necessitating further action (such as assignment to persons for unit work completion) can help and reduce the otherwise manual effort associated with task allocation stemming from such meetings. As such, our approach provides an effort-reducing team decision aid. How salient items are presented is important (Noyes and Garland, 2003), and may include the visual identification of items most frequently mentioned, revisited, or stressed at meetings. It follows that intelligent information extraction and display provides a decision aid that may facilitate teams with tasks directly related to prioritisation. In the following section we expand further on how our approach first captures meeting audio as text, then intelligently extracts topics from this text, and how it identifies and displays these topics for consideration by the team.

Smart Meeting Systems Using Audio Records

Creation of meeting documentation requires significant effort. Many techniques of automatic speech recognition (ASR) have been developed to transcribe audio records (Gütl, 2008; Yu and Nakamura, 2010). The key challenge for ASR – conversion of input audio (speech) to written text – is not a trivial task. In addition, free text – output of ASR methods – is difficult to manage, search and process. As such, additional steps, for example *text summarization*, are required to improve the quality of *information extraction* methods that enable transformation of the unstructured content to structured forms that can more naturally support agile team activities. Generic tasks for the extraction of relevant information from text include *Sentiment Analysis* and *Topic Extraction*. Topic extraction methods mine and identify topics mentioned in the text and their relevant opinions (that is, the context in which they are discussed), which are then analysed in terms of articulated sentiment about these topics (*Sentiment Analysis*). For example, "Code unit 4 will take 3 days to do, which we don't have" "Yes, I agree" would identify Code Unit 4 as a topic, but with an overall negative sentiment.

In the following sections we discuss the process of generation of structured content from audio meeting records in more detail. First we give an overview of methodologies and tasks for *Speech Recognition*. We then discuss the processes of *Topic mining* and *Sentiment Analysis* of text generated from meeting records using information extraction methods.

Speech Recognition and Text Summarisation

Automatic speech recognition is a well-established research problem. Rabiner (1994) describes three classes of speech recognition applications: isolated word recognition systems (pauses between the words), highly constrained systems using continuous speech but with small vocabulary and limited to specific phrases, and finally, large vocabulary continuous speech recognition (LVCSR) systems – widely applicable but also the most challenging to implement. In the past years many different methods have been developed to address these tasks including: hidden Markov models (MMH) (Rabiner and Juang, 1993) and phoneme (sub-word) based approaches (Creutz et al., 2007). Summary of the literature (Yu and Nakamura, 2010) reveals the following generic tasks that an ASR system must support. First, the speech record is transformed using signal-processing techniques so that the distinct sounds and words are easier to distinguish (*audio pre-processing*) (see Figure 2). Further, the voice record is analyzed using statistical methods and training data to match phonemes in the audio stream (*Acoustic modelling*). The L*anguage model* provides possible combinations of phonemes (a grammar) and word sequences according to the language used. These two models are used together to decode the audio stream into text. Quality speech recognition systems are capable of handling background noise (Pearce and Hirsch, 2000). Also, due to the characteristics of English language (morphological simplicity), its modelling has provided more than satisfactory results (Creutz et al., 2007).

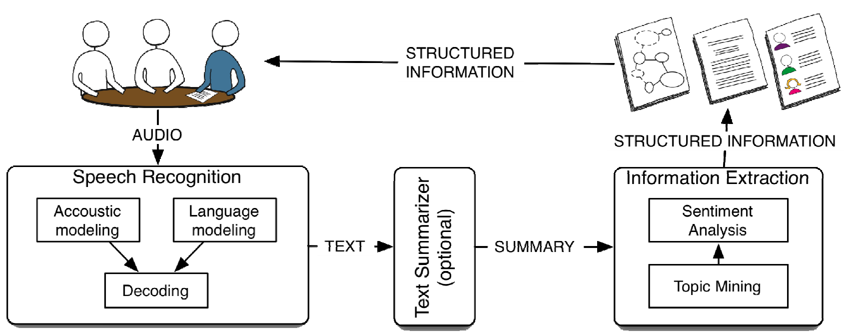

Figure 2. A generic architecture for supporting decision-making with information extracted from meetings audio records.

Meeting summarisation results can be presented by either text or speech (Furui et al., 2004). Text summarisations are considered superior as they can be easily looked through, interesting fragments can be easily extracted (not a case for audio/video records that require annotation (Belkhatir, 2010)), "information extraction and retrieval techniques can be easily applied" to text documents (Furui et al., 2004), and they provide an ancillary benefit of producing traceable meeting documentation. Further, state-of-the-art research (Furui et al., 2004; Stolcke et al., 2006) has provided a number of fairly accurate methods for text summarisation. On the other hand, audio and video records require content indexing for easy access to original parts of the data (e.g. combining electronic note taking with audio for better indexing (Stifelman et al., 2001)). Capturing and combining audio and video records of meetings have recently gained interest (Belkhatir, 2010), especially with the development of multimedia conference rooms (Chiu et al., 2000). Furthermore, in the recent years, context-aware topic-sentiment analysis received attention in the research (Mei et al., 2007).

In the next section we describe the information system we developed to extract information from meeting transcripts that can be created using the above methods

Information Extraction

There are three generic tasks that topic mining systems needs to fulfil: *identification of the interesting concepts*, *discovery of their descriptions (opinion phrases)*, and *sentiment analysis* (Popescu and Etzioni, 2005). In our method, the first of these tasks is performed using domain knowledge for a given topic of interest. The set of concepts interesting to a particular decision maker are captured in a hierarchy (concept hierarchy). Every concept is associated with a collection of labels (i.e. synonyms). Therefore, our approach is flexible and can be used for extraction of any topic-related opinions. After identification of the relevant concepts in the text, their descriptions ("opinion phrases") need to be recognised. To extract concept descriptions and to select sentences containing potential opinions, we used a rule-based method similar to Aciar et al. (2007). Using a set of domain-independent rules we extracted descriptions of relevant concepts as chunks of text. Overall, the method we used is similar to approaches based on word proximity windows (Hu and Liu, 2004), involving the computation of syntactic dependencies between words (Popescu and Etzioni, 2005). However, our approach accommodates language structure, in contrast to Hu and Liu's approach (2004), and is more efficient than that proposed by Popescu and Etzioni (2005). A more detailed description of the discussed framework for extraction of information from unstructured text can be found in (Dabrowski et al., 2010).

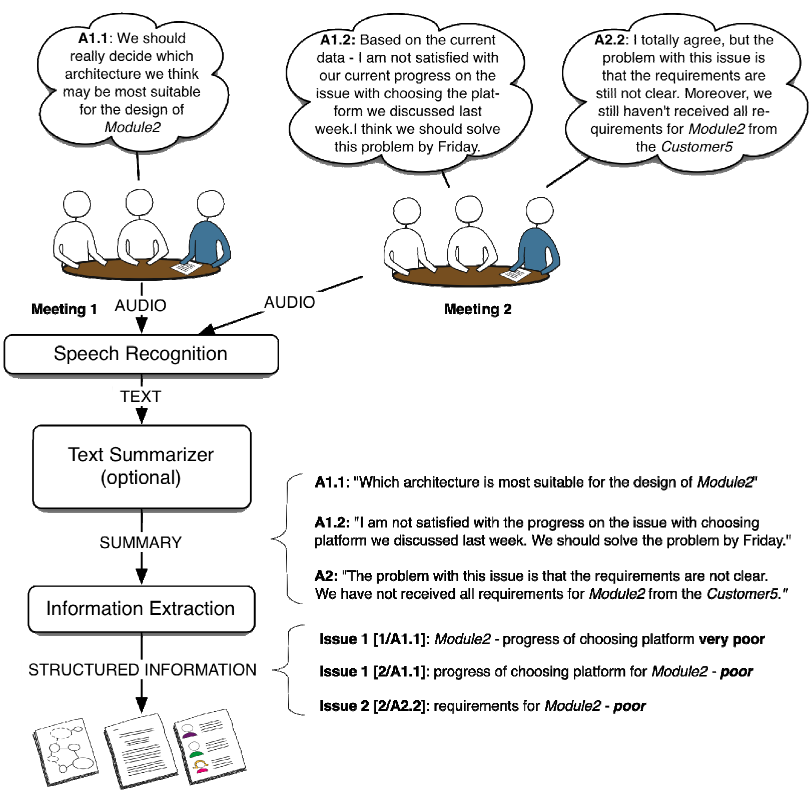

Figure 3. A practical example of issue tracking and summarisation across meetings.

Example

We now describe a scenario demonstrating the support for agile project management provided by our decision aid (see Figure 3). Imagine you are a member of a distributed, multinational large agile team that is working on a delivery of an Information System. During every meeting the team consisting of many actors, including A1 and A2, discusses current progress, tasks that will need to be addressed in the near future and occurring issues. Dialogs (e.g. A1.1, A1.2, A2) are recorded live for further analysis without additional effort from meeting participants. During the first of a series of meetings, a participant (A1) mentions his concern on a task (*Issue1*) related to *Module2.* This issue is than again mentioned during the second meeting (*Meeting 2*). Both actors (A1 and A2) provide their concerns about the progress of the task reported ("architecture of *Module2*"). Moreover, A2 reports on another issue (*Issue2*) related to the same task. Meeting audio records are converted to text transcripts by the *Speech Recognition* module and summarised by the *Text Summarisation* module (see Figure 3).

Further, summarised dialogs are examined for relevant information (e.g. reported issues and their context). For every issue, the system provides a description and its sentiment (e.g. "positive", "negative"). These results are later summarised into a concise tabular representation (other presentation formats may be provided). When preparing for the next meeting (or when dealing with tasks) team members will be able to consult a short, structured list of issues that were mentioned during the meeting together with participant's sentiment representing the progress (see Figure 3). Thus, tracking recurring issues or actors reporting them (e.g. particular customer) is possible with minimum additional effort required.

Evaluation

Spontaneous speech is often ill-formed, includes repetitions and misspellings (Furui et al., 2004). On the other hand, product reviews are very informal, typically grammatically incorrect and misspelled paragraphs of text that closely resemble characteristics of a meeting transcript. Evaluating our approach required a large amount of input data: as an initial step we designed a simulation using a dataset consisting of product reviews we gathered from *whatcar.com*. Every sentence in the set (203 reviews (1233 sentences) was annotated by a group of human annotators for comparison with system annotations, following similar studies in the domain (Hu and Liu, 2004). Annotations consisted of a list of explicit and implicit concepts, their descriptions and overall opinion sentiment using a 5-step scale: -2 (very negative), to 2 (very positive). Annotators negotiated inconsistencies to avoid a potential negative impact of subjective opinion on polarity and strength of the sentiment. We evaluated the performance of our method with precision and recall metrics for our test dataset and accuracy of the sentiment analysis technique (see Table 1). *Precision* refers to the fraction of topics/issues that were correctly identified (i.e. is the team member actually mentioning Issue A1.1 in his IM?) and *recall* represents the percentage of successfully identified issues that were actually present in the text. *Accuracy* of Sentiment Analysis represents the fraction of correctly identified sentiment of an agile team member towards the identified issue.

Topic mining		Sentiment Analysis
Precision	Recall	Accuracy
76.3%	77.5%	82.6%

Table 1. Opinion Mining evaluation results

Overall, the results indicate that our prototype was able to correctly identify four out of five issues and the expressed sentiment. We note that performance of the presented method can be further improved if additional steps (e.g. text preprocessing for misspellings) are utilized.

DISCUSSION

Our approach supports decision-making in providing a decision aid that enables agile teams to examine salient issues discussed at meetings. Such an aid can facilitate prioritisation of tasks, identify problem issues, and highlight topics requiring address by team members. The system proposed is passive, in that it does not require team effort, and automates both the capturing and coding of meeting audio as text, as well as the analysis and presentation of summary issues. The system also facilitates tracking of recurring issues, in that it can analyse meetings cognisant of previous analyses, and therefore offer a tracking facility for unresolved issues. Further, the system provides automated documentation for agile teams.

In this paper we focused on the aspects of the system concerned with extracting meaning from unstructured meeting documentation (e.g. transcripts of audio records), and so we presented summary results of a simulation focusing on these aspects. Table 1 shows that our approach can provide in excess of 82% accuracy in analysing contextual sentiments surrounding topical items, with in excess of 75% accuracy in information extraction. Although these results are extremely promising at this early stage, perhaps the most valuable asset is the lack of human effort required. This is in line with previous studies examining the importance of a reduced effort in terms of using decision aids (Johnson and Payne, 1985; Todd and Benbasat, 1993).

This decision aid therefore has multiple benefits for agile teams. The minimal human effort required is a salient characteristic because it allows agile teams to maintain focus on delivering software over documentation while still maintaining a record of project team discussions, decisions and issues. Such documentation is also important because the team shares the accountability for decisions. This accountability is increased as agile methods are more and more scaled to large, distributed, multi-project teams. The coordination issues facing such teams are challenging, as they must find some way to substitute for co-location, face-to-face meetings and verbal project updates. This decision aid can assist in coordinating these teams and supporting the large-scale accountability on larger, distributed teams. It can also enhance project meetings with analysis and presentation of meeting summaries and recurring issues, which not only addresses the scalability, but also the cultural and language barriers of distributed teams. Finally, such a tool can provide structured information to better support agile decision-making. We are in the early stages of developing such a decision aid tool to document meetings, track information over time, and extract particular information from such meeting summaries. Initially, this tool will aid agile team's decision-making processes about recurring issues and project progress.

As a future work, we propose extending our decision aid into a larger project management system to assist distributed and multi-project agile teams by integrating various media types (e.g. video and audio) from web-conferencing meetings, providing samples of previously used code, tracking task estimations and prioritization, and providing best practices for customer stories based on previous projects. Overall, we see immense improvements in coordination and tracking of data for agile development teams while still maintaining minimal documentation, even for large-scale, distributed and multi-project agile teams.

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