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A Survey on Smart Meeting Rooms and Open Issues

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Abstract

Decision Making is one of the most important activities of the human being. Nowadays decisions imply to consider many different points of view, so decisions are commonly taken by formal or informal groups of persons. Groups exchange ideas or engage in a process of argumentation and counter-argumentation, negotiate, cooperate, collaborate or even discuss techniques and/or methodologies for problem solving. Smart Meeting Rooms (SMR) are the election spaces where groups can perform these activities in a local or distributed setting. SMR definition has evolved and in this article we present its evolution side by side with several projects that have been developed during the last decade. We also present the features and evaluation methods present in literature and we make a discussion on the open issues.

Keywords: *Smart Meeting Rooms, Intelligent Environments, Ambient Intelligence*

1. Introduction

Ambient Intelligence (AmI) deals with a new world where computing devices are spread everywhere, allowing human beings to interact with physical world environments in an intelligent, unobtrusive and sensitive way [1-[2]. AmI concept can be introduced in several different environments and involves several disciplines which can be summarized in five main areas: Human-Computer Interaction (HCI); Sensors; Networks; Artificial Intelligence; Pervasive and Ubiquitous Computing [3].

In [4] a generic AmI environment is proposed and authors refer two main components, an intelligent layer and an operational layer, and their interaction with the space and themselves. The Operational layer is composed by reliable sensing information, and actuation capabilities, such as raw sensors, sensors nets, GPS, Robots, communications or databases, etc. The Intelligent layer must incorporate AI methods and techniques and the tasks reserved to this Intelligent Layer are: Interpret the environment's state; represent the information and knowledge associated with the environment; model/simulate/represent entities in the environment; learning about the environment and participants preferences; interact with humans and with the environment.

Intelligent or Smart Meeting Rooms (SMR) is a sub discipline of Ambient Intelligent Environments [5] and is generally defined as an environment that should support efficient and effective interactions among their occupants. The generic goal of a SMR system is normally referred as a system that supports multi-person interactions, locally or distributed, in the environment in real time [6], but also as a system that is able to remember the past, enabling review of past events and the reuse of past information in an intuitive, efficient and intelligent way [1, 7], so as to make the meeting process more efficient [7]. In [8] they consider that a SMR should mainly support the decision making process considering the emotional factors of the intervenient participants, as well as the argumentation process.

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In summary we can define SMR as spaces used by groups in their interaction on the decision making process that are capable to identify, maintain and reuse the information created by groups, generating knowledge from this information. Where to be aware of meetings events, contents and emotional state of users is a determinative to maximize the group performance on the Decision Making process.

2. SMR Features

In literature we can find several attempts to design these SMR, and [1] [7] give a good summary on existent projects. From the analyses of several projects we are able to categorize them in two sections: the projects that focus on the Operational Layer which only cover Pervasive and Ubiquitous Computing, HCI, Sensors and Networks areas, who approach the problem based on an Information System approach [10] [14]; and the ones that are also targeting the Intelligent Layer which propose developments in semantic processing and thus falling down on the Artificial Intelligence (AI) area [6, 9, 11, 13, 15-20, 26].

As we consider that the Intelligent Layer and AI are a decisive characteristic for AmI spaces we will focus this article on the second category. We will now detail the functionalities that can be observed from the literature review. In [7] work is identified the following features:

2.1. Meeting Capture

This feature include audio and video processing as well as contextual information like temperature, room layout, agenda, calendar schedules and notes. Example projects are SMART [10], SMART M3 [20], LAID [9] and [6], [26].

2.2. Meeting Recognition

This section includes features like Person Identification; Speech Recognition; Summarization[19]; Attention Detection – like detecting who is looking at what or whom during a meeting; relevant Hot Spot Recognition that refer to parts of a discussion in which participants are highly involved like heated arguments, points of excitement, etc.; Activity Recognition[19], that distinct individual activities and group activities where the group ones are the most important and include human social behaviors, like proposing an idea, commenting, expressing a positive opinion, and requesting information. Example projects are M4 (Multi Modal Meeting Manager) [11], AMI (Augmented Multi-party Interaction) and ORIGAmI [13]. In this last section are also attempts to recognize the people emotions and social aspects of people [25].

2.3. Semantic Processing

Here are included: Meeting Annotations [9] or the process of creating labels for the meeting shots which consists of acquiring descriptors and then labeling data with them; Meeting Indexing, that mainly use events as an index to access meeting information. At a more raw data level, a temporal search is the most used approach to navigate on data streams; Meeting Browsing is a commonly present feature that acts as the interface between the smart meeting system and end users. It consists of visualizing, navigating, and querying meeting semantics as well as media content. Emotion aware [25] and argumentation support [8, 9] which consist on describing the emotional state of the meetings participants and use that knowledge to establish facilitation support [25] and/or argumentation strategy definition [9]

3. SMR Evaluation Methods

The criteria used to evaluate a smart meeting system include user acceptance, accuracy, and efficiency [7]. It is possible that some proposals use more than one type of evaluation.

User acceptance is measured by conducting user studies and analyzing user feedback.

Accuracy tests the recognition mechanisms by means of different objective methods: recognition rate, precision and recall. Where **precision** can be used as a measure of the ability of the system to identify correct objects only. **Recall** is used to test the ability of the system to recognize all correct objects.

Efficiency is usually employed to evaluate a meeting browser. The only know evaluation metric proposal we are aware is a browser evaluation test (BET) that uses the number of observations of interest found in the minimum amount of time.

Case studies and features comparison are also very used to exemplify and demonstrate the outcomes of a proposal.

4. SMR Projects

CyberOffice [31] is smart meeting Android application which is based on Wi-Fi Direct APIs of the Android platform showing that they can be effectively applied for file sharing and event exchanges. This is one more example of the kind proposals that focus on meeting capture features.

From now on we will explore some of the existent projects that also complement the AI area of AmI Environments.

Some works in literature are focused on developing ontologies for context specification in a specific domain to reach the goals of knowledge sharing across distributed systems. For instance, CONON [21] introduces extensible context ontology for pervasive computing environments. Eleni Christopoulou et al. focused on an ontology-based context modeling, management and reasoning process developed for composing context-aware UbiComp applications from AmI artifact [22]. COBRA [23] proposed by Chen et al., used ontology to describe person, places and intentions. Huq et al. [24] diverged from CONON and COBRA general purpose ontology model and proposed a model divided into two parts. On the one hand they proposed a Smart Space domain or a general ontology, adding the concepts of Environment, Service and Platform, which could be reused for other smart spaces. MTO and IGMTO ontologies [13] where proposed as an extension and complement of the precious ones and their mean is to be used to define the logical context of a meeting, like participants, GDSS techniques used, topics discussed by participants and they preview the existence of a property that is able to connect this Task information with the knowledge of the meeting participants produce.

The Context Toolkit [32] is a context-aware architecture that aims at facilitating the development and deployment of context-aware applications. It consists of functional components to acquire, aggregate and interpret context information and provides applications with access to context information while hiding the details of context sensing. JCAF [33] is a Java-based context-awareness infrastructure for creating context-aware applications. It uses an object-oriented model to represent context and suggest a compact Java API for context-awareness, which can be implemented and extended in special-purpose context-awareness systems. In [30] an ontology-based framework for developing NFC-based context-aware applications, which can perceive user context and offer appropriate context-aware services to the user by combining the NFC technology with context-aware technology. They model the context with a context ontology using OWL and a rule-based context reasoning

is performed over the context ontology model. In none of these proposals a task identification is proposed and their examples a generic approach is followed.

IConAwa system [29], an intelligent context-aware system, developed for proactively providing mobile users with context-aware information, using a rule-based context-aware and reasoning in a multi-agent approach. For context and the point of interest representation are used ontologies modelled in a flexible and extensible way. Knowledge sharing and knowledge reuse are also provided by using the ontology models. Authors makes use of rule-based context reasoning providing high level derivation of the implicit context from low level explicit context.

In terms of architectures the Smart-M3 [20] [27] is an interoperability platform operating on principles of space-based information exchange. The authors defined an architecture consisting of knowledge processors (KP) and a semantic information broker (SIB) concepts. The SIB stores and makes available information inserted to it by KP and they use a communication mechanism called the smart space access protocol, or SSAP. This SSAP is the main integration point in the architecture, and any KP or SIB that implementing it can participate in the system. The KP co-operating in different scenarios are extremely loosely coupled in the Smart-M3 world, though they may have dependencies outside the Smart-M3 platform, so they argue that the appearance or disappearance of KP will have little effect on other KP. Authors included an Ontology API but the focus is to use it only as a translator for SSAP and RDF to Objects. The semantic engine they provide is a service built on a RDF Store that is open to receive some basic instructions like insert, update, and query and subscribe.

We were not able to identify any kind of autonomy that cloud be given to this SIB, neither any kind of process for governing ontologies and there is any evidence suggesting that the task performed is somehow stored on the RDF Triples Store.

5. Discussion

Not all literature proposals fall on all the features identified in section 2 but what we want to highlight is that Meeting Recognition are the features where we can find more AI methods used to automatically recognize the meeting events and possibly to act in order to support the meeting facilitation process or to help the participants individually in the decision process by analyzing strategies that cloud be used to take participants will ahead.

Surprisingly in Semantic Processing we are not able to find much evidences on the usage of AI. The approach identified is more a presentation approach where the user is able to navigate on the meeting contents mainly thought time and events labels.

The most part of projects on SMR focus on aspects connected to Pervasive and Ubiquitous Computing, HCI, Sensors and Networks. This is clear, for instance on the ontologies proposed to be used on SMR [23, 24] or Smart environments [29] where MTO and IGMTO are an exception [13]. Such advances on Pervasive and Ubiquitous Computing, HCI, Sensors and Networks are important but we believe they are not enough to achieve the concept of Ambient Intelligence, due their lack of Artificial Intelligence mainly on the level of Knowledge Management.

A widespread definition of Context-aware computing [3] refers to a general class of systems that can sense their physical environment, like their context of use, and adapt their behavior accordingly. Such systems are a component of a ubiquitous computing or pervasive computing environment. Three important aspects of context are: where you are; who you are with; and what resources are nearby. Context-aware in contrast is used more generally to include nearby people, devices, lighting, noise level, network availability, and even the social situation.

However for meeting environments it is obvious for us that what people are discussing about is a fundamental for define the context of a meeting. We believe that only having such capabilities we will be able to support users in a sensitive and intelligent way.

Some exceptions to projects that only focus on Pervasive and Ubiquitous Computing, HCI, Sensors and Networks can be identified like [28], [27], [29], [20], [16] and [13] who proposed definitions of context and semantic processing of that information in order to be able to define the context of a smart space. Smart-M3 propose a generic architecture suitable to different kind of AmI Spaces [27] introducing the concept of domain ontologies for knowledge management despite their general approach as services without any kind of initiative, autonomy and reasoning services [27].

However only in [16] and [13] this concept goes further, because the others try a higher level approach who targets any area of application, like houses, public spaces, etc. In [16] and [13] they detail that a meeting space as a specialization of Smart Spaces. Once again we argue that the space should know what people are discussing during the meetings, in order to the space to be able understand the meeting contents, what participants are discussing and try to provide intelligent contextual feedback. For this they propose Ontology for defining a meeting task context [13] and a model to use this task identification to define a context. Despite they don't specify how the contextual feedback is provided they state the path to achieve it and made the necessary proposals to achieve such goal.

6. Conclusions

In this paper we presented the features that Smart Meeting Rooms present on the literature. We crossed this features and the projects were they appear with the general architecture for Ambient Intelligence Environments. Based on this we've made a discussion about the fulfillments of the AmI characteristics that should be present in SMR projects highlighting when they exist and exposing our concerns about the author's proposals. We also presented some existing projects in literature as well as how the community is evaluating their proposals.

We can conclude that most of the work in literature doesn't put SMR as a very specific environment and they try to feet such space on a more general approach. We believe this generic approach will fail to target the specific needs of these environments on the support of meetings and support of decision making process. Other conclusion we can provide is that efforts to take into account the participant emotions and the social events that are present in meeting environments are few. As humans we are strongly influence but such kind of aspects, and in SMR environments mainly in group meetings this as to be taken into account.

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References

[1] C. Ramos, "Ambient Intelligence Environments", Encyclopedia of Artificial Intelligence, J. Rabunãl, J. Dorado, and A. Sierra, eds., Information Science Reference, **(2009)**.
[2] D. J. Cook, J. C. Augusto and V. R. Jakkula, "Ambient Intelligence: Technologies, applications and opportunities", Pervasive and Mobile Computing, vol. 5, **(2009)**, pp. 277-298.
[3] J. C. Augusto, "Ambient intelligence: Basic concepts and applications", In Software and Data Technologies, **(2008)**, pp. 16–26, Springer.
[4] C. Ramos, J. C. Augusto and D. Shapiro, "Ambient Intelligence, the next step for AI, IEEE Intelligent Systems magazine, vol. 23, no. 2, pp.15-18.
[5] C. Ramos, G. Marreiros, R. Santos and C. F. Freitas, "(2010). Smart Offices and Intelligent Decision Rooms. In H. Nakashima, H. Aghajan, & J. C. Augusto (Eds.)", Handbook of Ambient Intelligence and Smart Environments, pp. 851–880, Springer US.
[6] R. K. Hegde, X. D. Huang, S. K. Cunnington, J. Li, M. Pahud, R. M. Burkhardt and Z. Zhang, "Smart meeting room", US20100228825, **(2010)** September 9.
[7] Z. Yu and Y. Nakamura, "Smart Meeting Systems, A Survey of State-of-the-art and Open Issues", ACM Computer survey, vol. 42, no. 2, **(2010)**, pp. 8:1–8:20.
[8] G. Marreiros, R. Santos, C. Ramos, and J. Neves, "Context-aware emotion-based model for group decision making", IEEE Intelligent Systems, **(2010)**, pp. 31–39.
[9] G. Marreiros, R. Santos, C. F. Freitas, C. Ramos, J. Neves and J. Bulas-Cruz, "LAID - a smart decision room with ambient intelligence for group decision making and argumentation support considering emotional aspects", International Journal of Smart Home, vol. 2, Issue 2, SERSC **(2008)**.
[10] A. Waibel, T. Schultz, M. Bett, M. Denecke, R. Malkin, I. Rogina, R. Stiefelhagen and J. Yang, "SMaRT, the Smart Meeting Room Task at ISL", in IEEE International Conference on on Acoustics, Speech, and Signal Processing, **(2003)**, 281-286.
[11] A. Nijholt, "Meetings, gatherings, and events in smart environments", In Proceedings of the 2004 ACM SIGGRAPH international Conference on Virtual Reality Continuum and Its Applications in industry, **(2004)**, pp. 229-232.
[12] I. Mikic, K. Huang and M. Trivedi, "Activity monitoring and summarization for an intelligent meeting room", In Workshop on Human Motion, **(2000)**, pp 107–112.
[13] C. F. Freitas, M. Helio, J. Barroso, and C. Ramos, "Ontologies for meeting contents awareness - MTO and IGMTO", Ambient Intelligence and Smart Environments, **(2011)**, pp. 651–662.
[14] J. Nunamaker, R. Briggs, D. Mittleman, D.Vogel and P. Balthazard, "Lessons from a dozen years of group support systems research, a discussion of lab and field findings", Journal of Management Information Systems, vol. 13, no. 3, **(1997)**, pp. 163-207.
[15] J. Carneiro, J. Laranjeira, G. Marreiros, C. Freitas and R. Santos, "A Context-aware Model to Support Ubiquitous Group Decision Making", Journal of Internet Services and Information Security (JISIS), vol. 2, no. 1 and 2, **(2012)**, pp. 105–118.
[16] C. F. Freitas, G. Marreiros, R. Santos, J. Barroso, and C. Ramos, "A Multi-Agents Framework for Contextual and Affective Decision Making", Ambient Intelligence and Smart Environments, **(2013)**.
[17] C. Freitas, C. Ramos, and J. Alferes, "ORIGAmI-ontology reuse for idea generation in AmI. In Proc. of the 2010 International Symposium on Ambient Intelligence (ISAmI'10)", Guimaraes, Portugal, vol. 72, **(2010)**.
[18] J. Laranjeira, G. Marreiros, C. Freitas, R. Santos, J. Carneiro, and C. Ramos, "A proposed model to include social and emotional context in a Group Idea Generation Support System. In Privacy, Security, Risk and Trust (PASSAT) and 2011 IEEE Third International Conference on Social Computing (SocialCom)", 2011 IEEE Third International Conference on **(2011)**, pp. 609–612.
[19] C. F. Freitas, A. Meireles, L. Figueiredo, J. Barroso and C. Ramos, "Context Aware Middleware for Supporting Idea Generation Meetings in Smart Decision Rooms", In Ubi-Media Computing (U-Media), 2011 4th International Conference on **(2011)**, pp. 53–58.
[20] J. Honkola, H. Laine, R. Brown, and O. Tyrkko, "Smart-M3 information sharing platform", In 2014 IEEE Symposium on Computers and Communications (ISCC), Los Alamitos, CA, USA, Computer Society, vol. 0, **(2010)**, pp. 1041–1046.
[21] X. H. Wang, D. Q. Zhang, T. Gu and H. K. Pung, "Ontology Based Context Modeling and Reasoning using OWL", In Pervasive Computing and Communications Workshops, IEEE International Conference on, Los Alamitos, CA, USA: IEEE Computer Society, **(2004)**, vol. 0, p. 18.
[22] E. Christopoulou, C. Goumopoulos, and A. Kameas, "An ontology-based context management and reasoning process for UbiComp applications", In Proceedings of the 2005 joint conference on Smart objects and ambient intelligence, innovative context-aware services: usages and technologies, **(2005)**, pp. 265–270, New York, NY, USA, ACM.
[23] H. Chen, T. Finin, and A. Joshi, "An Ontology for Context-Aware Pervasive Computing Environments", The Knowledge Engineering Review, vol. 18, no. 03, **(2003)**, pp. 197–207.
[24] M. R. Huq, N. T. Tuyen, Y. K. Lee, B. S. Jeong and S. Lee, "Modeling an ontology for managing contexts in smart meeting space", In SWWS'07: Proceedings of the 2007 International Conference on Semantic Web and Web Services, **(2007)**.

[25] J. Laranjeira, G. Marreiros, C. Freitas, R. Santos, J. Carneiro and C. Ramos, "A Proposed Model to Include Social and Emotional Context in a Group Idea Generation Support System", In 2011 IEEE Third International Conference on Privacy, Security, Risk and Trust (PASSAT) and 2011 IEEE Third International Conference on Social Computing Social Com, **(2011)**, pp. 609–612.
[26] E. Nathan, Y. Kadishay and D. Cooper, "SMART MEETING SERVICE, United States Patent Application" 20150058425, **(2015)** February 26.
[27] J. Kiljander, A. Ylisaukko-oja, J. Takalo-Mattila, M. Etel, and J. –P. Soininen, "Enabling Semantic Technology Empowered Smart Spaces", Journal of Computer Networks and Communications, e845762, **(2012)**.
[28] X. Wang, J. S. Dong, C. Y. Chin, S. R. Hettiarachchi and D. Zhang, "Semantic Space, an infrastructure for smart spaces. IEEE Pervasive Computing, vol. 3, no. 3, **(2004)**, pp. 32–39.
[29] O. Yılmaz and R. C. Erdur, "iConAwa – An intelligent context-aware system", Expert Systems with Applications, vol. 39, no. 3, **(2012)**, pp. 2907–2918.
[30] J. Luo and H. Feng, "A Framework for NFC-based Context-aware Applications", International Journal of Smart Home, vol. 9, no. 1, **(2015)**, pp. 111-122.
[31] D. K. Kim and J. Y. Jung, "CyberOffice, a Smart Mobile Application for Instant Meetings", International Journal of Software Engineering and Its Applications 8.1, **(2014)**, pp. 43-52.
[32] A. K. Dey, G. D. Abowd and D. Salber, "A Conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications", Human-Computer Interaction, vol. 16, **(2001)**, pp. 97-166.
[33] J. E Bardram, "The java context awareness framework (JCAF) - A service infrastructure and programming framework for context-aware applications", In Proceedings of the 3rd International Conference on Pervasive Computing, **(2005)**, pp. 98-115.
[34] Wikimedia - Context-aware pervasive systems http://en.wikipedia.org/wiki/Context-aware_pervasive_system

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