WENCHAO JIANG

INVESTIGATING INTERACTIONAL ISSUES OF AGENT PLANNING SUPPORT

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Disaster Response as an example

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—– something.
Family means nobody gets left behind, or forgotten.

— Lilo & Stitch

Dedicated to the loving memory of Rudolf Miede.

1939 – 2005

ABSTRACT

This thesis contributes to the understanding of the potential socio-technical issues that might emerge from the interaction between responder teams and automated planning support and propose design solutions to them.

(Problem) Recently, Frequent natural and man-made disasters in Haiti, Chile and Japan drew attention of Researchers. A lot efforts have been made to study the technologies that can assist human responders to improve their performance. In the disaster response domain, a disaster response team, which contains several incident commanders and field agents, is faced with the problem of carrying out geographically distributed tasks under spatial and time constraints in a quickly changing task environment.

Effective planning and coordination can be a key factor for the success of disaster operation but it is difficult to achieve. Recent advance in the multi-agent technologies leads to the possibility of building agent software which supports Team coordination by automating the task planning process. However , it is unknown how the agent software can fit into the team organisation in a way that improve rather than hinders the team performance.

(method) This work presents three field studies which investigates the impact of different interactional arrangements between human teams and automated planning support. The studies adopt serious game approach which is arguably an established vehicle to vehicle to explore socio-technical issues in complex real world settings.

We developed AtomicOrchid, an emergency response game to create a task setting which mirrors real aspects of disaster response operation. In the game trials, participants are recruited to play as field responders and incident commanders to carry out rescue missions. Participants' experiences are observed and recorded as they coordinate with each other to achieve game objectives, with the support from an intelligent planner software. Interaction analysis is carried out on the data, leading to descriptive results which unpacks interactional issues. By iteratively designing and examining different interactional arrangements through three iteration of studies, we progressively explore requirements and social implications of planning support system for responder teams.

In the 1st study,field responders and incident commander coordinate without support of the intelligent planner. The study establish baseline performance of the game play and derived several requirements for planning support system. In the 2ed study, an intelligent planner was introduced to support field responders directly. In the third study, Incident commander mediate task assignment between field responders and the planning agent.

(results) Overall these studies show that ...

PUBLICATIONS

Some ideas and figures have appeared previously in the following publications:

Wenchao Jiang, Joel E Fischer, Chris Greenhalgh, Sarvapali D Ramchurn, Feng Wu, and Nicholas R Jennings. Social Implications of Agent-based Planning Support for Human Teams. 2014

ACKNOWLEDGMENTS

To my parents, wife, friends

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ACRONYMS

1 INTRODUCTION

This Chapter will give an overview of the PhD work including research objectives, approach, research questions and contributions, followed by a list of publications related to this thesis and an overview of thesis structure.

1.1 PROBLEM DEFINITION AND OBJECTIVES

Disaster response operations such as Urban Search And Rescue (USAR) can be very challenging. In large-scale disaster, DR teams may have limited resource and personnels to deal with multiple incidents across a large impact area. Task planning and execution need to be carried out by geographically distributed DR teams in real time against uncertainties in the environment. The challenge requires DR teams to carry out highly coordinated activities in an uncertain task environment. The challenges create the opportunity of technology support for real time Task planning and execution.

Recently, various Information and Communication Technologies (ICT), ranging from communication infrastructures to social media platforms, have been playing increasingly significant role in the disaster management. Moreover, Muti-agent system researchers have devised various real-time task planning algorithms to automate planning in time critical task domains such as disaster response. The advances in both ICT and Multi-agent algorithms lead to the opportunity of intelligent planning support in the DR domain.

However, many CSCW literatures have pointed out ill-designed work-flow management/automation system can lead to undesirable results, not only fail to improve work efficiency but also hinders human performance. Field studies of CSCW technologies have shown that it is vital to study technology in use to understand potential tensions raised for teamwork. Bowers et al. found that extreme difficulties might be encountered when introducing new technology support for human teams. New technologies might not support, but may disrupt smooth workflow if they are designed in an organisationally unacceptable way.

We believe the same is true for intelligent planning support. Before we can build intelligent systems that support human task planning, field trials are needed to understand the potential impact of technology support for team coordination. Although most multi-agent coordination algorithms have been tested to perform well in the computational simulations, they have never been excised to guide real human responders in the real world environment. Currently, there are few studies aimed to unpack the interactional issues relating to a socio-technical aspects of the intelligent planning support system. Interactional issues of a human-agent system can be defined as the issues related to interaction design and more importantly, the social aspects of the a human-agent. system. "Social issues" of human-agent systems are thought to be as important as technical issues []. Therefore, this PhD work is aimed to fill this gap by exploring and unpacking interactional issues of intelligent planning support system from a HCI perspective.

1.2 APPROACH

To meet our research objective, we adopt a serious-mixed reality games approach (Fischer et al., 2012) to create a game probe (i.e. AtomicOrchid) that enables studying team interaction with planning support system in a real-world disaster scenario whilst providing confidence in the efficacy of behavioural observations. Mixed-reality games bridge the physical and the digital (Benford et al., 2005). Arguably, They serve as a vehicle to study distributed interactions across multiple devices and ubiquitous computing environments in the wild (Crabtree et al., 2006).

The AtomicOrchid is a serious mixed-reality game designed to mirror aspects of real-world disaster. In this game, field responders use smartphones to coordinate, via text messaging, GPS, and maps, with headquarters players and each other. The players in the game faces a distributed task planning problem with both time and spatial constraints. To achieve game objectives, the players need to dynamically change their team configurations. The task planning process in the game is supported by a planning support agent software. In Chapter x, design and implementation of AtomicOrchid will be introduced in more details.

In order to explore human agent interactional issues, three studies are conducted with different research focuses. In the 1st study,field responders and incident commander coordinate without support of the intelligent planner. The study establish baseline performance of the game play and derived several requirements for planning support system. In the second and third studies, an intelligent planner was introduced to support task planning with two different interactional arrangement. The second study adopts a arrangement of human-on-the-loop in which the planning agent automatically generate plans and instruct field players to execute plans. In the third study, we adopts an human-in-the-loop arrangement in which every plan generated by planning agent will need to be approved and edited before it is sent to field players for execution. More details of these two interactional arrangements will be introduced in Chapter x.

The work also adopted an ethnographically-inspired approach for data analysis. Game plays were recorded and qualitative interaction analysis were carried out to unpack human agent interactional issues.

1.3 SCOPING

This thesis is relevant to several big research areas.

- Information and Communication Technology (ICT) for Disaster Response(DR). With the vision of HACs system, the current ICT for DR may eventually evolve into HACs in the future. The thesis is aimed to help realise the vision by providing design implications for ICT systems with intelligent task planning agents.
- Multi-agent systems. The muli-agent simulation technologies form the technical base of intelligent planning support, providing the opportunity space of human agent collective planning.
- Human agent interaction. Existing human agent interaction research is the overarching research area of this thesis.
- Ethnography. The thesis adopts a Ethnographically-inspired approach to study human system interactions in field trials.

There are various ICT and AI-based technologies supporting disaster management activities in the different stages of the crisis circle including preparedness, response and recovery. This thesis is going to limit the scope on operations of rescue and evacuation in the immediate aftermath of a disaster impact, which typically requires high level of real time task planning and execution.

The thesis also focus on socio-technical issues related to human team interacting with the intelligent planning support from a HCI perspective. The work involves planning support agents based on multi-agent coordination algorithms, but the effectiveness of particular coordination algorithms are not concern of this work.

This PhD work is sponsored by ORCHID project (EPSRC grant xxxxxxx).The work is closely related to disaster response vignette the of the ORCHID project. As computation increasingly pervades the world around us, The ORCHID project envisions a future in which human and computational agents operating together in a large global scale, forming human agent collectives (HACs). The objective of ORCHID project is to realise the vision by studying the principled science that allows us to reason about the computational and human aspects of these systems (www.orchid.ac.uk).

As part of ORCHID project, the AtomicOrhid serious game platform was developed as A research "Probe" to trial human agent collective planning in the domain of disaster response. As mentioned in section x.x, the AtomicOrchid platform consists of two major components: a game engine, and a embeded task planning agent. The core game engine was developed , deployed and maintained by the author, whereas the task planning agent was developed by ORCHID research partners - Feng Wu and Savapali Ramchun. Both Feng and Ramchun have expertise and research interest in the performance of task planning algorithm, where the author's research interest is the interaction between human and the intelligent task planning agent.

1.4 RESEARCH QUETIONS

What interactonal issues will emerge if we try to automate planning process

How can we design interaction to support human agent collaboration in task planning.

1.5 CONTRIBUTIONS

This thesis contributes to the knowledge in the following areas:

A The field observation of serious game trials leads to enriched understanding of interactional issues surrounding human agent interaction in disaster response domain.

B For each study, field observations are further analysed to generate design implication which contribute to future deployment of agent-based planning support algorithms.

1.6 PUBLICATIONS OF THIS THESIS

Fischer, Joel E., Wenchao Jiang, and Stuart Moran. "AtomicOrchid: a mixed reality game to investigate coordination in disaster response." In Entertainment Computing-ICEC 2012, pp. 572-577. Springer Berlin Heidelberg, 2012.

Fischer, J.E., Jiang, W., Kerne, A., Greenhalgh, C., Ramchurn, S.D., Reece, S., Pantidi, N. and Rodden, T. (2014). Supporting Team Coordination on the Ground: Requirements from a Mixed Reality Game. To appear in: Proc. 11th Int. Conference on the Design of Cooperative Systems (COOP 14). Springer.

Jiang, W., Fischer, J.E., Greenhalgh, C., Ramchurn, S.D., Wu, F., Jennings, N.R. and Rodden, T. (2014). Social Implications of Agent-based Planning Support for Human Teams. To appear in: Proc. of the 2014 Int. Conference on Collaboration Technologies and Systems (CTS 14). IEEE.

1.7 STRUCTURE OF THE THESIS

Part I

BACKGROUND

You can put some informational part preamble text here.

2 LITERATURE REVIEW

2.1 SOFTWARE AGENT AND HUMAN AGENT INTERACTION

2.1.1 *A History of Automation*

The definition of Automation is to replace the tasks originally performed by human with a machine. [1] . At early stages, the straightforward question is that what task can automated? Fitts listed strengths and weaknesses of humans and machines to identify what can be automated. [2] .

However the division of labour would not be as simple as labour division according to strength and weakness. Firstly the time factor could be important because human and machine's availability may change overtime. Secondly By delegating the same task to machine, the nature of human tasks can be changed as well. [1]

Movevoer,w ith advance of technologies, the boundary between human machine capabilities has blurred. Machine can involved in sophisticated judgements now-days. A new approach to view the human machine relationship has been proposed by Licklider called un-Fitts list [3] in which automation is aimed to leverage and extent human capability by using machines.[1]. The un-fitts list highlights the importance of mutual interaction between human and agents that can enhance the competencies of both human and agents. From this perspective, the aim of automation is no longer "replace" human but achieve an effective human-machine symbiosis. As researchers realize the effective human-machine symbiosis requires sophisticated social interactions between human and agent, the "social" issues of automation is thought to be as important as technical issues. [1]

2.1.2 *Definition of Software Agent*

Since creation of the term "software agent", there are a lot of debates about its definition . One definition commonly shared by the Multi-Agent system(MAS) literatures is that the software agents are designed to operate independently without constant human supervision. In the AI community, the software agent evolves from multi-agent system research which in turn, derived from the field of Distributed AI [6]. This strand of work investigates infrastructure, language and communication to realize coordinated agent software system. The goal was to specify, analyse, design and integrate systems comprising of multiple collaborative agents.[5]

More recently, the use of the word software agent become much more diversified. [5] has made attempts to investigate broader classes and types of agent. Nwana's [5] topology of agents identified three characteristics of agents, learning, autonmous and collabroitive, Based on this characteristics, software agents can be categorised into 8 classes, ranging from collaboration agents, information agents to interface agents.

The thesis will adopt a boarder view of the agent software.

2.1.3 *Issues in Human Agent Interactions*

Why the social issues of designing agent system is important? [Norman1994]

Flexible autonomy.

Mixed initiative.

2.2 TASK PLANNING IN DISASTER RESPONSE

What is coordination(Coordination theory) Team Coordination. Malone (1990 361) defines coordination as the act of managing interdependencies between activities performed to achieve a goal. One of the very important component of coordination in DR, following sections will firstly... and then discuss how the coordination is carried out through command structure of DR team.

2.2.1 *Task Planning*

In disaster response, team coordination is essential in order that groups of people can carry out interdependent activities together in a timely and satisfactory manner (cf. Bradshaw et al., 2011). Disaster response experts report that failures in team coordination are the most significant factor in critical emergency re- sponse (Toups et al., 2011: 2) that can cost human lives. Shared understanding, situation awareness, and alignment of cooperative action through on-going communication are key requirements to enable successful coordination. Convertino et al. (2011) design and study a set of tools to support common ground and aware- ness in emergency management.

One important characteristic of large-scale disaster is the presence of multiple spatially distributed incidents (Chen et al., 2005). To deal with multiple incidents, the disaster response team has to coordinate spatially distributed resources and personnel to carry out operations (e.g. search, rescue and evacuation). Depending on the proliferation of incidents, response personnel may need to dispatch, deploy and redeploy limited resources. Coordination is required to efficiently allocate limited resources to multiple incidents with temporal and spatial constraints imposed by the nature of disasters.

(The requirements of multiple incident response from Chen.)

((Coordination game) Below confirms that in a single target need multiple responder teams) While the present work applies generally to disaster response, our iterative design and theory-building processes have been specifically informed by work practice in the subdomain of fire emergency response. We work from fire emergency response in small-scale structural fires, observing practice in the United States of America. Fire emergency response is undertaken by small teams distributed throughout the incident, coordinated by an incident commander (IC) [Toups and Kerne 2007; Landgren 2006; Jiang et al. 2004; Landgren and Nulden 2007; Wieder et al. 1993; Carlson 1983; U.S. Department of Homeland Security 2008]. Multiple response teams, or companies, are dispatched to any incident and cooperate around the fireground (Figure 1). A company officer leads each team, which consists of firefighters and/or engineers.2 Normally, each company is associated with a firefighting vehicle; an apparatus, such as an ambulance, engine, or ladder truck.

The fireground and surrounding space constitute a dangerous and dynamic interface ecosystem [Kerne 2005] of distributed cognition, connecting responders, victims, fire- fighting equipment, communication media, and information artifacts. Upon arriving at an incident, multiple companies distribute in and around the fireground. Compa- nies and their apparatuses are placed at strategic locations, and are moved as needed. Human operators work on and from these platforms. Firefighters and rescue workers deploy from them, taking equipment into the fireground; equipment, such as firehoses and radios, may be technologically supported by the apparatus itself (pumps and water sources, or high-power repeaters, respectively). Each apparatus, and in many cases, each human worker, is equipped with a half-duplex radio to facilitate long-range, broad- cast communication.

(Geographic distribution as a also a key factor)
Muti-objective natural of the the DR response lead to its connection with multi-agent simulation and optimisation.

Therefore task planning envlove xxx challenges and opens the opportuntiy for technology intervention. Current state of art practice will be reviewed in section........

2.2.2 *DR Command structure*

A relatively generic model of C and C is proposed by The development of Information Technology System (ITS) to support the emergency response team work has many work published in the literature. For long time, crisis management systems were based in the military model of CC [1]. For many authors [2, 3 and 4] the need to change the theories of emergency management creating new paradigms is imperative to improve the flexibility of the CC structures. Their aim is to make them more efficient, multi-disciplinary and multi- institutional, increasing the collaboration between CC and the field responders and allowing sharing planning and resources to stabilize the crisis [5]. Stanton et. Al. [7] proposes a new generic model of CC based on field observation. One important conclusion he made concerning common characteristics in the different domains of CC: 1. The presence of a remote control room; 2. The great dependency on verbal communication and; 3. The existence of collaborative discussion between field teams and command.

Gold-Sliver-Bronze control model is documented in xxxx(wiki)

2.3 TECHNOLOGY SUPPORT FOR TASK PLANNING

This section reviews state of art technological practice to support task planning. Task planning toolbox containing various components including data sets, (meta-)information, storage and query tools, analysis methods, theories, indicators.

Greetman review of planning system. not real time, The systems can be categorized according to several criteria (Aims, Capabilities, Content, Structure, Technology). None of them is adapted to real-time coordination.

Multi-agent paraghim

Graph to position the my system.

2.3.1 *Disaster simulation, optimisation*

The section will briefly review current status of the simulation and optimisation technologies for disaster response.

2.4 A ECOSYSTEM VIEW

Taking Muti-agent paradim and ecological view of disaster response operation. Combined them with DR response structure to produce a view of future Dr ecological system backed by simulation and optimisation technologies.

So what is the problem now, -> social ! issue.

2.5 CSCW

2.5.1 *Workflow Management*

2.6 SERIOUS GAME

2.7 MIXED REALITY GAMES

2.7.1 *Definition and examples*

2.7.2 *Game for Serious Purpose*

Part II

METHODOLOGY AND APPROACH

3 APPROACH

3.1 A FRAMEWORK OF INTERACTIONAL ARRANGEMENT

3.2 SERIOUS GAMES

3.3 THE ATOMICORCHID PLATFORM

4 METHODOLOGY TO INVESTIGATING HUMAN AGENT INTERACTION

4.1 MIXED METHOD APPROACH

4.2 ETHNOMETHODOLOGICAL PERSPECTIVE

4.3 INTERACTION/VIDEO ANALYSIS

Part III

STUDIES

5 SUPPORTING TEAM COORDINATION ON THE GROUND: REQUIREMENTS FROM A MIXED-REALITY GAME

We investigate requirements for time critical distributed team support relevant for domains such as disaster response. We present the Radiation Response Game to investigate socio-technical issues regarding team coordination. Field responders in this mixed-reality game use smartphones to coordinate, via text messaging, GPS, and maps, with headquarters and each other. We conduct interaction analysis to examine log data and field observations revealing local and remote coordination, danger and trust, and situational awareness. We uncover requirements that highlight the role of local coordination, decision-making resources, geospatial referencing and message handling.

5.1 SYSTEM EVOLUTION

5.2 STUDY DESIGN

5.3 DATA ANALYSIS

5.4 DISCUSSION

6 SOCIAL IMPLICATIONS OF AGENT-BASED PLANNING SUPPORT SYSTEM

6.1 system evolution

6.2 study design

6.3 data analysis

6.4 discussion

7 STUDY 3

7.1 SYSTEM EVOLUTION

7.1.1 *Workshop with Rescue Global*

7.2 STUDY DESIGN

7.3 DATA ANALYSIS

7.4 DISCUSSION

Part IV

CONCLUSION

8 CONCLUSION

What can we take away from it? Implication for future work?

Part V

APPENDIX

A APPENDIX TEST

Lorem ipsum at nusquam appellantur his, ut eos erant homero concludaturque. Albucius appellantur deterruisset id eam, vivendum partiendo dissentiet ei ius. Vis melius facilisis ea, sea id convenire referrentur, takimata adolescens ex duo. Ei harum argumentum per. Eam vidit exerci appetere ad, ut vel zzril intellegam interpretaris.

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A.1 APPENDIX SECTION TEST

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More dummy text.

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A.2 ANOTHER APPENDIX SECTION TEST

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LABITUR BONORUM PRI NO	QUE VISTA	HUMAN
fastidii ea ius	germano	demonstratea
suscipit instructior	titulo	personas
quaestio philosophia	facto	demonstrated

Table 1: Autem usu id.

Listing 1: A floating example

```
for i:=maxint to 0 do
begin
{ do nothing }
end;
```

Ei solet nemore consectetuer nam. Ad eam porro impetus, te choro omnes evertitur mel. Molestie conclusionemque vel at, no qui omittam expetenda efficiendi. Eu quo nobis offendit, verterem scriptorem ne vix.

[1] Jeffrey M Bradshaw, Paul Feltovich, and Matthew Johnson. Human-Agent Interaction. In G Boy, editor, *Handbook of HumanMachine Interaction*, chapter 13, pages 293–302. Ashgate, 2011. URL http://books.google.com/books?hl=en&lr=&id=4opHlu05SNIC&oi=fnd&pg=PA283&dq=Human-agent+interaction&ots=vxrpDdLbSa&sig=07dujtzGjIcBLlZ6FVH33HjrWos.

[2] Fitts. Human Engineering for an Effective Air Navigation and Traffic Control System. 1951.

[3] Robert R Hoffman, Paul J Feltovich, Kenneth M Ford, West Florida, David D Woods, Gary Klein, Klein Associates, Anne Feltovich, Grinnell College, Editors Robert R Hoffman, and Patrick J Hayes. Human-Centered Computing A Rose by Any Other Name . . . Would Probably Be Given an Acronym. 2002.

[4] Wenchao Jiang, Joel E Fischer, Chris Greenhalgh, Sarvapali D Ramchurn, Feng Wu, and Nicholas R Jennings. Social Implications of Agent-based Planning Support for Human Teams. 2014.

[5] Hyacinth S Nwana. Software Agents : An Overview. pages 1–49, 1996.

[6] Nikos Vlassis. *A Concise Introduction to Multiagent Systems and Distributed Artificial Intelligence*, volume 1. January 2007. ISBN 9781598295269. doi: 10.2200/S00091ED1V01Y200705AIM002. URL http://www.morganclaypool.com/doi/abs/10.2200/S00091ED1V01Y200705AIM002.

colophon

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DECLARATION

Put your declaration here.

Nottingham, August 2012

Wenchao Jiang