WENCHAO JIANG

INVESTIGATING INTERACTIONAL ISSUES OF AGENT PLANNING SUPPORT

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In Disaster Response domain

August 2012 – version 0.1

—— 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. The interaction between human operators and planning support systems need to be carefully designed before technology deployment.

(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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INTRODUCTION

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 optimisation algorithms lead to the opportunity of intelligent planning support in the DR domain. However, before we apply this algorithm to to support, we need to understand how can we configure the interactions between responder team and planning support system in a way that improve team rather than hinder. The aim of this work is aimed to explore potential interactional issues surrounding a planning support system, which in turn, informs interaction design of such systems.

This PhD work is a ORCHID sponsored research, which contributes to the understanding needed to build Human Agent Collectives (HACs) in disaster domain. As computational systems becoming increasingly embedded into our life, the researchers from ORDHID project envision a future in with people and computational agents operates at a global scale, forming human agent collectives. The ORCHID project is aimed to realise the vision of HACs by studying the science that is needed to understand, build and apply HACs that symbiotically interleave human and computer systems (www.orchid.ac.uk).

This Chapter will give an overview of the PhD work, which covers 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

In large scale disasters, Disaster Response team(DR) may have limited resource and personnels to deal with large amount of incidents across large geographic area under time pressure. In this situation, task and team allocation become a grand challenge for DR team. The responders and resources need to be assigned to teams and tasks in a way that to minimise loss of life and costs (e.g., time or money) . For instance responders with different capabilities (e.g., fire-fighting or life support) have to form teams in order to perform rescue tasks (e.g., extinguishing a fire or providing first aid). Thus, responders have to plan their paths to the tasks (as these may be distributed in space) and form specific teams to complete them. These teams, in turn, may need to disband and reform in different configurations to complete new tasks, taking into account the status of the current tasks (e.g., health of victims or building fire) and the environment (e.g., if a fire or radioactive cloud is spreading). Furthermore, uncertainty in the environment (e.g.,road connectivity, task status update) or in the responders abilities to complete tasks (e.g., some may be tired or get hurt) means that plans are likely to change continually to reflect the prevailing assessment of the situation.

Recent advances in multi-agent systems research leads to some real-time simulation and optimization technologies, some of which has great have potential to be adapted to support task planning for DR teams. One of a good example can be coalition formation algorithms devised by xxx (More details, see section x) Although the opportunity space has been recognised, most coalition formation algorithms has only be tested in computational simulations. None of them has be deployed to guide real human in DR situations. 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 surrounding the 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 [reference the AO2012 paper] 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. The planning support agent is based on a state-of-art coalition formation optimisation technology. 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 techniques. The second study adopts a arrangement of human-ON-the-loop(HOTL) 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 (HITL) technique in which every plan generated by planning agent will need to be approved and edited before it is sent to field players before 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 research areas.

- Human Computer Interaction (HCI) 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 from a HCI perspective.
- Multi-agent systems. The muli-agent simulation technologies underpin the technical possibility 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 team coordination and 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.

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

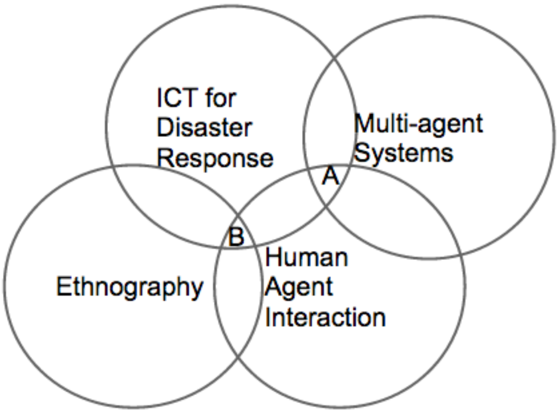
The recent advances in ICT and multi-agent optimisation technologies have created the opportunity space for intelligent planning support system in disaster response domain. Before we deploy such a planning support system, a deep understanding of interactional issues are required for appropriate interaction design between human teams and computational agents. This work adopted serious game approach to explore the interaction design space. Integrated with intelligent planning support, the AtomicOrchid game platform is used as a testbed for human agent interaction techniques. The AtomicOrchid is further configured with two different interaction techniques to produce game "probes" for field trials. Through field observation, this work is aimed answer the following two research questions:

A What interactonal issues will emerge if we try to automate planning process in a disaster response team? Interactional issues can be seen as an umbrella term for all issues relating to interaction design, which can range from social, organisational issues to interface design issues. This work is aimed to conduct an exploration of the interactonal issues in the interaction design space of agent planning support.

B How can we design interaction to support human agent collaboration in task planning? Following the first question, the emerged interactional issues will need to be handled with approprate interaction design. This work seeks to produce interaction design implications through field observation and interaction analysis, both of which are grounded in literature review (Chapter x)

[The research is primarily interested in two interaction techniques, what are they and why?] Both two questions will be answered with respect to the two different interaction techniques which will be detailed in Chapter x.

1.5 CONTRIBUTIONS



This thesis contributes to the knowledge in the following areas:

A A real-world interactive prototype and trials to investigate team coordination in a disaster response settings.

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

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

1.6 PUBLICATIONS OF THIS THESIS

Parts of the contents of this thesis have been accepted by peer-review for publication in conference proceedings in HCI or are in submission:

Chapter x expands on the contents in 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.

The exploration of Requirements for building coordination support system in Chapter x has been published in 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.

The exploration of interactional issues related to human-on-the-loop arrangement in Chapter x have been published in 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. In: Proc. of the 2014 Int. Conference on Collaboration Technologies and Systems (CTS 14). IEEE.

1.7 STRUCTURE OF THE THESIS

This thesis is structured as four parts. Part I surveys the relevant background literatures. The chapter of literature review will firstly introduce a brief history of automation, agent software and Study of human agent interaction. In the following section, an overview of task planning activities will be introduced together with command and control structure of DR teams. In particular, the section will review the state-of-art agent simulation technologies that can help support task planning. The following section will review relevant CSCW Literatures which will lead to the potiential challenges of real deployment of the agent technologies. The rest of the chapter give an overview of serious mixed reality games which underpins the foundation of research approach of this PhD work.

Part II develops the approach and methodology employed to study interactional issues of planning support system in two chapters. The first chapter develops framework of interactional arrangement under which interactional issues can be explored. The rest of this chapter will introduce serious mixed reality game as approach to study interactions ,followed by detailed description of a game used as testbed for this study - AtomicOrchid. Chapter 5 describes the methodology used to study the interactional issues. In particular, this chapter will describe ethnographic observation and interaction analysis, which is supplemented by interviews and questionnaires.

Part III covers observational studies in this thesis. Chaper x reports the first observational study with AtomicOrchid. This version of AtomicOrchid do not have planning support agent included. The study establishes baseline human performance of task planning and derives general requirements of communication support. The Chapter x give an account of second observational study of AtomicOrchid. In this study, an planning agent was built into the game with human-on-the-loop interactional arrangement. Chaper x reports the third field study of AtomicOrchid with human-in-the-loop arrangement.

Finally, Part IV concludes this thesis with a summary of contributions and future work.

Part I

BACKGROUND

You can put some informational part preamble text here.

2

LITERATURE REVIEW

2.1 AUTOMATION AND HUMAN AGENT INTERACTION

The study Automation design and Human agent interaction are two heavily intersected research areas which overarches this PhD work.

2.1.1 *A History of Automation*

The original goal of Automation is to replace the tasks originally performed by human with a machine. [1] . It can be defined as the execution by machine, usually computer, of a function previously performed by human [Parasuraman and Riley 1997] The tasks that can be automated is used to be limited by technical capabilities, but this is no longer the case. With quick growth of machine's speed and intelligence, the tasks that can be automated is rapidly increasing, including complex cognitive activities such as information analysis, planning and decision making.[RAJA] The boundary between human machine capabilities has blurred. With little cannot be automated, the automation designers have to make hard choice about what to automate and to what extent.

One traditional approach for automation design is to simply automate all system functions that can be automated easily in a cost-effective way, leaving the all remaining tasks to human operators. The main considerations in this approach are technical capability and cost. The assumption of this approach is that the automation of sub systems functions can lead to optimisation of whole system with no detrimental impact results from the automation. However this is not always the case, Large body of empirical work in automation design have shown that xxxx .

The other approach is to achieve division of labour between human and automation according to their strength and weakness. As in Fitts list [2] , a set of strengths and weaknesses of humans and machines is identified. However the division of labour would not be as simple as a 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. Large body of work has shown clearly that automation does not simply supplant human activity but rather changes it, often in a way that is unanticipated by the system designer. [Coordination and Supervision interaction required, expand] [1]

2.1.2 *The Level of Automation*

More recently, another alternative model of automation to guide automation design is proposed by proposed by xxx,known as 10 level model of automation. The model 10 levels of automation (LOA) has been later extended by xxx with more detailed classification of automation types. The extended model of LOA informs study approach of this PhD work, which will be documented in chapter x. This section will give an introduction of this model.

Most tasks can be fully or partially automated, which implies that automation is not all or none, but can vary across a continuum of level[]. At the lowest level, all system functions are performed manually by human operators. At highest level, system are fully automated, taking over all system functions. In between this two extremes, 10 different levels of automation are proposed by xxx. As shown in table x.

2.1.3 *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.

With a broader definition, researchers begin to investigate broader issues surrounding development of agent systems, among which human agent interactions have attracted a lot of attention of researchers and practitioners.[get one reference here!!!]

2.1.4 *Human Agent Interactions*

Automation design and Human agent interactions have big overlaps as both concerns the impact of automation(by computational systems) on human performance. While automation design is trying to answer the question of what and to what extent the automation should be, the study of human agent interaction concerns the issue of interaction design related to development of human agent system, with the aim to develop agents which is good at teamworking with human operators.

Human - automation

A new approach to view the human machine relationship is 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 systems. 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 interactions design between human and agent, the "interactional" issues of automation is thought to be as important as technical issues. [1]

[define the interactional issues!!!!]

2.1.5 *Issues in Human Agent Interactions*

Fusion of buothon

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

Flexible autonomy.

Mixed initiative.

2.1.6 *lesson from CSCW*

2.1.7 *A summary*

Because this PhD work sits in the overlapping research area of human agent interaction and automation design, the later chapters will consider automation and agent software as two interchangeable concepts.

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.

2.4.1 *Workflow Management*

2.5 serious game

2.6 MIXED REALITY GAMES

2.6.1 *Definition and examples*

2.6.2 *Game for Serious Purpose*

Part II

METHODOLOGY AND APPROACH

3 APPROACH

3.1 Serious Games

3.2 The AtomicOrchid Platform

We designed and implemented the Radiation Response Game in order to study team coordination through a location-based, mixed-reality game probe. In the following sections, we describe the game design including grounding of the design rationale, game interfaces, iterative design process, and the system architecture.

3.2.1 *Game Design*

The Radiation Response Game is based on the fictitious scenario of radioactive ex- plosions creating expanding and moving radioactive clouds that pose a threat to re- sponders on the ground (field responders), and the (virtual) targets to be rescued from around the game area. We chose a radiation scenario because other than disasters that cause physical devastation it poses an invisible threat, which creates the need to monitor the environment closely with sensing devices, and communicate frequently.

Field responders are supported by a centrally located headquarters (HQ) control room, staffed by coordinators who exchange messages with field players through an instant messaging style communication system. The messages are broadcasted, which means they are visible to all players. Whilst formal response teams tend to use radio to communicate (e.g., Toups et al., 2011) we chose text-based messages for its flexi- bility to support scenarios with many distributed (volunteer) field responders.

Core game mechanics are designed to allow us to explore specific aspects of team coordination. In particular, this is inspired by the real coordination challenge of re- source and task allocation to coordinate spatially distributed resources and personnel 5. Comto cmarryaonut- dopaernatidonsC(Cohoenredt ail.n, 2a00t5i).on Organisational Structure The two-tiered organisational structure of the game is derived from real world dis- aster response organisation we have observed in a multinational training exercise of The command and coordination structure for the purposes of the Fort Widley training USAR forces (see figure 1). The game s HQ is loosely modelled on sector coordina- exercise was hierarchical starting from the USAR Coordination (UC) Cell (top), to the sector tors, whose role is to manage resources and communications between their assigned Comman- dertesa,mtsh,eanTdecaom/mCarnedwanLdecaodoerdrisnatendactihone wteitahimn thmeiermsebcteors(D(beopatrttommen)t. fFoirgCuorme - 5 shows a munities and Local Government, 2008). Field responders are modelled on team lead- simple schematic of the structure. ers and members, we ignore this distinction to keep roles, assignments, and game rules simple.

means they are visible to all players. Whilst formal response teams tend to use radio to communicate (e.g., Toups et al., 2011) we chose text-based messages for its flexi- bility to support scenarios with many distributed (volunteer) field responders. Core game mechanics are designed to allow us to explore specific aspects of team coordination. In particular, this is inspired by the real coordination challenge of re- source and task allocation to coordinate spatially distributed resources and personnel 5. Comto cmarryaonutdopaernatidonsC(Cohoenredt ail.n, 2a00t5i).on Organisational Structure The two-tiered organisational structure of the game is derived from real world dis- aster response organisation we have observed in a multinational training exercise of The command and coordination structure for the purposes of the Fort Widley training USAR forces (see figure 1). The game s HQ is loosely modelled on sector coordina- exercise was hierarchical starting from the USAR Coordination (UC) Cell (top), to the sector tors, whose role is to manage resources and communications between their assigned Commandertesa,mtsh,eanTdecaom/mCarnedwanLdecaodoerdrisnatendactihone wteitahimn thmeiermsebcteors(D(beopatrttommen)t. fFoirgCuorme - 5 shows a munities and Local Government, 2008). Field responders are modelled on team lead- simple schematic of the structure. ers and members, we ignore this distinction to keep roles, assignments, and game rules simple.

The radioactive cloud. The cloud is a danger zone that can incapacitate field re- sponders. It imposes spatial and temporal constraints on task performance and well- being. The cloud is analogous to various spatial phenomena in disasters (e.g. spread- ing fires, diseases and floods). In require communication between HQ and field re- sponders, the spatial position and movement of the cloud is only known to HQ.

Command-and-control structure. The division of responsibility into HQ and field responders simulates a situation where volunteer responders are connected to a simple two level Command-and-control structure, similar to the real-time layer of the exist- ing professional disaster response organizations (e.g., Chen et al., 2005).

3.2.2 *Game Interface*

Field responders are equipped with a mobile responder app providing them with sensing and awareness capabilities (see figure 2). The app shows a reading of radioac- tivity, their health level based on radioactive exposure, and a GPS-enabled map of the game area with the targets to be collected and the drop off zones for the targets. Icons according to responder roles that additionally have their initials on them can be used to identify individuals. Another tab reveals the messaging widget to broadcast messages to the other field responders, and to headquarters.

HQ is manned by at least two coordinators who have at their disposal a browser- based coordination interface that provides an overview of the game area, including real-time information of the players locations (see figure 2). HQ can also broadcast messages to all field responders, and can review the responders exposure and health levels. Importantly, only headquarters has a view of the radioactive cloud. Hotter zones correspond to higher levels of radioactivity.

3.2.3 *The planning agent*

3.2.4 *Iterative Design*

The game has been developed through 3 iterations of design and evaluation. In the first iteration, we used a paper-based prototype to test and refine the core game mechanics. We recruited 12 participants, allocated one of four roles to them, and equipped them only with paper maps with locations of targets. They had to form different kinds of teams to retrieve the different kinds of boxes placed in the game area. The paper prototype highlighted the demand for better support of situation awareness and communication to enable coordination.

The technology prototype was first tested with users in the second iteration. Users used the responder smartphone app to communicate, navigate, locate and pick up targets in teams formed according to role requirements. However, researchers staffed HQ. A pilot study was conducted with members of the public that visited an Open Day at a local university. A total of 20 members of the public tested the game in four game sessions. The lessons learned in the pilot study revealed problems with user interaction, networking, and game parameter tuning that were addressed accordingly.

In the third iteration, we improved system stability and interface designs and con- ducted a pilot study at the campus of another university, to test the system in place. The full-fledged study we report on here was conducted shortly after.

3.2.5 *System Architecture*

The Radiation Response Game is based on the open-sourced geofencing game Map- Attack3 that has been iteratively developed for a responsive, (relatively) scalable ex- perience. Our mixed-reality game relies especially on real-time data streaming be- tween client and server. The client-server architecture is depicted in figure 3. Client-side requests for less dynamic content use HTTP. Frequent events, such as location updates and radiation exposure, are streamed to clients to avoid the overhead of HTTP. In this way, field responders are kept informed in near real-time.

The platform is built using the geoloqi platform, Sinatra for Ruby, and state-of- the-art web technologies such as socket.io, node.js, redis and Synchrony for Sinatra, and the Google Maps API. Open source mobile client apps that are part native, part browser based exist for iPhone and Android; we adapted an Android app to build the Mobile Responder App.

3.3 TWO DIFFERENT LEVEL OF AUTONOMY

HUMAN-ON-THE-LOOP AN HUMAN-IN-THE-LOOP

need a review of models of level of autonomy

Lucy suchman to build a system.

3.4 A FRAMEWORK OF INTERACTION ISSUES

interaction techniques [Which Interaction Technique Works When] refer to interaction techniques may refer to is a set of interface widget design.

We follows a process of interaction design documented in the [Designing interactions p 15], the process is interactive, with a special focus on understanding issues and generating design implications . The issues emerges in previous iterations will be feedback to next iterations.

interactional issues:

Interface aspects: tech dependent or not? interaction aspects: concerned with interaction patterns Social aspects: Corncerned with what?

(Sedig, K.Parsons, P) pattern based approach. (Most interaction techniques literature reviewed so far is about study in visual representation.) (Interaction design, wiki)

Build up the literature of LOA and combine it with interaction techniques.

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.

Errem omnium ea per, pro congue populo ornatus cu, ex qui dicant nemore melius. No pri diam iriure euismod. Graecis eleifend appellantur quo id. Id corpora inimicus nam, facer nonummy ne pro, kasd repudiandae ei mei. Mea menandri mediocrem dissentiet cu, ex nominati imperdiet nec, sea odio duis vocent ei. Tempor everti appareat cu ius, ridens audiam an qui, aliquid admodum conceptam ne qui. Vis ea melius nostrum, mel alienum euripidis eu.

A.1 APPENDIX SECTION TEST

Ei choro aeterno antiopam mea, labitur bonorum pri no. His no decore nemore graecis. In eos meis nominavi, liber soluta vim cu. Sea commune suavitate interpretaris eu, vix eu libris efficiantur.

More dummy text.

Nulla fastidii ea ius, exerci suscipit instructior te nam, in ullum postulant quo. Congue quaestio philosophia his at, sea odio autem vulputate ex. Cu usu mucius iisque voluptua. Sit maiorum propriae at, ea cum primis intellegat. Hinc cotidieque reprehendunt eu nec. Autem timeam deleniti usu id, in nec nibh altera.

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;
```

A.2 ANOTHER APPENDIX SECTION TEST

Equidem detraxit cu nam, vix eu delenit periculis. Eos ut vero constituto, no vidit propriae complectitur sea. Diceret nonummy in has, no qui eligendi recteque consetetur. Mel eu dictas suscipiantur, et sed placerat oporteat. At ipsum electram mei, ad aeque atomorum mea.

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.

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colophon

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DECLARATION

Put your declaration here.

Nottingham, August 2012

Wenchao Jiang