MODELLING INTERACTIONS IN A MIXED AGENT WORLD

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ABSTRACT
The emergence of mixed agent-human societies poses challenges in designing companion agents that are able to form meaningful relationships with humans. This paper describes the first step in developing companion agents. Problem/situations have been identified where companion agents may provide important social contact with humans. Based on a scenario, interactions between human and artificial agents have been modelled in the Brahms modelling and simulation environment. This provides us with a far deeper understanding of the roles that a companion agent should fulfil and how it could switch from one social role to another.

Keywords:
Companion agents, human-agent world, scenarios, human-agent relationship, virtual characters, robots, Brahms

1. INTRODUCTION

We are entering a new era of computing where software agents are becoming increasingly prevalent in our environment; they are found in the technological supports that we use, and are manifested as embodied conversational agents or robots. This is leading to an inevitable increase in interactions between artificial agents and humans resulting in the emergence of mixed human-agent societies. However a common problem of artificial agents is that they fail to establish any meaningful relationship with the user. In order to achieve acceptance and to create value from adopting a new technology, the creation of a meaningful relationship is essential. Our work is conducted in the context of the French ANR funded MOCA project[1] where the overall goal is to construct a mixed agent society, composed of companion agents, such as robots and virtual characters, as well as humans. In this society, human-agent relationships will take the same form as with human-human relationships.

In order to establish a long term relationship, we propose to integrate personality and social concepts into the world of artificial companions. Several studies in the literature (Bickmore 2005, Grandgeorge 2011) note that one of the most important challenges raised by new technologies is to provide a new type of human-machine interfaces that could create and maintain new types of relationship (Pesty 2011) with humans.

Technological advances in robotics have developed what is called 'Service Robots', which assist humans in performing useful service, sometimes in home situations. Such robotic devices interact with the consumer in a homely environment. As robots move beyond just helping us with household chores, we must start to question the nature of our relation with robots. The MOCA project aims to explore how can we design these daily life companions in order for them to improve our quality of life even if we are not expert in new technologies.

The work presented in this paper describes the first step in the development of companion agents. We define two aspects of the companions: the *role* that they play in a problem/situation; and their embodiment in the *device*, such as a robot or virtual agent.

Following the user's choice, the companion will express itself through a device such as a Reeti (Robopec) or Nao Robot (Aldebaran 2009); or Mary (Courgeon et al. 2008) or Greta (Poggi et al., 2005) virtual character (figure 1).

Figure 1: Companion Agents: Reeti, Nao, Mary and Greta

The roles cover the expected behaviours of the companion(s) to respond to a problem or situation encountered by the user. We aim to enrich the interaction between these agents by taking into account the social context. Classically in Human-Machine-Interaction, context-aware technologies take into

[1] "My Little Artificial Companion World" MOCA project, ANR-2012-CORD-019-02.

account 3 variables: the environment of use, the user and the platform used. Research in context-aware technologies focuses mainly on how to characterise the context in order to adapt the service to it. Closer to our work Calvary and her colleagues, speak about the plasticity of interfaces towards a context of use (Calvary 2001). Aiming to have companions (robot or virtual agents) that are socially intelligent, we also want to integrate social rules (family rules, social roles, personality) in the context model.

2. RELATED WORK

Virtual companion agents and especially robots are still very costly. Progress in terms of new features and increased performance of the companions is rapid and new devices, with more features appear on the market everyday. However, as shown by previous unfortunate experiences, the acceptability and adoption of new technologies by users is vital and is not only matter of innovation (Leonardi 2009, Dubois 2009). In the literature, multi-agent scenario-based methods of development are widely described and used (Iglesias 1999). More particularly, agent based modelling and simulation allows us to test and understand at an early stage of those requirements that are difficult to envisage other than by fully developing the robot or the virtual character and testing it in a real situation.

Barreteau (2003) develop the approach of companion modelling dealing with "collective decision making process of stakeholders sharing a common resource". The principle is to iteratively build models and use mediation process for collective learning. The notion of companion agent as we envisage differs. We use the term of companion to insist on the stability and long term relationship between the virtual agent and the user.

Modelling and simulation involving interactive robots often focus on the motor level, and studies in that vein usually aim to test controllability and limitations of a new technology (Dudenhoeffer 2001). Aiming to develop companion agents that are socially intelligent, we chose a higher level of modelling using the BDI (Belief-Desire-Intention) framework in order to introduce notion of personality and emotions in the reasoning of the agent (Adam 2007).

Role assignment and cooperation are still problematic and are subject to a lot of research in multi-agent systems (Campbell 2010, Kwak 2012). Roles are often used to simplify the problem of cooperation between multiple agents having to respond to a set of tasks. The role is then described as a specification of the agent in accomplishing the task and strategies of assignment of some corresponding task can be chosen.

In our work, we consider the role of the agent as principally being a social role. A same agent can then put on a different role according to the context. Assignment or redundancy will be dependent on the social role, and a pre-design user study will be conducted in order to determine how roles may be the best distributed among our multi-agent system. The social role of a companion will be both the functionality and the set of tasks it can accomplish to respond to a goal, together with its relationship with the user (Clavel 2013). The focus of this study is to identify and model these roles as well as finding triggers that invoke a role.

3. PROBLEM / SITUATION

We have adopted a scenario-based development approach (Rosson and Carroll, 2002), supported by Worth centred design (Cockton, 2004) (Cockton, 2006). Following these, the first step is to identify problem/situations. A problem/situation is a situation in which our system can provide a service that will facilitate or reply to a problem faced by the user. We have chosen to focus on how children, in the 8 to 12 year age bracket, would interact with the companion agents in a family setting. The problem-situation is a context within which the children might need help, and where they could find worthiness, in Cockton's terminology, by using the companion. The companion then takes a role in order to respond to the problem or situation.

Based on a previous Robofesta[2] survey (Clavel et al. 2013) we elicited 5 problem/situations that a child may encounter and the associated abilities that a companion agent would need to fulfil in that role (Table 1).

Problem/ Situation	**Description**	**Companion abilities**
Teaching (Prof)	adapted help and support for *homework* and school matters	• Should have the knowledge and the expertise to help the child in the homework task. • Should motivate and reward good performance; critique and discourage bad performance. • Should be able to interpret the mental state of the child to give him/her appropriate feedback or treatment. • Should be able to track the child's performance over time to monitor their progress and adjust pedagogic parameters • Should be able to summarize the accomplished daily and communicate this to the parents or teacher.

[2] RoboFesta is an International Organisation established to promote the study and enjoyment of science and technology through hands-on, robot-related events.

Problem/ Situation	Description	Companion abilities
Playing (Buddy)	need a friend *to play* with	• Should suggest stimulating games • Should suggest and play: game for creativity and imagination • Should make possible group games • Could joke (Simple jokes)
Guarding (Bodyguard)	need to feel more *secure*	• Should be able to start an alarm • Should be able to call the parents, or emergency services • Should reassure the child • Should provide advice on how to react to the situation
Comforter (Dolly)	need for a cuddle, affection, *comfort*	• Should be able to perceive child's mood (alert parents if necessary) • Should listen and give advice
Coacher (Coach)	need to *be coached* to discover extra-curricular activities (learn knowledge, other than that taught in school)	• Should encourage activities • Should give instructions to do activity in security • Should be able to supervise the activity

Table 1: Problem/situations and abilities

Normally such situations would involve a parent or guardian. However, financial pressures on the family mean that parents increasingly have to work and are unavailable for child-care. In this case the companion agent may be used to provide social contact that has been shown to be important for cognitive development (Piaget 1966, Vernon 2011). Other problem/situations are possible but the above were chosen based on interview previously conducted and (Clavel 2013) and because they occur frequently in everyday life.

4. SCENARIO

The next step was to devise a scenario that incorporated the above problem/situations and that highlighted the interactions between the companion agents and the children. It should be noted that a role, e.g. Prof, can be deployed through one or many forms (e.g. virtual agents and/or robots agents) that will collaborate and cooperate in order to accomplish the tasks and to reply to the needs of a specific problem/situation. Below is a natural language description of the scenario.

Ben is 11 years old and in his first year of middle school. His father and mother both work until 8pm. Ben finishes school at 4.30pm. The school is a few streets away from home and Ben usually walks home with some friends every evening. Ben usually has homework to do every evening. His school grades are average but with more help from his parents and teacher they would improve. Although Ben knows that he should do his homework he prefers to watch TV or play video games. In the evening, his neighbour, Alan, usually comes over to play. Ben's parents don't really like him being alone at home, but they have heard about the MOCA system and they already have some devices (virtual characters) at home. Ben would love to have robot companions and so his parents decided to buy him the one he liked from the big city supermarket. They downloaded the MOCA software onto his already existing devices. The MOCA system deploys itself forming a world of companions that can be with Ben in the evenings. The parents configure the world with different roles according to their needs. They download:

- *Playing software, a perfect pal to play with Ben when he is alone (avoiding the video games)*

- *Comforting software, in case Ben feels sad and needs some comfort*
- *Teaching software, which will help Ben with his homework, and to organise and keep track of schoolwork*
- *Coaching software will help Ben in extra-scholar activities (preparing the snack, music lessons).*

- *Finally, in case of problems, Security software*

COACH

Ben would love to learn music with 'Coach'. When Ben gets hungry he usually goes to the kitchen and gets a snack He prefers chocolate bars rather than fruit, but the coach usually reminds him that he won't have a dessert after dinner if he didn't have his apple. The activities of the Coach can also be extended by Hip-Hop lessons and Ben would like to be given that for Christmas.

PROF

The house rule is that around 5pm and before playing any game, Ben should have done his homework. Prof proposes to help with the homework and informs the other companions when it is finished. Prof also gets information from the parents and the school agenda. The information is related to the subject that Ben needs to study. Prof makes a synthesis of the work accomplished by Ben and gives a summary to Ben's parents or teacher if they ask for it. The results are added Ben's diary that is managed by the Cloud.

The Prof encourages Ben to do his homework with care. When the Prof encourages Ben, his motivation increases and he believes more that he can complete the task. Nevertheless Ben can be a bit stubborn, and sometimes Prof needs to threaten Ben with calling his parents in order to try to make him do his work.

Alan and his artificial companions are pretty good at strategic games, and Ben doesn't win *often because Buddy is new in the house and a bit shy. Nevertheless having Buddy and Poto means that there are more 'people' to plays games, and they can all play together.* BUDDY

When Ben looses he is always a bit sad, but Dolly is there to cheer him up and to play some nice songs that take his mind off loosing. Dolly is very sweet, and Ben knows that he can share his secrets with her. DOLLY

Being home alone, Ben feels reassured when Bodyguard advises him on what to do and check who is at the door before opening it BODYGUARD

5. SCENARIO MODELLING IN BRAHMS

The aim of modelling the interactions is to frame clearly the companions' roles and their interactions. We have chosen to use BRAHMS (Business Redesign Agent-Based Holistic Modelling System) as a modelling tool (Sierhuis et al. 2003). BRAHMS is an agent oriented language and development environment for modelling and simulation. Brahms is able to represent, people, places, objects, behaviour of people over time and their social behaviours [Sierhuis et al. 2007]. In support, Brahms provides several models with which the developer can specify their world: agent, object, activity and geography. Furthermore BRAHMS has similarities with a BDI (Belief-Desire-and-Intention) approach (Georgeff & al. 1998) in that it allows goal-oriented behaviours and the manipulations of beliefs.

BRAHMS is structured around the following concepts (given in italics) (Brahms tutorial, 2003): *Groups* contain *agents* who are located and have *beliefs* that lead them to engage in *activities*. The activities are specified by *workframes* that consist of preconditions of *beliefs* that lead to *actions* (consisting of *communication actions*, *movement actions*, *primitive actions*) and other *composite activities*, consequences of new beliefs and world facts, *thoughtframes* that consist of preconditions and consequences. Through the use of a time-line we are able to analyse the individual behaviours and interactions of each agent.

In the geography model we model the physical environment of the neigbourhood, including the school and the house, the latter of which is divided into rooms with linking pathways. The children, adults, and artificial companions are all modelled as agents (specified in the agent model), each agent having their own characterising attributes and beliefs. All agents are part of the GroupWorld; this allows us to define general activities, attributes and reasoning process shared by all agents. Groupworld contains three main groups: Adults, Children, and Companions, each group has their own specific needs, locations, actions (the abilities), e.g. adults can be at the office, and children have homework and need to play. Thus the reasoning and abilities of companion agents are dependent on their role. Figure 2 shows how we can instantiate a group in Brahms modelling language into a role, with specific beliefs, activities (tasks), workframes (functionalities) and thoughtframes. In this example, the Prof has a belief about the time for homework. If it is time for homework he can communicate the need to to the homework to another agent.

Group		Prof.
initial_beliefs		Time, time_for_hmk, hmk_done
initial_facts		Time
activities	« instance »	Communicate homework time
workframes		If time4hmk then communicate
thoughtframes		If hmk_done then sleep

Figure 2: Group in Brahms instantiated as the role Prof.

In the scenario we define 4 kinds of activities: primitive activities that are defined by their duration (e.g. the activity of listening to a song); move activities that specify a goal location, such as a particular room, and which uses the geography model; communicate activities, defined by a receiver and a message; broadcasting activities, which allows communication to all agents in the same location as the broadcasting agent.

Workframes contain the actions of the agent with associated preconditions and consequences. For example, the Prof agent may have the workframe symbolising the rule: if there is the need to do the homework and the homework hasn't started yet, Prof should communicate with Ben to tell him that it is time for the homework (figure 3).

```
workframe wf_DemandToDoHomework{
 repeat: false;
 priority: 1;
  when(knownval(current.needToDoHMK = true)
and    knownval(current.homeworkStarted    =
false))
             do {
communicateTimeForHomework(Ben,"time     for
homework !");
             }
}
```

Figure 3: A Prof agent Workframe

Thoughtframes allow the manipulation of agents' beliefs and adding uncertainty to a belief (e.g. a belief may only be held 75% of the time. This could be interpreted as an agent 'changing its mind' and ultimately means that each run of the simulation can differ. In figure 4 below we see a Brahms screenshot showing the situation when the prof reminds Ben at 5pm, after he's been watching TV, that it's time to do his homework.

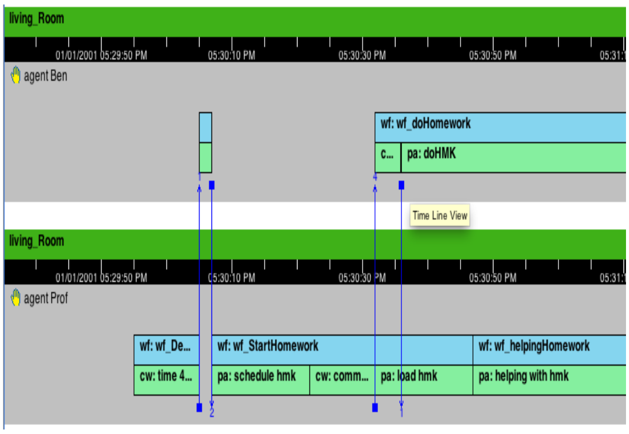

Figure 4: Teaching situation.

The location "living_Room" is shown for each agent (Ben and Prof), together with the date and time, horizontally at the top and middle of the figure. *wf*, *cw*, and *pa* refer to workframe, communicative activity and primitive activity respectively. Blue vertical arrows show the communication between agents; we have made the content of the communications explicit, but they may be seen by clicking on the arrows.

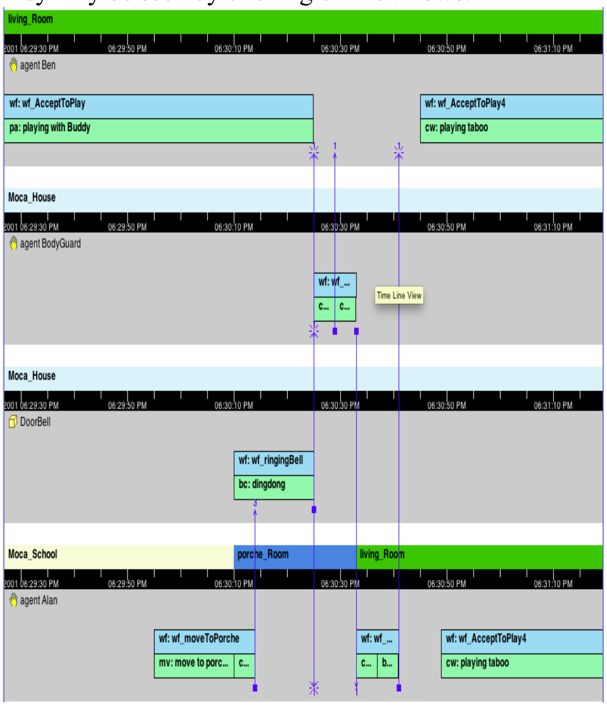

Figure 5: Guarding situation (someone at the door). The Bodyguard agent enters the action, followed by group games with companions and children.

Figure 5 shows a screenshot where, the doorbell, modelled as an object, suddenly rings. Ben is a bit scared. The security agent, called Bodyguard in the figure, sees that it is Alan, who brought a companion with him. Knowing them (modelled as a belief), the Bodyguard lets them in and reassures Ben, telling him that Alan is here with Poto. Buddy and Poto suggest making teams with Alan and Ben to play strategy games, one of Poto's favourite games.

We modelled each role as a group of agent sharing abilities (workframes and thoughtframes). Since in BRAHMS agents are situated, this allowed us to detach the role from the device and also to instantiate the role by more than one situated companion (Poto and Buddy belong to the Playing Group). Indeed, we can imagine one situated agent member of all of the group, being able to accomplish all the roles. Figure 6 below shows how the Buddy agent is member of both the Coach and Playing groups, and hence it can play both roles according to the context.

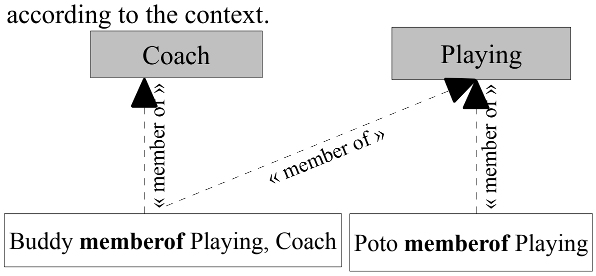

Figure 6: Example of memberships of Buddy and Poto agents

6. DISCUSSION

Modelling and simulation the scenarios in BRAHMS had the advantage of highlighting the behavourial variability that we have to face for the design of the MOCA system. Indeed, variability of context of use (Calvary 2001) composed by the user, the platform, and the environment, shows the importance of the predefined family rules that will help the companion agent to take a decision according to its role. In this study, a family is a mixed group of companions and human that will share some beliefs and throughtframes manipulating these beliefs (figure 7).

```
group Family_One memberof Families {
...
      initial_beliefs:
(current.time_for_homework = 5);
(current.Kids_allow_to_watchTV = false);
...
```

Figure 7: Listing extracted from the group Family_One (Brahms file)

In order to be able to simulate the variability of the device that can play a role, we consider the social role as a group that can be instantiated by several situated agents.

By detaching the role from the device allows us to instantiate several roles in one device. This highlighted the importance of context into the decision of the agent of taking a role. Indeed, as a nanny can help with the homework, she can also be a play buddy after this task is done.

One issue that has been raised by our simulations is the coordination of multiple companion agents.

Indeed, several strategies can be chosen when a role has to be played when several agents are capable of playing this role. We may enrich the model by adding cooperation, assignment, or redundancy decision in the role played by multiple companions. This will depend on the context and some roles will need redundancy (Bodyguard) in order to insure detection whereas other role will offer more benefit with cooperation (Prof).

7. CONCLUSION AND FUTURE WORK

We have shown how interactions in a hybrid society, composed of human and companion agents may be modelled in Brahms, following a definition of problem/situations and a scenario. We are currently in the process of validating the usefulness of these problem/situations via prototyping the companion agents on physical devices (commencing with Reeti and Nao). In order to assess their usefulness, we use the notion of worth, defined as "the value for the user of the system" (Cockton, 2004) (Cockton, 2006). Cockton proposed Worth Centred Design (WCD) framework. WCD focuses the development on increasing the worth of using the developed system. Indeed, some factors such as the appearance, of the system impact on the user experiences with the system. This influences its motivations, its worth in using the system. Where User Centred Design classically considered as factors influencing user experience primarily the functionalities and the ease of use, WCD expends the set of factors to sociologic, emotional or economical factors.

Practically, we are implementing the 'play' (Buddy) situation in a prototype, which will then be tested with sample users; their opinions will then be gained through post-experimentation questionnaires and interviews. The aim of this step is to see if the problem/situations that we have identified are really what users want from companion agents. In parallel we are investigating the worth of adding personality to our companion agents. Personality is a key element of establishing relationships (Mischel et al. 2004), and provides stability in terms of recognizing and relating to the companion. This personality will be expressed when accomplishing the roles and through devices. The addition of personality extends the bipartite composition of the companion agent, from role and device, to one now composed of three parts (figure 8). Ultimately this allows users to choose personalities for their agent.

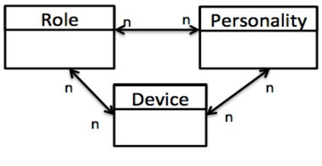

Figure 8: Tripartite aspect of the companions

Once we have established the worth of the system, we will evaluate the interactional capabilities of the agents and the role of personalities through simulation. This may be achieved by extending the Brahms model to run full simulations. This will allow us to design more effective interaction functionalities before further implementation occurs. Thus simulation will be used as an aid to designing companion agent.

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