Artificial companions as personal coach for children: The Interactive Drums Teacher

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ABSTRACT

The MOCA Project that aims at designing and studying the interaction and relationship between artificial companions and children in everyday life at home activities. Artificial companions are digital embodied entities that can be either robotic or virtual. In this paper, we focus on a single activity, subpart of the whole project: a coaching application that uses two artificial companions to teach the basics of drums to children. One device is a Nao robot, the other is a virtual agent. This application offers a wide variety of interaction situation that will enable us to conduct several experiments. Future directions are discussed, in terms of user-computer interaction and in terms of coaching and e-learning applications.

Author Keywords

Artificial companions, human robot interaction, virtual humans, e-learning.

ACM Classification Keywords

H.1.2 User/Machine Systems, H.5.2 User-centered design, Prototyping, H.5.1 Animations, Artificial, augmented, and virtual realities, H.5.3 Asynchronous interaction

INTRODUCTION

Over the last twenty years, an increasing number of digital devices were included as part of our daily life; market studies show that this dynamic will continue to accelerate. Yet most – if not all – of these devices do not have the capacity to establish a relationship with the user. In affective computing, this ability is considered as a key factor to ensure significant added value in everyday life. Where, in history, the tool is an extension of the hand of man, the collective of modern digital devices must form a true extension of himself in the world. To do so, one must use this constantly evolving collective as artificial entities incarnated in each of the different devices. From the relationship created with these entities, emerge the concept of "artificial companions". Artificial companions have to be reliable, fair, unselfish, safe, fast, credible and empathetic. The MOCA project aims to develop and study this relationship through virtual agents, personal robots and communicating devices. In this article, we present a sample application showing the complementarity of Robotics and Virtual Agent: A virtual coach for children dedicated to interactive learning of drums.

RELATED WORK

Artificial companions are embodied entities that may use a robotic body or a virtual body. Embodied Conversational Agents (ECA) are commonly used in affective computing [7], as they display a human like form and expressive capacities (see [8] for a review). However, in most of this system, the agent is only a service provider, like a virtual butler.

Using ECA as coaches have already been explored in several specific domains. For example, they have been used in assisting users to quit smoking [3], training them for job interviews [4], and so on. Yet, few of these applications are building a personal and social link with the user.

Fasola and Matarić [2] created and studied a robot designed to engage elderly users in physical exercise. While it is not designed to create any social relationship with the user, the robot was effective. They also compared the real robot to its virtual counterpart displayed on a TV. Their results show 'a clear preference by older adults for the physically embodied robot coach over the virtual coach in terms of enjoyableness, helpfulness and social attraction'.

Lisetti *et al.*[5] created a coach to help users to quit drinking that uses a dynamic empathy expressive system to establish a personal relationship with the user. They show that social behaviors improve users' motivation and engagement, and increase system's acceptability.

CALONIS [9] is one of the few attempt to model the social relationship with the user. CALONIS aims at providing cognitive support for cognitively disabled army veterans. Unlike previous works in this area, its design considers the relationship that emerges from interactions, mostly to ensure this relation will not interfere with the real career and his patient. The robot is being involved in a three-party relation: patient-career-robot.

Pesty and Duhaut [6] defend the importance of building an "impacting relation" with artificial companions. They argue that this relation 'will enable believable interactive ECAs or robots to become believable impacting companions able to build a kind of lifelong relationship with the human'.

MOTIVATIONS

Artificial companions are expected to be more than simple butlers. Their interaction domain is wide and does not limit to providing service to the user. They are not specific to a task and can fulfill different type of roles. In the application that is presented in the remaining of this paper, our companions are coaches and teachers.

While real teachers cannot – and must not – be replaced by virtual entities, we believe that artificial companions are appropriate as complementary learning coaches. For example, when a child is learning a musical instrument, he must practice alone at home between the lessons. In this context, having virtual companions to motivate him and give insightful feedback would be valuable.

Inducing motivation to practice any learning activity however require to create some form of relationship with the user. Unlike most previous researches using a single companion, we believe that a unique multipurpose companion is not adapted. For example, the companion dedicated to games should establish a friendship relation, but the companion dedicated to homework should not, if it is to maintain a minimum level of authority over the child. Furthermore, using several companions as a collective better allows for exploiting their complementarity.

While small personal robots, such as Nao, are designed to be attractive to children, they are rather limited in its motion dynamics. Nao for example, walks slowly and it is not capable of holding objects, except for very small and light objects. Because of these limitations, we cannot use the Nao robot to demonstrate drums gestures.

On the other end, virtual agent might be less attractive than robots [5], as they are only present in virtual worlds. However, they can move without limitation and even faster and wider than real humans. It's not difficult to animate an agent that will play drums with enough precision. We will not discuss the realism issue of gesture dynamics in this paper, but it is clearly a challenge to make a believable virtual drummer.

The combination of both technologies – robots and agents – is in our view an efficient approach for a drums coaching system. That is why we designed the system that we describe in the following section.

SYSTEM

The drum coaching system is composed of a game drum kit (Xbox drumband), a Nao robot, and a virtual agent managed by the MARC toolkit [1]. The child is sitting in front of the Xbox drum kit and interact with Nao and the virtual agent on a 48inch TV. (See fig 1)

Description of User-Side Drumming System

As the MOCA project aims at designing children – computer interaction, we try to restrain interaction devices we use to general public game controllers. In this case, we used an

Xbox MadCatz "Drums Band" controller. It is composed of 4 drums and 3 cymbals, plus a central kick pedal.

Figure 1. The interactive system: a Xbox Drums Band controller, a Nao robot and one of the MARC toolkit virtual agent on a virtual drum.

Drums and cymbals are pressure sensitive. Their precision is limited but they can differentiate a strong stroke from a light one. The kick pedal however is an on-off switch.

Sound is generated within the computer. The drums controller is a xInput device that only transmit events, but does not generate sound effect. To ensure the minimal latency, we use a sampler based engine using ASIO audio. ASIO is a very low latency (max 10ms) audio system that enable a very high responsivity. Using high level libraries, such as OpenAL for example, introduces a delay of about 200ms to 300ms. The sound has thus a temporal offset that is very disturbing when playing the drums. Sounds sampler are 44khz wav files of real drums elements. Their volume is modulated by the stroke intensity.

Description of Virtual-Side Drumming System

The real drum kit is facing a TV screen on which a virtual character is sitting in front of a virtual drum kit. The virtual drums kit is designed to react on stroke event by generating sound (also using ASIO) and by animating visual element. For example, virtual cymbals oscillate softly when they are stroked. It increases the audio-visual consistency.

To facilitate the animation of the virtual character, all gesture are dynamically computed using a rhythm description sheet. These descriptions are timed sequence of "body part / drums element" pair (i.e. "Right hand / Crash Cymbal" "Left hand / Snare drum", or "Right foot / Kick Pedal")

The character animation is performed by the MARC Toolkit [1]. The animation of MARC is keyframe based. For each possible stroke combinations, we manually created three key poses: preparation, stroke, release. The animation is then created dynamically by combining the keyframes, body parts by body parts. To increased motion credibility, the

interpolation between keyframes is not linear, but a squared factor for prestrike interpolation and square root factor for post stroke interpolation. It create an acceleration effect with a speed apex on the stroke (fig. 2). On the stroke apex, we added a 16ms delay. Our software is running at 60hz. The 16ms delay is meant to ensure that the stroke impact is always visible (at least one rendering frame will render this position)
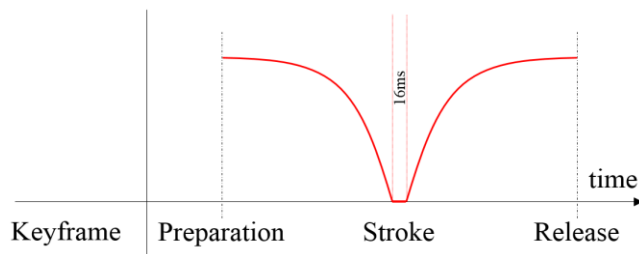

Figure 2. Stroke dynamics based on 3 keyframes.

Nao Animation
Nao animation is also keyframe based. We have predefined a set of gestures that can be used during the interaction. We used a custom animation editor and Nao is remotely controlled using the Proxy included in Nao by Aldebaran.

Do we Need a Robot?
In the application presented here, Nao does not really take part in the tutoring. However, its physical presence is used as a motivation factor. By dancing, and commenting the interaction, it supposedly creates a more complex and more fun interaction system. However, a user study must be led to validate this hypothesis.

Interaction and Scenario
For now, interaction is based on a scripted scenario. The scenario consists of an introduction, in which the two companions (virtual and robotic) introduce the activity and joke about one another. They create a convivial situation to increase children engagement. During this phase, the user is mostly an observer and the two companions are looking alternately at the child and at each other.

Once the introduction is finished, the child is engaged in a series of drums exercise that start simple and increased in time. These exercises are each described by a rhythm description sheet. They can easily be modified or new exercise can be added.

Each exercise is done as follows: the virtual drummer shows the exercise once and then starts to play is on a loop softly. During this phase, the virtual point of view switch to a "from the top" view of the virtual drum kit, making it easier to see what the virtual drummer does. Then Nao give a few specific advices (included in the exercise description) and encourage the child to try to play. During the exercise, Nao is motivating the child, detecting mistakes and providing advices accordingly. For example, detecting rhythm errors, Nao will say "Your rhythm is not good, you can try to focus on what you hear more than on what you see." (Note:

focusing on reproducing the gesture rather than the music is a common mistake that we observed).

More adaptive advices will be added as we proceed to more interaction session with children.

One of the key challenges is to preserve child's engagement in the activity, even when he fails an exercise multiple time. To this end, we included several mechanisms. Frist, Nao is always positive. It congratulates the child and give positive comments. Then, each time an exercise is failed the expectations are lowered. The coach is thus more and more tolerant to mistakes. Most children we eventually get the exercise right and move on to the next one. If the child keeps on failing, Nao eventually stops it and the interaction moves on to the next level. On one of the exercises, Nao also start singing and dancing.

Empirical Tests with Children
We conducted a set of first empirical tests by bringing the system to classes of children at different ages. The first test was conducted on 8 and 9 y-o children. While they were really engaged in the task at first and quite fond of the Nao robot, the drumming experience was somehow difficult for them. Except for the few ones already learning music as a hobby, they could not manage to play the exercises right, which led to a quick disengagement from the task.

Our second informal test was conducted on older children, 11 and 12 y-o (fig. 3). This time, most of the child were strongly engaged in the task for the entire duration and all exercises were successfully finished.

Figure 3- Photo of a class of 12 y-o children discovering the virtual drum teacher (faces blurred for anonymity). In this class, we used a projector instead of a TV.

Surprisingly, even when they had already seen the scripted interaction between the two companions several times, they seemed to rather enjoy it. We informally asked a few questions. Every single one of them were interested in having such companions at home. This is, in our view, a strong informal result that validates our approach. Further experimentation must be led to fully validate our system. We had a lot of questions about what other tasks the companions could do and interact with, showing a strong interest of children for the technology.

Future Improvements
One of the main improvement that must be made is the ability to speak with the companions in natural language. The current system features a set of vocal commands, for example to restart or skip an exercise, but the vocal interaction is limited. Natural language processing is a significant challenge but could help to establish a relationship. Our experiments will thus include a Wizard of Oz approach to enable such interactions.

Children have different abilities regarding music and rhythm. We are planning on adding an auto adjustment system to the sequence of exercise, skipping exercises when the child is outperforming, and adding sub-steps when the child is underperforming.

One other approach would be to include our coaching system as part of real drumming learning. Ideally, the children would have real, usual, lessons with a teacher, and use our coaching system at home, when they practice between lessons. In order to create a meaning full system, the teacher should be able to configure the exercise remotely and get feedback on the child activity between lessons.

Designing such a system would allow us to test the real impact of our system on children learning. We could compare progress two groups of children, with and without the virtual coaches, and over a long period of time, at least several weeks.

FUTURE EXPERIMENTATION
Preliminary studies with children have shown us that they are attracted to our virtual drum teacher. However, we need to validate how this system could be beneficial on a long term basis.

We intend to conduct an experiment with 3 conditions. 1) Using only the robot, the agent being replaced by charts indicating where to play, in which order. 2) Using only the virtual drummer, showing the exercises, with minimal explanations and no motivational components, and finally 3) the whole setup. Our main hypothesis is that the combination of both is more engaging and more motivating. Consequently, it should lead to more progress in learning the drums.

We could also test the physical presence effect. By using a virtual Nao robot versus a real robot, we could compare the engagement and motivation level.

Finally, this drums coaching system will be part of a bigger MOCA experiment involving several kinds of activity (from games to homeworks) and including more companion. This experimentation will aim at evaluating the global acceptance of artificial companions by children left alone for some time in a living lab. Companions will be endowed with personality, style, and will be designed to build a relationship with the user.

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