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Abstract

Based on the idea of a flexible applicable and entertaining theme a draft for a set of animal characters was created by UAU. For each of the agent roles "Basic help", "Critic", "Teachable Agent", "Model Comparison", "Learning Companion" and "Quiz" models were built and customized to communicate the intended purpose visually. Creation of animation and applicability concerning real-time 3D and prepared movie clip technologies was eased using an incremental multi resolution mesh model together with skeletal and morphing systems.

Document History

Version	Modification(s)	Date	Author(s)
01	Initial version	2009-07-02	Bühling
02	Improved wording	2009-07-03	Wissner
03	Content completion and improvements	2009-07-20	André
04	Added animation viewer info, fixed numbers	2009-07-24	Bühling

Contents

1. Draft and Concept

DynaLearn aims at the development of an interactive learning environment where learners are able to model conceptional system knowledge individually or in collaboration with others. The objective to provide students' with an individual learning environment with teachers and learners that adapted to their skills immediately leads to the metaphor of a virtual classroom. In this classroom, students may directly engage in a dialogue with virtual teachers, mentors or learning companions. They may help other agents by teaching them and subsequently watch their performance in a test or quiz. In this way, the virtual world becomes a (virtual) class room inside a (real) class room. The agents may either inhabit their own environment or reside on the user's desktop as part of the GARP system. In the latter case, the monitor will serve as the agents' living space.

1.1. Design Requirements

There are a number of factors that influence a user's attitude towards a virtual agent and the effectiveness of the application, such as the character's degree of realism, its ethnicity, and so forth, see a handbook article by André for an overview [1]. In the following, we review this work with the objective to come up with a set of criteria for characters to be employed in the virtual class room in DynaLearn:

1. **<u>Degree of Realism:</u> It seems obvious that the believability of virtual agents increases with their degree of realism. Empirical studies have shown, however, this is only the case until a point is reached where small imperfections become so disturbing that the believability of the agents suddenly falls again. Virtual agents that look almost like real beings, but no completely may appear rather creepy and even cause feelings of fear in humans. This phenomenon is called the "Uncanny Valley" effect and was first discovered by the Japanese Mori when working with robots [9]. Cartoon-like agents bear the advantage that animations can be reduced to a few meaningful elements that will not only contribute the comprehensibility of a character's presentation, but also increase its entertaining value. Indeed the Disney characters show that believability is not a matter of realism, but rather of expressiveness. There is also evidence from empirical studies that users prefer less realistic agents in learning environments [2].**

2. **<u>Expressiveness:</u> To facilitate interaction with the learning environment, the DynaLearn characters will emulate communication styles common in human-human conversation. No matter whether the virtual character represents a human like being or an animal, verbal and non-verbal signals have to be communicated in a convincing manner. This requirement excludes the use of a number of animals. Gestures might look awkward for animals that are not able to stand up straight. For animals with a small mouth, it might be hard to convey well visibly certain emotional expressions, such as surprise. In order to give the student the impression that the character is attentive, its sensing organs, such as ears and eyes, should be clearly visible. A high degree of expressiveness is not only necessary to increase the comprehensibility of a character's presentation, it also helps make the students feel with the character and create an affective bond with it.**

3. **<u>Degree of Anthropomorphism:</u> When interacting with anthropomorphic characters, people often form unrealistic expectations regarding a character's conversational skills. Despite tremendous efforts, robust technology for processing arbitrary multimodal user input and responding to it in an appropriate manner is not in sight. As a consequence, the users' expectations are often not met resulting into disappointment and irritation. Virtual animals offer a promising work around**

since they help keep the user's expectations at a realistic level and leave enough space for a user's own interpretation. If the characters' verbal response is not satisfying, the users will forgive them because usually animals do not verbally communicate at all, see also Mateas [8].

4. Consistent Audio-Visual Quality: Studies conducted by Nass and co-workers reveal the importance of consistencies in an agent's multimodal behavior. Lee and Nass [6] observed that a user's feeling of social presence is positively affected if the personality that an utterance conveys is reflected by the employed synthetic voice as well. Nass and Gong [10] claim that maximizing the quality of each modality does not necessarily improve human-computer interaction. Even though recorded human voices are more natural than the output of a text-to-speech synthesizer, an interface may become more appealing when a synthetic face is accompanied by a synthetic voice. The use of speech bubbles might be an acceptable compromise if there is no speech synthesizer available which matches the style and the personality of the character.

5. Compelling Agent Roles: The classroom metaphor enables us to explore different roles of characters in learning scenarios, such as the role of a teacher and the role of a learning companion. The role a character is supposed to portray should not only be reflected by the character's appearance, but also its verbal and non-verbal behavior. A compelling character has to convey a consistent behavior that reflects its role and is in line with assumed personality traits and its status relative to other characters. A virtual learner should be less formally dressed than a virtual teacher and use more colloquial phrases when talking to a learning companion than when talking to teacher. An introvert learning companion less likely to take the initiative in a dialogue than an extrovert learning companion. In order to enable role plays with multiple characters, the design of the characters needs to match a particular character type and rendering style. However, the characters should be customizable to a certain extent in order to assign each user a character with its own personality. Furthermore, it should be possible to slightly modify the outfit of a character by the use of accessories.

6. Culturally Neutral: The DynaLearn test users come from a wide spread of countries (Austria, Brazil, Bulgaria, Israel and UK). There is some evidence that users prefer characters that belong to the same culture as the user. Nass and Gong [10] have shown that computer agents representing a user's ethnic group are perceived as socially more attractive and trustworthy. Similar results were obtained by Baylor and Kim [4]. For DynaLearn, the realization of culture-specific agents is no option. First of all, the project budget does not allow us to create multi-character scenarios for five countries. Considering four character roles (two of them with different genders) and five countries, twenty-five different characters would have to be created requiring about ten Person Months just for the modeling of the characters. Second, the realization of culture-specific characters would either require that partners from the educational field bring competence in character design or that the partner developing the characters knows the cultural background of all five user countries. Since none of these conditions is fulfilled, the characters should rather reflect a "neutral" culture. Such a requirement can be easier met with virtual animals than with anthropomorphic characters. If the animals' communicative behavior does not reflect a particular culture, the users might still find the behavior plausible because animals usually do not communicate at all. Furthermore, the use of animals prevents us from having to visualize properties of a particular ethnic group.

7. More than just a decorative feature: There is empirical evidence that pedagogical agents lead to an increased sense of ease and comfort and motivate a learner to engage in a learning task. Studies that investigate whether or not an embodied conversational agent directly contributes to learning after shorter interactions have led to inconsistent results so far. A lot of research is still required to investigate in which cases an embodied agent improves learning. In any case,

creators of agents should make sure that the agent is more than just a decorative feature, but has a functional role in an educational setting. Otherwise, there is the danger that that agent just produces an additional cognitive load for the learners and distracts them from the actual contents. For example, it makes little sense to have an agent reproduce contents of a conceptual model that are visible anyway. See also, Thomas' first rule for writing cartoon dialogues [12]: "Do not write dialogue that describes what you are seeing."

8. Creation of Affective Bonds: Most tutoring applications so far employ virtual agents mainly for the purpose of communicating information to the learners assuming that the pure presence of the virtual agent will increase the learners' motivation. While such virtual agents might still have a certain novelty to learners, they are unlikely to be sustainable in the medium to long term. In order to engage the students over a longer period of time, we need to design characters that are able to create affective and social bonds with the students. The success of Tamagotchis has shown the potential of virtual pets to create sustainable relationships with people. The metaphor of a virtual pet that is fed with knowledge by the student in order to survive in a later competition with other virtual pets seems to perfectly match the concept of a teachable character in DynaLearn. In order to ensure that the students have a genuine interest in the agent's learning progress, we need to create teachable characters for which the students care. Animals that are perceived as cute may facilitate the creation of affective relationships.

Cartoon-like pets match the criteria above quite nicely. They are expressive, but do not raise too high expectations regarding their conversational skills. Furthermore, they may evoke strong emotions in users and thus have the potential to engage in long-term relationships with them. The DogZ and CatZ product developed by PF. Magic [11] show that users enjoy training virtual pets. Finally, interactive virtual pets have already been widely researched and we can draw on experience with virtual pets, see http://www.virtualpet.com/vp/research/research.htm.

We decided to employ hamsters because of their familiarity as pets and their strong presence in digital media. Once discovered by an Israeli zoologist in the Syrian Desert, gold hamsters became more and more popular as pets – first in the United States and a little bit later also in Europe (see http://www.pfma.org.uk/overall/pet-population-figures-.htm). The fact that hamsters have been heavily exploited as laboratory animals and specific kinds of hamster are now protected species in several countries, such as the Grey Hamster in Bulgaria, raises the awareness of the environmental problems to be addressed in DynaLearn.

Due to the heterogeneous target group in DynaLearn (five countries from three continents), a huge number of subjects would have been necessary to reliably identify the preferences of our users for a particular character. Another difficulty arises from the fact that it is hard to draw any reliable conclusions from user preferences. Consider, for example, a study conducted by Ventura and Ventura [13] with four different characters (see Figure 1). There study revealed that the users had a preference for the bird and the scientist. Based on the small set of characters, it is of course hard to say why the users chose a particular character. Did the users choose the bird and the scientist because they look less human-like than the butler and the woman? Or did they choose the scientist because it matched the application, a tutor system teaching physics, in a better manner?

Figure 1: Characters evaluated by Ventura and Ventura

In order to get a more comprehensive and informative picture regarding the popularity of characters across different

countries, we decided to investigate the spread of virtual pets in the digital media. In particular, we looked at avatar web pages, computer games and movies. Our study revealed that the popularity of hamsters was also reflected by their coverage in the digital media. Avatar web sites, such as http://www.iconator.com/, offer a large variety of hamsters see Figure 2 (upper left). A recent Disney movie features a hamster called Rhino, see Figure 2 (upper right). The Virtual Pets expansion pack of The Sims 2 includes hamsters as well, see Figure 2 (lower left).

Figure 2: Hamsters in digital media

Last but not least, hamsters have already been used to motivate students in educational settings, see for example the Java-Hamster-Model by the University of Oldenburg (see Figure 3). This model has been successfully taught to students a bit older than the DynaLearn target group since ten years now.

Figure 3: Java Hamster by the University of Oldenburg

2. Design of Interaction Types

Virtual agents may take on a diversity of roles in learning scenarios including virtual teachers, advisors, learning companions, and autonomous actors in educational role play. The characters' role is not only reflected by the characters' outfit, but also by the character's verbal and non-verbal behavior. Baylor and Kim provide useful hints regarding the realization of different character roles in educational settings: the role of an expert, a mentor and a motivator. Basically, their agents were characterized by the content they conveyed and the level of expressivity. For example, the expert focused on the pure communication of information without displaying any emotions while the other agents also tried to encourage the students and used a richer set of animations. An empirical study revealed that the expert fostered the acquisition of information while the motivator and the mentor increased the students' self efficacy. In a further study, Kim and Baylor [4,5] investigated how a character's competency influenced the learning process and the students' self-efficacy. Again they found that a high-competency virtual companion led to a better learning performance than a low competency agent, but decreased the students' self-efficacy. A low-competency agent on the other hand showed to increase the students' self-efficacy.

Another important feature that reflects the character's role is the interaction style which refers to the amount of initiative a character takes. Proactive characters start acting without explicit request and offer their knowledge immediately to the user. According to an experiment by Kim and Baylor [5], a proactive characters seem to have a positive impact on recall. It is furthermore shown that in particular, novice users might profit from a more proactive character since they help pass inhibition thresholds. The user does not have to be afraid of making mistakes because the character leads him to the right way. Responsive characters on the other hand only act when the user requests a function. This limits interference by the character and leads to a more liquid work flow. Especially advanced users quickly feel annoyed when they are disturbed by a very active avatar all the time. The responsive one is present all the time, but does not bother users when they wish to work independently. There is also evidence from empirical studies that people wish to keep control which suggests the avoidance of dominant characters. The right amount of activity also depends on user characteristics, such as prior knowledge, personality, and age.

Starting from the work by Kim and Baylor, the level of competence and interaction style for the DynaLearn characters will be set by the educational and motivational goals to be achieved. In the following, drafts for the required tasks "Basic help", "Critic", "Teachable Agent", "Learning companion", "Model Comparison" and "Quiz" will be shown.

2.1. Basic Help

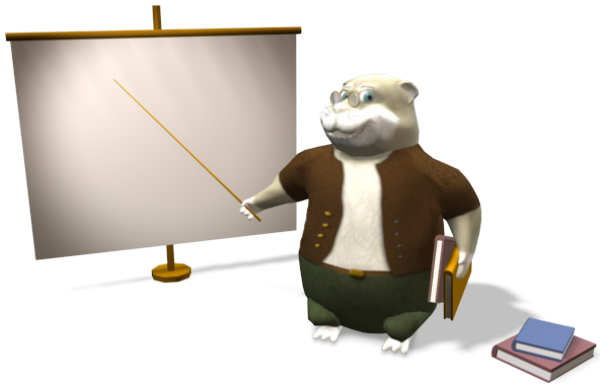

Fig. 4: Teacher like character for the Basic Help role.

The Basic Help character introduces the user to workbench use and content meaning.

Fig. 4 shows a teacher-like design for this role. Similar to a real teacher, the character conveys a higher level of competence than the learner. To avoid an intimidating dominance, an older and calmer character was chosen.

Offering basic help on using the DynaLearn software, this character can be employed in a welcome session for novice users. It is furthermore suitable as an interface to encyclopedias or reference books.

2.2. Provide Feedback / Critic

Fig. 5: The teacher as an advising helper.

The Critic Character makes use of pedagogical tactics to support learners in interactively refining their conceptual ideas and ultimately arriving at a model that matches their expectations. In order not to impose pressure onto the student, instructions should be phrased as suggestions. Furthermore, the the Critic Character should not give complete solutions. Instead he should provide hints that encourage the students to further explore their ideas. It respects the users' knowledge and gaps to collaborate with them in a professional, but peer-like way.

Again the teacher design was reused (Fig. 5) in order to create a positive and comfortable learning atmosphere. He was already introduced in the welcome phase and is hence known to the user as a competent helper.

2.3. Teachable Agent

Fig. 6: A teachable hamster sitting on his school desk.

Teachable Agents represent and reflect the user's knowledge and can be taught by the learner.

In order to motivate students to teach their agents, they have to make the students care for them. This is achieved by reproducing the learner's situation. Similar to real students, teachable agents have a low competence which may increase when they are supplied with knowledge from the student.

Fig. 6 shows an agent that takes the part of the student. He has a young informal design and uses colloquial language.

2.4. Learning Companion

Fig. 7: Two students meet on the network.

Virtual learning companions ensure the availability of a collaborator and may increase the students' engagement in a task (see the work by Craig and colleagues [2]. They allow us to simulate networking and community features. Following the metaphor of a virtual class room, they are casually dressed like students in their early twenties in order to convey the image of a peer learner at the age of our target users.

The hamsters displayed in Fig. 7 stage the situation of meeting and learning together in school. Different users may have different avatars that represent the participants on the colleagues' screens.

2.5. Model Comparison

Fig.8: Taught characters discuss their knowledge.

During the Model Comparison two or more agents engage in a dialogue comparing models.

As in the previous paragraphs, we do not have to create completely new characters, but just add new conversational tactics to the existing school model.

Fig. 8 depicts a school yard where the earlier taught characters discuss their knowledge emphasizing differences and similarities between their models.

By watching the agents they have taught earlier, students can test their own knowledge indirectly in a scenario that preserves privacy.

2.6. Quiz

Fig. 9: The showmaster invites the student to a quiz.

In Quiz mode, the character questions the learner about the contents of a model.

Because of its playfulness, this mode is suited to be integrated into a kind of mini game. Accordingly, the character that asks the questions is designed as an entertaining and comical show master (Fig. 9) and has a kind of pseudo-competence. Knowing the answer to the question, he edges over the student. This answer is no real knowledge of the show master though, but only read from the moderation card.

The user or his/her teachable agent becomes immediately a temporary candidate of a quiz show when this mode starts.

This mode was inspired by a study conducted for the Betty agent where students suggested a kind of game in order to make the teachable Betty appear more interactive [7].

3. Animation

Depending on the used runtime system the characters have to be suitable for real-time 3D engines as well as movie clip players. As the DynaLearn development addresses both with the Horde3D real-time client and the Flash based animation client the models were created in a low polygon version that can be used as realtime content. Using modifications filters on this model a high resolution version could be created easily out of this draft for the graphically higher quality movie clip approach with low effort.

For the different models which base on the same original mesh with different textures and assets, helper systems were used to ease the creation of animation sequences. The screenshot on the left hand side of Fig. 10 shows the skeletal system connected to the actual skin mesh. It can be used to easily animate the whole body and create gestures or body motion. The picture on the right image side displays some created morph targets that directly influence the spatial mesh. Using simple slider values it is possible to animate facial expressions this way. Both systems can also be exported to the Horde3D engine and used to animate the avatars in realtime.

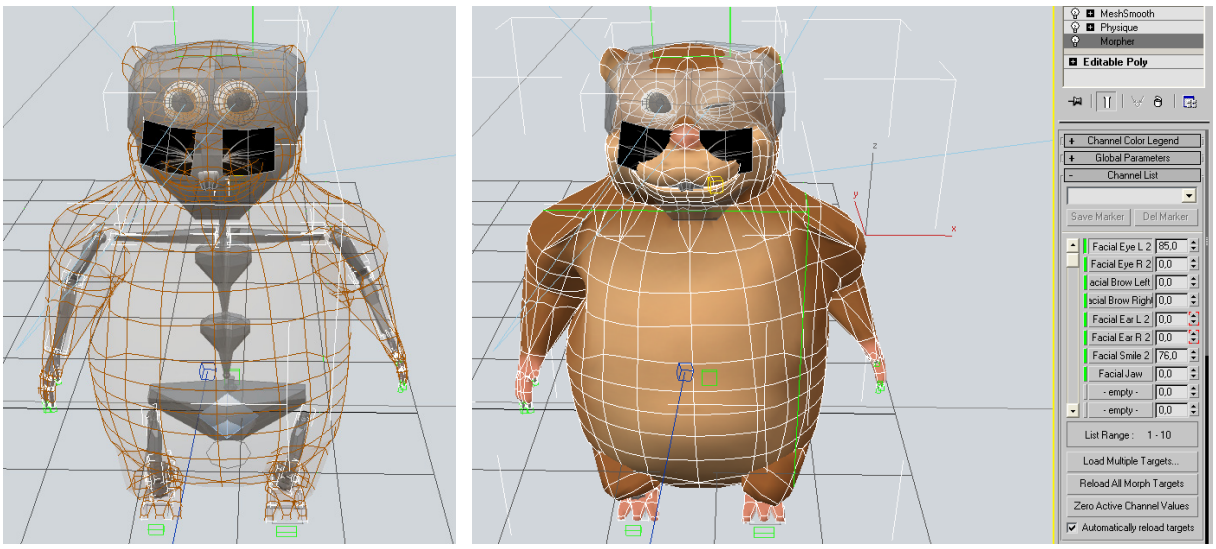

Fig. 10: Easing the process of animation using a bones system (left) for body actions and a morph system for facial expressions (right).

3.1. Sequence Types

All animations required in DynaLearn can be classified into the three global type categories "Idle", "Action" and "Transition". Idle animations are played when the avatar waits for events or when no action is currently executed. They are important for creating a believable character that seems to life. Fig. 11 shows an example of an idle animation that is played when the avatar simply stands in the room. Beside some discreet full body motion like soft swinging of the arms the eyes are winking periodically to refer to real behaviour.

Fig. 11: Idle animations like casual winking makes the character lively even in low action times.

The second category of Action animation is the most obvious one. Animations of this type show an actual act and displays events or activities. In many cases assets, stage objects or other creatures are involved like the note book shown in Fig. 12. This animation example visualizes the collection of knowledge in an easy understandable picture language. Depending on contents also the camera perspective of the character may change during Action animations like during the run to another location on screen as displayed in Fig. 13.

Fig. 12: Action animations visualize the current (inter)action mode or happenings.

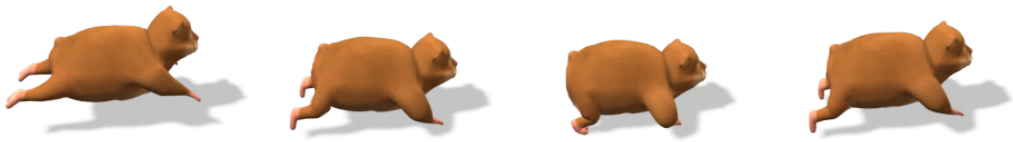

Fig. 13: Walk cycles are a typcial case of full body animation with different perspektives on the creature.

Transition animations are necessary to avoid visual breaks when the virtual character turns from one animation sequence into another. Fig. 14 shows the animation sequence that is played before the actual walk cycle is shown. As in real life the hamster turns down from its standing position to the running pose before starting to leave the place. Transitions require a high effort to produce and a good technical management but they smooth the user experience and beautify the whole motion aesthetics.

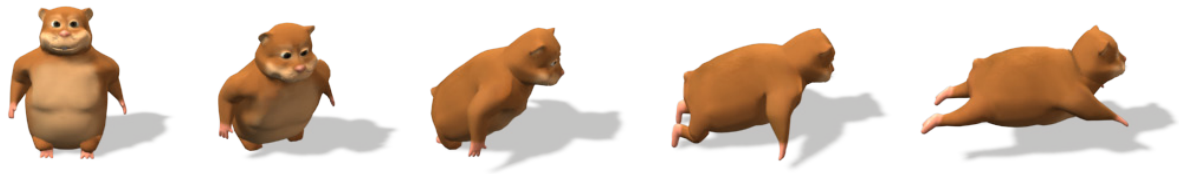

Fig. 14: To avoid perceptible breaks in animation when changing from one state to another, transition animations have to be created. The sequence displayed here shows the transition when the hamster switches from standing into running.

An overview of the set of created avatars is given by the hamster viewer website provided by UAU[1]. Fig. 15 shows this Flash applet that structures all available animations into a tree navigation sorted by characters and animation content type like communicative, navigational or facial expressions.

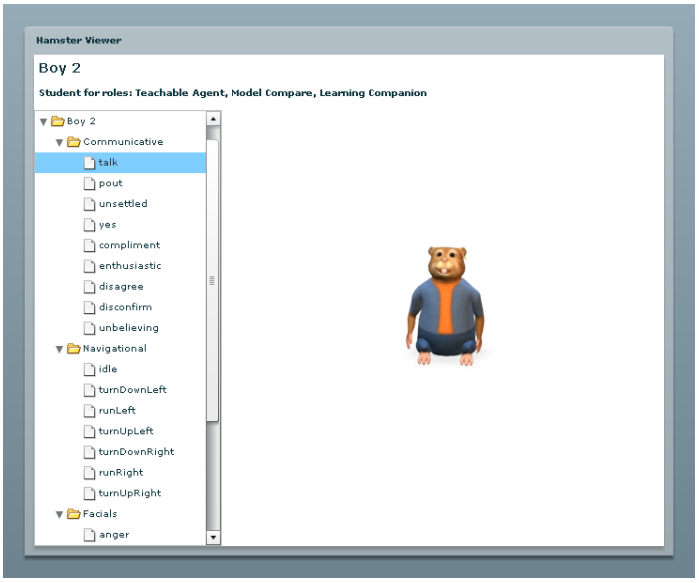

Fig. 15: The Hamster Viewer Flash application can be used to browse created character animations grouped by content meaning.

[1] http://mm-werkstatt.informatik.uni-augsburg.de/downloads/DynaLearn/HamsterViewer/

4. Conclusion and Discussion

The designed animated characters match all intended roles occurring in the DynaLearn software experience. Some of the roles were applied to the same. For example the teacher character takes knowledge providing tasks while student avatars are able to be taught, to meet each other and to discuss their education. Quotation of real life school yard experiences formed the basis of these ideas.

In further steps the already successfully tested prototype integration of the characters has to be improved and extended. Furthermore the characters have to be included in the Horde 3D engine as a completion of the technical setups.

The designs will be evaluated with potential users to ensure that the intended roles are successfully communicated by the graphical designs. Additionally the impact of different settings (Monologue vs. Dialogue) on learning and motivation will be analyzed.

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