Simulating human movement

VIRTUAL CHARACTERS

New methods to automatically generate virtual character movements.

In computer games and simulations humans are represented by virtual characters. The realism of their motor behaviour critically determines user engagement and the validity of interactive simulations. Based on the experimental study of human manoeuvring performance, we are developing realistic parameter-based motion models for virtual characters.

Our objective is to identify the principles of natural human maneuvering performance (motor behavior, speed, accuracy). By studying human motor behavior in complex structured real environments, we can derive general parameterized motion models that allow automatic generation of a diversity of virtual character movements. This will enable a more realistic simulation of the motor behavior of autonomous virtual characters, and a more natural interaction with avatars driven by users that are restricted by the limited field-of-view of display devices. Particularly in serious gaming and training applications, this may ultimately lead to increased user engagement and enhanced transfer of skills to the real world.

"Realistic movement of virtual characters enhances user engagement and simulation validity"

Viewing restrictions reduce walking speed

We investigated human obstacle avoidance behaviour under restricted viewing conditions. We varied both the horizontal and vertical viewing angle independently. We found that even a small restriction of the horizontal visual angle causes a considerable decrease in speed while traversing an obstacle course. The results show further that restrictions in both directions affect obstacle avoidance behaviour. However, enlarging the vertical viewing extent yields the largest performance improvements. These results indicate for instance that most commercially available head-mounted displays (HMDs) are not suitable for use in cluttered simulated environments (e.g. military and first responder training applications), due to their limited vertical viewing angles. Our findings can be used to select and develop of HMDs and other display devices with appropriate field of view extents for any given application.

Vertical viewing restrictions increase step length and toe clearance

Using a motion capture system, we are currently analysing several kinematic parameters representing human obstacle crossing behaviour. This enables us to model behavioural changes as shifts in strategy. Our initial results show that, in normal (unrestricted) viewing conditions, humans adopt strategies prioritizing energy conservation and time efficiency. With a restriction of the vertical viewing angle, people appear to counter the risk of tripping by increasing their step length and toe clearance while maintaining their speed, thus sacrificing energy conservation. Additional viewing restrictions appear to cause participants to further reduce their speed and increase their step length and toe clearance even more. Next, we will investigate the effects of viewing restrictions on a range of different manoeuvring tasks and in various circumstances. The results of this research will be useful for implementing realistic manoeuvring performance in virtual environments, and for driving virtual agents.

Workpackage
2.1 Modeling motor behaviour

Partners
Utrecht University
TNO Human Factors

Budget
500.000 euro

Key Publications

S.E.M. Jansen et al. (2008). Effects of horizontal field-of-view restriction on manoeuvring performance through complex structured environments. Proc. 5th symposium on Applied perception in Graphics and Visualization, pp. 189-189.

S.E.M. Jansen et al. (2010). Restricting the vertical and horizontal extent of the field-of-view: effects on manoeuvring performance. The Ergonomics Open Journal, 3, pp. 19-24.

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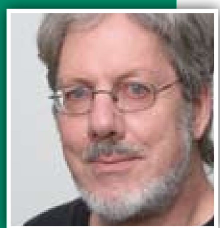
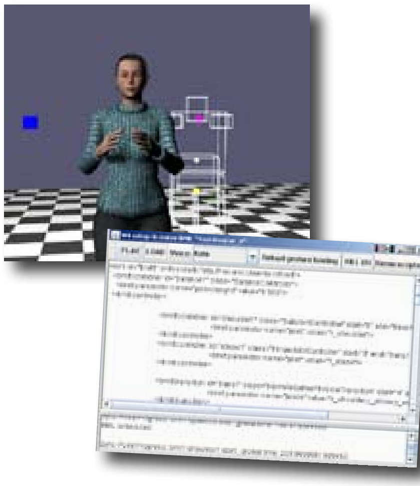


Continuous interactive dialogs with Embodied Conversational Agents



New methods to make Interactive Embodied Conversational Agents appear more natural by continuous and parallel interaction through verbal and non-verbal communication.

VIRTUAL CHARACTERS

Workpackage
WP2.1 Modeling motor behavior

Partners
Human Media Interaction,
University of Twente

Budget
500.000 euro

Key Publications

H. van Welbergen et al. (2009). An Animation Framework for Continuous Interaction with Reactive Virtual Humans. Proc. 22nd Annual Conf. on Comp. Animation and Social Agents, pp. 69-72.

A. Nijholt, et al. (2008). Mutually Coordinated Anticipatory Multimodal Interaction. In: Nonverbal Features of Human-Human and Human-Machine Interaction, pp. 70-89.

H. van Welbergen et al. (2009). Real Time Character Animation: A Trade-off Between Naturalness and Control. Proc. Eurographics, pp.45-72.

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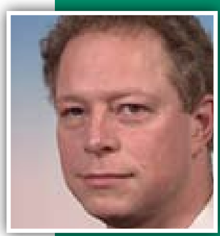


Interactive Embodied Conversational Agents (ECAs) are currently used in an interaction paradigm in which the user and the system take turns to talk. If the interaction capabilities of ECAs are to become more human-like and they are to function in social settings, their design should shift from this turn-based paradigm to one of continuous interaction in which all partners perceive each other, express themselves, and coordinate their behavior to each other, continually and in parallel.

The main objective of this project is to develop a continuous interactive ECA that is capable to perceive and generate conversational (non-)verbal behavior fully in parallel, and to continuously coordinate this behavior to perception. We will thereto develop and implement the sensing, interaction and generation components required to realize continuous behavioral interaction.

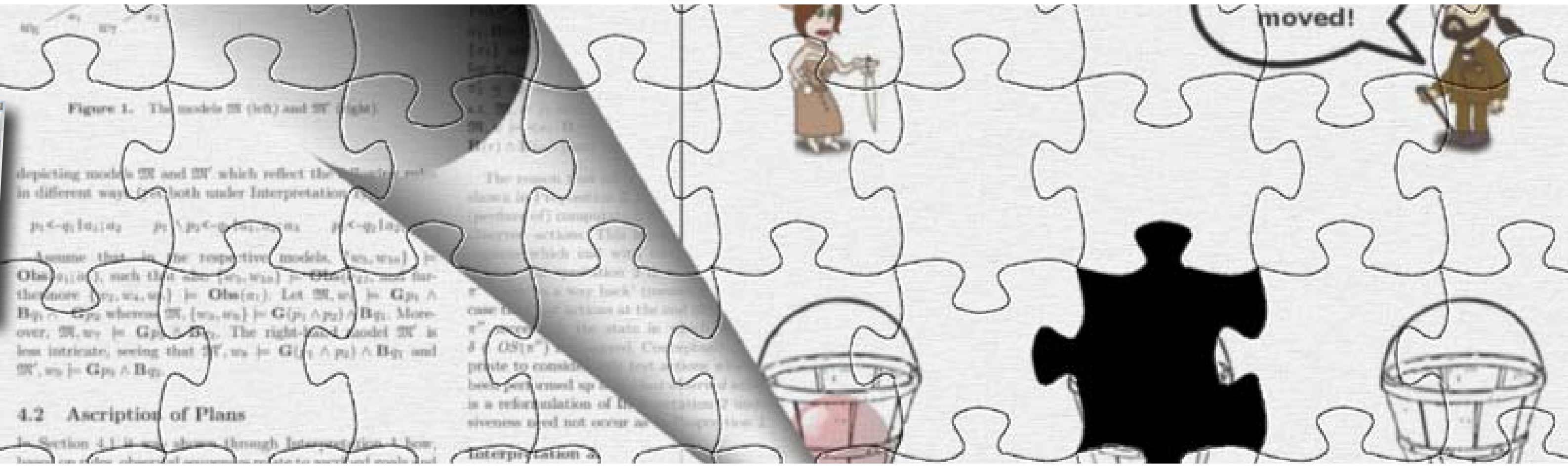
Elckerlyc: A Behavior Markup Language Realizer

We developed the virtual human platform "Elckerlyc" (http://hmi.ewi.utwente.nl/showcase/Elckerlyc) for generating multimodal verbal and nonverbal behavior for Virtual Humans (VHs). Elckerlyc is designed for continuous interaction with tight temporal coordination between the behavior of a VH and its interaction partner. It provides a mix between the precise temporal and spatial control offered by procedural animation and the realism of physical simulation. It is highly modular and extensible, and can execute behaviors specified in the Behavior Markup Language. Elkerlyc allows continuous interaction by direct revision of bodily behavior, based upon (short term) prediction. This leads to a flexible planning approach in which part of the planning can be done beforehand, and part has to be done on the fly. In the latter case, parts of the behavior have already been executed, and other parts can still be modified. We focus on the specification and execution of such flexible plans. We have provided abstractions for the prediction of sensor input and show how we can synchronize our multimodal output to these predictions in a flexible manner. To demonstrate the feasibility of the multimodal output generation part of our system without investing a lot of work in the sensing part, we have currently implemented placeholders for the predictors.

Continuously interacting Embodied Conversational Agents can be interrupted

At the Enterface 2010 workshop a virtual human system will be designed and built, that employs Elckerlyc's continuous interaction capabilities. This ECA will be able to perceive and generate conversational (non-)verbal behavior fully in parallel, and will coordinate this behavior to perception continuously. hus, the ECA responds to (or explicitly ignores) head nods, short vocal utterances such as "yeah" and "hmm" of the user and can try to evoke or encourage such verbal or non-verbal utterances from him or her. Actively dealing with and responding to the user's verbal and nonverbal behavior requires the ECA to be capable of handling overlap, to re-plan and re-time expressions, to ignore interrupt attempts by the user, and to abandon planned utterances (letting itself in effect be interrupted). We will model and implement the sensing, interaction and generation required for this continuous interaction. An evaluation study will be performed to investigate how the newly developed ECA is perceived by human users in terms of politeness and certain personality traits.

Mindreading virtual characters



VIRTUAL CHARACTERS

Logic-based techniques to read others' minds from their observed behavior.

The term 'mindreading' (alarmingly esoteric as it may sound!) in psychological terminology designates an everyday human activity: thinking about what others believe or want. Our goal is to make virtual characters a bit more human by providing them with mindreading capabilities, which are grounded in observable behavior.

BDI-based virtual characters are designed – or even programmed – in terms of their 'mental state', i.e. their beliefs, goals, and plans. This powerful high-level abstraction allows for flexible behavior, and several tools (formalisms & software) exist for specification. However, little work deals with inferring mental states from observed behavior (mindreading), which is a desirable capability for virtual characters that should exhibit awareness of the mental states of others. Our work aims to contribute in this respect, by formalizing mindreading for BDI-based agents in regard to the observed behavior of other BDI-based characters and human players.

"Giving virtual characters mindreading skills will increase their believability"

Different possible pasts

We have developed a generic approach for relating observable behavior to plans, which allows inference of BDI-based agents' mental states from knowledge of rules. This approach deals with plans that are partially observed, which can occur because the agent is still busy with its plan and/or because not all actions are observed. Inference of others' mental states along the lines of our framework is defeasible, meaning that conclusions – although plausible – could be false. In line with this view, a valid interpretation of an observed sequence of actions is that such a sequence represents a set of different 'possible pasts' in which the observed agent had different mental states, of which one was its actual mental state. We have formalized this view for the case in which all actions are observed, in a framework based on dynamic logic.

In the case of human players, a virtual mindreader has even less information available than in the case of software agents. Knowledge of characteristics of the environment are then a possible source of information, and we have investigated this source formally by means of logic, and practically by means of an implementation in the 2APL agent programming language of the classical Sally-Anne false-belief test scenario.

Some explanations are better than others

Inferred mental states can be considered explanations for observed behavior, and the fact that defeasible inference generates multiple different possibilities warrants the search for means to select a 'best explanation' from the possible ones. In this regard we have already considered information from organizational context (roles and norms), and mean to incorporate other sources such as spatial distance metrics or probabilities extracted from past observations. Logical programming approaches come to mind for implementation and evaluation of our methods, of which answer set programming offers some promising possibilities that we intend to explore. Furthermore, recent work in agent programming has focused on the specification of emotions in terms of BDI concepts, and we consider applying our insights to such specifications in order to formalize the inference of (particular) emotions from observed behavior.

Workpackage
2.2, Modeling Cognitive Behavior of Virtual Characters

Partners
Utrecht, Intelligent Systems Group

Budget
500.000 euro

Key Publications

M.P. Sindlar, M.M. Dastani, F. Dignum & J.-J.Ch. Meyer (2008), Mental State Abduction of BDI-Based Agents, Proceedings of the 6th International Workshop on Declarative Agent Languages and Technologies (DALT 2008), pp. 161-178.

M.P. Sindlar, M.M. Dastani & J.-J.Ch. Meyer (2009), BDI-Based Development of Virtual Characters with a Theory of Mind, Proceedings of the 9th International Conference on Intelligent Virtual Agents (IVA 2009), pp. 34-41.

M.P. Sindlar, M.M. Dastani & J.-J.Ch. Meyer (2010), Mental State Ascription Using Dynamic Logic, Proceedings of the 19th European Conference on Artificial Intelligence (ECAI 2010), to be published.

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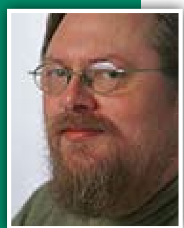

Explaining virtual character behavior

VIRTUAL CHARACTERS

Explanations of characters to increase trainees' learning of serious games.

Workpackage
2.2 Modeling cognitive behavior of virtual characters

Partners
Utrecht University, TNO

Budget
500.000 euro

Key Publications

Harbers et al. (2009). A methodology for developing self-explaining agents for virtual training. Proc. MALLOW'009.

Harbers et al. (2009). A study into preferred explanations of agent behavior. Proc. international conference on Intelligent Virtual Agents, pp. 132-145.

Harbers et al. (2009). Modeling agents with a Theory of Mind. Proc. international conference on Intelligent Agent Technology, pp. 217-224.

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Behavior of virtual characters in games sometimes seems incomprehensible. But if people are supposed to learn from a game, they need to understand why characters behave the way they do. Therefore, virtual characters are being developed that are able to explain the reasons for their actions.

Serious games are used for training of complex tasks like leadership, crisis management and negotiation. Virtual characters play the trainee's team members, colleagues or opponents. For effective training, the characters need to display realistic behavior. Moreover, it is important that the trainee understands why virtual characters behave the way they do. For instance, why did virtual team members not follow the instructions of their leader, or why did a negotiation partner make a certain bid? New technologies will allow players to actually ask virtual characters for the reasons behind their actions.

Explanation by beliefs and goals

Human explanations have been taken as a starting point for developing virtual characters that are able to explain their behavior. Humans usually explain their own and other's actions in terms of underlying desires, intentions and beliefs. For instance, 'I did this because I wanted to...', or 'he did that because he thought that...'. To obtain similar explanations of virtual characters, they are programmed in a BDI programming language, in which their Beliefs, Desires (goals) and Intentions (plans) are explicitly specified. This makes it possible to explain each action of a character by the particular beliefs, goals and plans underlying that action.

Often a set of goals and beliefs are responsible for one action, but not all of them are needed to explain the action. To avoid too long explanations, a selection of the beliefs and goals must be made. In experiments, subjects were asked to provide feedback on possible explanations of virtual characters. The results showed that for some types of actions beliefs were considered more useful as an explanation ("I thought that ..."), but for other action types goals were preferred ("I wanted to ..."). Furthermore, it was found that students more often preferred belief-based explanations, whereas teachers tended to prefer explanations in terms of goals.

Effect on learning

Besides a virtual character's beliefs and goals, other factors like theory of mind, emotions or norms may explain its behavior. A theory of mind refers to the ability to attribute beliefs and goals to others. For instance, a character will act differently when he knows about someone else's plans, when he is angry or when he has to obey certain rules. An approach to incorporate these aspects in the BDI models of virtual characters is currently being developed.

Finally, an experiment is being prepared in which the effect of explanations of virtual characters on learning is investigated. Two groups of subjects will play a training game, and afterwards their understanding in the played session will be measured.

"Players can ask virtual characters for the reasons behind their actions"

In between, one group will receive explanations of virtual characters, and the other group will not. The results of this study will show the contribution of explaining virtual character behavior.

Social virtual humans

VIRTUAL CHARACTERS

Enhancing conversational virtual humans with social and emotional capabilities.

The demand for virtual humans that can engage in sophisticated dialogue with players of serious games and training-simulations is rapidly increasing. To facilitate this we aim to build new models of dialogue systems that incorporate social and emotional capabilities. Such enhancements increase the believability and realism of virtual humans.

Virtual humans in serious games and training-simulation need to fulfill the same function as humans in the real life equivalent of such situations. These functions may include performing training-related behaviors and provide explanations for the selection of those behaviors for which they may need to engage in natural conversation with the user. Some applications of virtual humans may concentrate completely on dialogue, for instance in the case of language and cultural learning. At the University of Twente we are working on improving the conversational skills of virtual humans by enhancing conversational virtual humans with capabilities to recognize and display social and emotional behavior.

"By modeling and integrating the relations between cognition and behavior, virtual conversational humans will become more believable and humanlike"

Cognitive modeling

In order to facilitate the enhancement of our virtual conversational humans we needed a solid and plausible framework of the cognitive processes that manages the processing, selection and realization of conversational behavior. In conversations, humans do not merely exchange information but they also engage in a social and emotional relationship. To that end we have examined various conversational virtual human systems and psychological approaches to cognitive, emotional and social processes to gain insight and inspiration. This has resulted in a cognitive model for virtual humans that represents the manner in which humans practically reason about mental abilities. In particular, the model tries to account for basic Theory of Mind modeling, i.e. reasoning about the intentions and emotions of the interlocutor. Through this model a virtual human is able to form beliefs about the world and have goals and intentions it wants to realize through conversational behavior. Furthermore it takes into account the emotional state of the virtual human and the social relation it has with its interlocutor so as to be able to calculate the expected effects of its conversational moves on the other's mental state. Subsequently we have studied how conversational behavior can be associated with the various components in the cognitive model.

Relation between mind and behavior

Currently we are studying how to model the relation between individual conversational behaviors and high level cognitive processes such as intentions, emotions and social roles. Additionally we investigate how the emotional state influences the selection and/or realization of conversational behavior. There is a distinction between the way emotions lead to a certain conversational behavior and the manner in which emotions affect the execution of conversational behavior. The same distinction holds for conversational behavior that is influenced by social rules. By modeling and integrating the relationships between cognition and behavior, virtual conversational humans will become more believable and humanlike.

Workpackage
2.2 Modeling Cognitive Behavior of Virtual Characters

Partners
Utrecht University
University of Twente
TNO

Budget
500.000 euro

Key Publication
B. van Straalen et al. (2009) Enhancing embodied conversational agents with social and emotional capabilities. In "Agents for Games and Simulations", F. Dignum et al. (eds.), pp. 95-106

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Virtual crowds

VIRTUAL CHARACTERS

New techniques to populate virtual worlds with thousands of characters.

Workpackage
2.3 Natural paths for virtual entities

Partners
Utrecht University

Budget
500.000 euro

Key Publications

I. Karamouzas et al. (2008). Adding variation to path planning. Computer Animation and Virtual Worlds 19, pp. 283-293.

I. Karamouzas et al. (2009). Indicative routes for path planning and crowd simulation. Proc. fourth international conference on Foundations of Digital Games, pp. 113-120.

I. Karamouzas et al. (2009). A predictive collision avoidance model for pedestrian simulation. Proc. Motion in Games, pp. 41-52.

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Contrary to real worlds, many game worlds contain only very few people. As a result the worlds feel uninhabited. To give game worlds a lively feeling we need to simulate large crowds of virtual characters. New techniques have been developed for this that are efficient and lead to natural crowd behavior.

A basic operation that virtual characters must perform is navigating from their current location in the virtual world to a desired new location. This problem is called the path planning problem. Often multiple characters move in large groups or crowds in the same environment, in which case we talk about crowd simulation. Path planning and crowd simulation play an important role in the immersion that a player experiences in a game. Existing real-time crowd simulation approaches fail to deliver motions that are natural. This project studies new, practical path planning and crowd simulation algorithms that efficiently generate convincing paths.

Indicative routes

We developed a new approach to path planning that is very fast and flexible. During a preprocessing phase we compute a network of routes through the environment, similar to waypoint graphs that are often used in games. But we do not follow these routes directly! The paths are only used as an indication. With each route we store a collision-free corridor. This corridor gives the character flexibility to choose its path. While it globally follows the indicative route to its goal, locally it can deviate from the path, as long as it stays within the corridor. This approach can plan thousands of paths simultaneously with little CPU usage.

We use this approach as the basis for our crowd simulation technique. While characters globally follow their indicative routes they must avoid other characters. We developed a new approach for character avoidance based on observations of behavior of real people. The characters predict collisions and take early action to avoid them by making small changes to their direction and speed. Recently we extended this to characters walking in pair and triples. The resulting motions are much more natural and we can simulate crowds of thousands of people at interactive frame rates.

Mood influences walking behavior

In different situations crowds of people behave differently. For example, in a railway station many people stand still while others run. But in a shopping center people tend to wander around slowly. We currently investigate these different types of behavior and we will design algorithms to simulate different types of crowds. Also the personality, mood, and age of people strongly influence their walking behavior. Angry people walk faster and are less willing to deviate from their path. People that are distracted, for example when using a mobile phone, walk slowly and pay

"Realistic simulation of crowds will considerably improve the immersion in game worlds"

little attention to other people. We will construct a general framework to deal with these different types of people in a crowd. Finally we will study replanning, which is required when a path that is chosen by a character is blocked. Integrating all these elements will lead to much improved and more generic crowd simulation software.