OPENCRIMESCENE REVIEW LOG
Interaction Log in a Virtual Crime Scene Investigation Learning Environment

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Abstract: In this paper we present a concept for visualising an interaction log in a virtual crime scene investigation learning environment called OPENCRIMESCENE. The interaction log shall be used for reviewing the user's behaviour after having examined the virtual crime scene. Furthermore, it shall serve as a valuable discussion background when it comes to self or teacher's control. As initial point the log visualisation therefore has to present an instant overview of user activity combined with significant user interactions. In order to keep track of the causal relations and the sequence of events we here focus on visualising time by combining different significant character positions in one image. This paper primarily aims at giving an overview of our system and introduces the review log as well as its first visualisation form.

1 INTRODUCTION

Due to the technological progress in Computer Graphics in recent years, 3D environments offer the possibility to lift various processes from real life onto a virtual level. This ranges from simple 3D model viewers to complex 3D learning environments or computer games. Because of latest improvements in 3D game engine's development even non-programmers can realise their own 3D virtual environment. However, mapping real life procedures onto a virtual level still is quite a challenge. This is also because character animation usually cannot keep up with real life motion.

The OPENCRIMESCENE project is a research project on developing a 3D learning environment for virtual crime scene investigation. It is conducted in collaboration between the local University of the Police and our Computer Graphics Group. The project primarily focusses on the realisation of procedures for securing a crime scene. In this context we also pursue realistic modelling of traces like finger- or shoeprints as well as tools to secure those traces. The virtual crime scene is implemented using the 3D game engine Delta3D[1] and is currently in a prototypical state.

The OPENCRIMESCENE system is divided into three parts: First, the authoring mode where the teacher can set up a virtual crime scene, arrange traces, and prepare for, e. g., a virtual examination. Second, a practice mode in which the student can recapitulate what he or she has learned in practical experience. This will also serve as examination mode. Third, we want the system to see over the virtual crime scene and allow for analysing the student's behaviour in a review mode.

Seen from the learning environment point of view the central question is: *How can real life procedures of crime scene investigation be turned into virtual interaction techniques which can be logged for reviewing the learning development of the student?* The focus therefore does not only lie on the realistic simulation of the crime scene investigation but also on the visualisation of the virtual interactions themselves. Hence, we want to make it possible to actually *see* what the student *has done* in a visual log – the OPENCRIMESCENE review log.

[1]http://www.delta3d.org

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In this paper we introduce our concept for this log. It aims at giving an instant overview of the student's behaviour when securing the crime scene. Therefore, significant interactions have to be captured. These are then to be displayed by different visualisation forms. Starting from the log's global view there will also be the possibility to take a closer look at certain events either by scene replays or more detailed logs.

Our first visualisation form that is presented here combines significant character positions in one image. We concentrate on encoding action over time by applying different rendering techniques. Even though we focussed on small scenes with only one viewing angle, we receive a first impression of user movement and behaviour.

2 THE REVIEW LOG

One main advantage of a virtual learning environment is that even complex scenarios like, e. g. a crime scene, can be represented virtually and, thus, be experienced even by multiple users whenever they want. Additionally, users can benefit from the fact that interactions within a virtual environment can be logged. Thus, they can step back and take over a more objective perspective on how his or her behaviour has been. Such an interaction log can also be helpful for teacher's control, not only in terms of a virtual examination but also for discussion.

The fact that virtual environments support synchronous as well as asynchronous communication is crucial when it comes to learning and understanding. Here, we focus on asynchronous communication first in the form of the visual review log. We have two reasons for that: First, we want the system to be quickly useable and have therefore postponed the realisation of multi-user access. Second, we believe that virtual environments cannot reproduce crime scene investigation procedures in such a detail that would hold for real life techniques. Hence, an afterwards discussion is still essential with the review log as initial point.

What is required for such an interaction log? Speaking in terms of crime scene investigation, the securing of traces is one of the major tasks to be fulfilled. There are certain rules a police student has to internalise. How to enter the crime scene without damaging existing traces? How to secure the traces with the correct tools, for instance only certain powders are best for securing fingerprints? Besides, there are crucial regions to look for traces first, e. g. fingerprints will rather be found at doorknobs than on the floor, and so on.

As a result the review log has to visualise important interactions, user awareness as well as false or missing actions and behaviours. However, at the current stage of implementation we cannot decide automatically for significance of interactions and user behaviour. We rather take a look at how to combine different character positions in one image in a pleasing way. Hence, as a starting point for the review log we simply track the character's position and posture over time. The combination in one image leads to a first impression of an instant user behaviour overview.

3 RELATED WORK

3D virtual environments have become a major application area for research. They not only offer graphically pleasing visualisations for complex scenarios but also the possibility to explore them in single or in multi-user mode.

Beside collaborative work and entertainment, learning is one of the most explored application areas of virtual environments (Mondjar-Andreu et al., 2006). Several different approaches towards designing such environments have been introduced, e. g. (de Antonio et al., 2005; Bouras et al., 2002; de Oliveira et al., 2000). Likewise, the application variety ranges from virtual hairstyling (Ward et al., 2006) to maths classes (Elliott and Bruckman, 2002) and many more.

Although most environments allow for synchronous online as well as asynchronous offline experience, realising collaboration is still a challenging task. As a result, innovative system frameworks often remain prototypes, e. g. (Lombardi and Lombardi, 2005). Thus, we focus on asynchronous communication first. This will be achieved by logging relevant interaction sequences in order to communicate student behaviour for review.

Current works on recording, summarising and visualising relevant user interaction are few. Nevertheless replay functionality is a required and common feature in most computer games and virtual environments, e. g. (Wagner, 2004; Logan et al., 2002). The challenge, however, is to decide for importance without losing causal relationships.

(Halper and Masuch, 2003) addressed the problem of summarising only significant game events. Their approach was to analyse game state variables and to visualise these as a series of according game snapshots afterwards. Although the attempt is promising, further improvements could be incorporated, e. g., different views of the scene to allow for a better connection of game event relationships. (Friedman et al., 2004) generate movie summaries from virtual environment logs. They put emphasis on causal relations to support story understanding.

In contrast, the works of (Chittaro and Ieronutti, 2004; Hoobler et al., 2004) concentrate on overall user activities by highlighting user navigation paths. Furthermore, Hoobler et al. also encode action over time by colouring whole game environment areas. Yet, the resulting overview images often take into account current activities only.

(Fielding et al., 2006) use reporter, editor and presenter agents to log, filter and visualise important events in a game environment. Their approach's novelty lies in the embodied reporter agents which try to balance player's and spectator's needs. Yet, no presenter agent has been realised entirely.

Although not focussing on summarising events, (Grammenos et al., 2006) have studied user activity in virtual environments in depth. They introduce the *Virtual Prints* as a concept to track user navigation, trace user interaction and leave marks to communicate to other users. Thus, beside game state variables also virtual prints could be used to make assumptions on the significance of user interactions.

Finally, speaking of virtual crime scene investigation itself most research activities focus on static photo-realistic crime scene reconstruction (Se and Jasiobedzki, 2005; Gibson and Howard, 2000; Howard et al., 2000). There is only the CRIME SCENE CREATOR by (Davies et al., 2004) which addresses similar issues as we do. Although the system is also intended for crime scene reconstruction only animated characters can be added to the created scenes. These can then act out simple crimes. Moreover, variable camera views make it possible to interactively view the scenes from different angles. The project's main focus is to support investigators by allowing for a fast and efficient evaluation of crime scenes and sequences of events. In contrast to our system, however, neither interactive crime scene investigation nor teaching purposes are considered.

4 LOG VISUALISATION

As stated above, logging the student's behaviour in the learning environment is the basis for asynchronously communicating how the crime scene investigation has taken place and which actions the student has done. However, our system is currently at a development stage which does not allow for automatic event logging yet. As a consequence we record significant events manually in order to concentrate on the log's visualisation.

Having examined the works from section 3 the visualisation of activities in games or virtual environments can generally be divided into two groups, taken animated replays aside. First, important events are presented in a series of snapshots, and second, regions with strong user presence are being highlighted. We call the former an *event-based* or *local visualisation form* putting emphasis on single events and the latter a *course-based* or *global visualisation form* representing overall activities.

In the OPENCRIMESCENE system we want to achieve a visualisation form which combines both. We need an overview of global user activity as well as the depiction of significant local interactions in order to receive an instant user behaviour summary. As a starting point we decide to use a set of snapshots from the character in the virtual world and combine the character's positions over time in one image. To facilitate the combination process further we use one static camera to record the character movement. Moreover we assume that only non-overlapping positions have been found.

4.1 Visualising Time

Simply combining certain character positions does not make any assumptions about the global process of crime scene investigation. Therefore, we need to encode time. As we only use one static camera position the only thing changing in the virtual environment is the virtual character. Hence, a possible solution to encode time would be to change the character's rendering in various ways.

Transparency: Probably the most natural way to encode time is to make the character more transparent as time passes. Hence, in the first stages in a crime scene investigation, the character is visualised highly transparent and the later an action is depicted the more opaque the character becomes, see Figure 1.

This visualisation is controlled by a linear function that maps the time to the level of transparency, however, this function needs to be designed in such a way that the transparency value of the first position to be visualised is not 100% in order to ensure the visibility of all positions.

Furthermore, it is important to make all positions distinguishable, therefore, the sole use of transparency is only possible, if two points in time are not too close together, see Figure 2.

However, if the character positions are distinguishable but user movement has been fast, transparency is also limited in indicating time differences, as shown in Figure 3. In those cases, additional visual clues have to be used. One solution is to employ any

Figure 1: Encoding position over time by different transparency values.

Figure 2: Transparency limits due to an accumulation of close character positions, see positions 1 and 2.

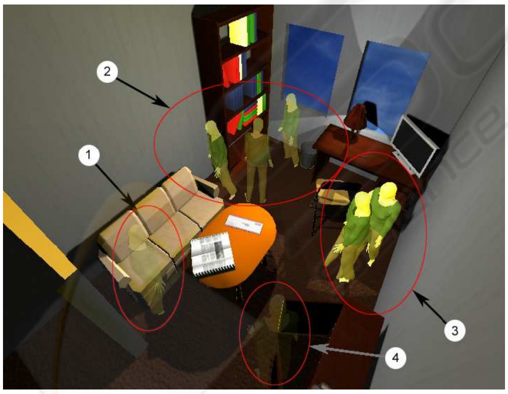

Figure 3: Transparency limits due to fast user movement. The sequence of positions 1 and 4 is hardly recognisable whereas positions 2 and 3 can be well distinguished.

user-defined mapping function to individually define transparency values for the single positions.

Colours: Another way of encoding time is to use colours on a colour scale and to map points in time to which the respective character position belongs to the chosen colour values. To do so, the image of the character is first de-saturated to achieve a grey value version and then re-coloured in the respective colour. If the starting point of this re-colouring is a more or less transparent version of the character image, the transparency clue can be enhanced. Otherwise the used colour scale is the only way in which time is visualised. This is somewhat problematic, since colour scales that are built on the basis of changing hues are barely useable when it comes to the visualisation of ordinal values (as time is in our case). Therefore, colour scales that are built on one specific hue with changing intensity are a better tool when no transparency is employed.

Silhouettes: One major concern when superimposing multiple positions of the character in the same image is that the character might not be optimally visible in a rather cluttered image showing multiple characters and the objects being present at the crime scene. Drawing the silhouettes of the character makes it stand out against the background of the crime scene and, hence, better visible, see Figure 4. The visual design of these silhouettes can be adapted to the visualisation of the character, i. e., their colour can be set to fit the colour of the character. On the other hand, the silhouette style can also be used to map different values, like importance or duration of time, see Figure 5. However, the priority in the visualisation is always to be set in such a way that the order of events becomes clearly visible.

Figure 4: Using silhouettes to further enhance the character's visibility.

4.2 Combining the Techniques

The rendering techniques presented above show different renderings to encode time. We believe that transparency is the main indicator for time-sensitivity in this scenario. Yet, transparency is limited when

Figure 5: Using coloured silhouettes to additionally encode time. For instance, fast user movement is indicated by the blue silhouettes.

it comes to visualising events which are very close in time. Silhouettes could additionally be applied either to better differentiate between close positions or to directly encode time-lags. However, the latter does not hold for short changes in time. Figure 6 shows a combination of both techniques with an additional legend relating transparency and silhouette colours to the actual time values. This seems to be an adequate visualisation for a small number of significant events.

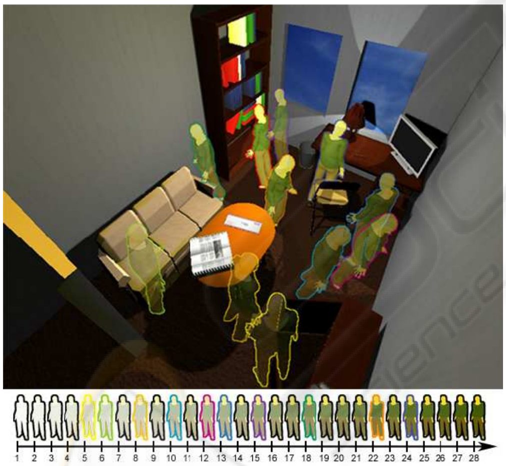

Figure 6: Combining the enhancement techniques in one image.

5 CONCLUSION

Our first visual review log shows how to combine different snapshots of character positions in one image. Furthermore, mapping rendering style parameters to time values seems to be an appropriate method to track the order of user activity. In this first scenario transparency seems to be the strongest indicator for time-lags whereas silhouettes increase the perception of the single character positions. Yet, the presented visualisation form concentrates on showing temporal relationships and significant character positions in a small scene only — without taking into account different camera angles, problems of cluttered images and the like. We nevertheless receive a first impression of how to combine a local and a global visualisation form and of how an instant user behaviour summary may look like.

6 FUTURE WORK

Having introduced OPENCRIMESCENE as well as the review log concept with a first visualisation form we now would like to address some of our ideas for future research. A first task will be to implement methods for automatic event logging and visualisation. Among others, this will also imply the integration of multiple camera views into the scene in order to decide for the event's best view.

Besides, we will need to further investigate the field of information visualisation, e. g. (Ware, 2000). The event's size or the silhouette's thickness might be better indicators for action over time than colour and transparency are. Colour could instead be used for grouping related interactions. A user study will therefore be essential to examine the rendering styles' applicability.

Above, we would like to realise additional visualisation forms, e. g. comic-like logs. Combining the works of (Halper and Masuch, 2003) and (Friedman et al., 2004) may serve as a starting point here. For this purpose rendering techniques like non-photorealistic or multi-perspective rendering shall be explored, e. g. (Strothotte and Schlechtweg, 2002; Glassner, 2000). The former to convey more and different information and the latter to describe causal relationships.

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REFERENCES

Bouras, C., Triantafillou, V., and Tsiatsos, T. (2002). A Framework for Intelligent Virtual Training Environment: The Steps from Specification to Design. *Educational Technology & Society*, 5(4):11–26.

Chittaro, L. and Ieronutti, L. (2004). A Visual Tool for Tracing Users' Behavior in Virtual Environments. In *Proceedings of the Working Conference on Advanced Visual Interfaces 2004*, pages 40–47, New York, NY, USA. ACM Press.

Davies, N., Mehdi, Q., and Gough, N. (2004). Virtual Crime Scene Reconstruction with Integrated Animated Characters. In *Proceedings of the 18th European Simulation Multiconference*, pages 338–393, Magdeburg, Germany. ECMS.

de Antonio, A., Ramirez, J., Imbert, R., and Mendez, G. (2005). Intelligent Virtual Environments for Training: An Agent-Based Approach. In *4th International Central and Eastern European Conference on Multi-Agent Systems, CEEMAS 2005*, volume 3690 of *Lecture Notes in Computer Science*, pages 82–91, Berlin Heidelberg. Springer.

de Oliveira, J. C., Shirmohammadi, S., Hosseini, M., Cordea, M., Georganas, N., Petriu, E., and Petriu, D. (2000). Virtual Theater for Industrial Training: A Collaborative Virtual Environment. In *4th International Multiconference on Circuits, Systems, Communications & Computers*, pages 294–299, Vouliagmeni, Athens, Greece. WSEAS.

Elliott, J. and Bruckman, A. (2002). Design of a 3D Interactive Math Learning Environment. In *Proceedings of the Conference on Designing Interactive Systems*, pages 64–74, New York, NY, USA. ACM Press.

Fielding, D., Logan, B., and Benford, S. (2006). Balancing the Needs of Players and Spectators in Agent-based Commentary Systems. In *5th International Joint Conference on Autonomous Agents and Multiagent Systems, Hakodate, Japan, May 8-12, 2006*, pages 996–998, New York, NY, USA. ACM Press.

Friedman, D. A., Feldman, Y. A., Shamir, A., and Dagan, T. (2004). Automated Creation of Movie Summaries in Interactive Virtual Environments. In *Proceedings of the IEEE Virtual Reality Conference 2004*, pages 191– 200, Los Alamitos, CA, USA. IEEE Computer Society.

Gibson, S. and Howard, T. (2000). Interactive Reconstruction of Virtual Environments from Photographs, with Application to Scene-of-Crime Analysis. In *Proceedings of the ACM Symposium on Virtual Reality Software and Technology*, pages 41–48, New York, NY, USA. ACM Press.

Glassner, A. (2000). Cubism and Cameras: Free-form Optics for Computer Graphics. Technical report, Microsoft Research MSR-TR-2000-05.

Grammenos, D., Mourouzis, A., and Stephanidis, C. (2006). Virtual Prints: Augmenting Virtual Environments with Interactive Personal Marks. *International Journal of Human-Computer Studies*, 64(3):221–239.

Halper, N. and Masuch, M. (2003). Action Summary for Computer Games – Extracting and Capturing Action for Spectator Modes and Summaries. In *Proceedings of 2nd International Conference on Application and Development of Computer Games*, pages 124–132, Hong Kong, China.

Hoobler, N., Humphreys, G., and Agrawala, M. (2004). Visualizing Competitive Behaviors in Multi-User Virtual Environments. In *Proceedings of the Conference on Visualization 2004*, pages 163–170, Los Alamitos, CA, USA. IEEE Computer Society.

Howard, T. L. J., Murta, A. D., and Gibson, S. (2000). Virtual Environments for Scene of Crime Reconstruction and Analysis. In *Proceedings of SPIE: Visual Data Exploration and Analysis VII*, volume 3960, pages 41–48, Bellingham WA, USA. Society of Photo-Optical Instrumentation Engineers.

Logan, B., Fraser, M., Fielding, D., Benford, S., Greenhalgh, C., and Herrero, P. (2002). Keeping in Touch: Agents Reporting from Collaborative Virtual Environments. In *Artificial Intelligence and Interactive Entertainment: Papers from the 2002 AAAI Symposium*, pages 62–68, Menlo Park, CA. AAAI Press. Technical Report SS–02–01.

Lombardi, M. M. and Lombardi, J. (2005). Croquet Learning Environments: Extending the Value of Campus Life into the Online Experience. *3rd International Conference on Creating, Connecting, and Collaborating through Computing*, 00:135–142.

Mondjar-Andreu, R., Garcia-Lopez, P., Pairot-Gavalda, C., and Gmez-Skarmeta, A. F. (2006). Tracking the Evolution of Collaborative Virtual Environments. *UPGRADE - The European Online Magazine for the IT Professional, http://www.upgrade-cepis.org*, VII(2):25–30.

Mueller, M.-L. (2006). Benutzerschnittstelle fr die Tatortsicherung. Master's thesis, Department of Simulation and Graphics, Otto-von-Guericke University of Magdeburg.

Se, S. and Jasiobedzki, P. (2005). Instant Scene Modeler for Crime Scene Reconstruction. In *Proceedings of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition - Workshops*, page 123, Los Alamitos, CA, USA. IEEE Computer Society.

Strothotte, T. and Schlechtweg, S. (2002). *Non-Photorealistic Computer Graphics. Modeling, Rendering, and Animation*. Morgan Kaufmann Publishers, San Francisco, CA, USA.

Wagner, C. (2004). Developing Your Own Replay System. Gamasutra Online Article, http://www.gamasutra.com/features/20040204/wagner_01.shtml.

Ward, K., Galoppo, N., and Lin, M. C. (2006). A Simulation-based VR System for Interactive Hairstyling. In *Proceedings of the IEEE Virtual Reality Conference 2006*, volume 0, pages 257–260, Los Alamitos, CA, USA. IEEE Computer Society.

Ware, C. (2000). *Information Visualization*. Academic Press, San Diego, 2nd edition.