A Demo of The Matrix Has You: Realizing Slow Motion in Full-Body Virtual Reality

Michael Rietzler
michael.rietzler@uni-ulm.de
Institute of Media Informatics
Ulm University

Florian Geiselhart
florian.geiselhart@uni-ulm.de
Institute of Media Informatics
Ulm University

Julia Brich
julia.brich@uni-ulm.de
Institute of Media Informatics
Ulm University

Enrico Rukzio
enrico.rukzio@uni-ulm.de
Institute of Media Informatics
Ulm University

Abstract

We perceive the flow of time as a constant factor in the real world, but there are examples in media, like films or games, where time is being manipulated and slowed down. Manipulating temporal cues is simple in linear media by slowing down video and audio. Interactive media like VR however poses additional challenges, because user interaction speed is independent from media speed. While the speed of the environment can still be manipulated easily, interaction is a new aspect to consider. We implemented such manipulation by slowing down visual feedback of user movements. In prior experiments we slowed down the virtual representation of a user by applying a velocity based low pass filter and by visually redirecting the motion. We found such a manipulation to be even contributing to realism, enjoyment or presence as long as it is consistent with the experience.

Index Terms: Human-centered computing—Visualization—Visualization techniques—Treemaps;

1 Introduction

The perception of time is based on intervals, while it is hard to define what the concept of now really is. The perceived reality is a sampled interpretation of our visual, auditory and other senses. While the single senses are processed using different temporal resolutions, our brain needs to sample this information to a unified perception [2]. Slow motion itself is an imaginary, mostly learned concept, something never experienced in the real world. The only baseline arises out of linear media like movies. There, slow motion usually leads to visual aspects like increased motion blur and slower movements.

Slow motion has been used in visual linear media like film and television as a storytelling tool to convey varying experiences like narrative flashbacks, different temporal planes, tactical replay scenes, or bullet time. Interactive media like VR however have the added challenge of users being able to navigate the world independently of media progression; interaction speed is thus essentially independent of the media speed. Simply manipulating the virtual world but leaving the user interaction in its own frame of reference, for instance with regard to speed, however breaks Heeters first dimension of presence, namely personal presence [3]. While manipulating environmental cues, such as visual playback speed, covers the aspect of environmental presence but does not influence the way a user interacts with the virtual environment. In turn, this means that effects that the user can perceive in the surrounding virtual environment, e.g. slow motion, could also impact the users visible avatar so as not to break the feeling of presence.

Applying time manipulation in interactive media is therefore comparatively harder, because not only the media time is being manipulated, but also the time as perceived by the user, with the user's interaction speed not necessarily changing with a change of media speed. In weakly immersive media like games played on a traditional PC screen this normally isn't a problem, because interaction occurs indirectly, with feedback separate from user input spatially as well as metaphorically. However, when working with highly immersive media like VR, real-world body movements are often represented in the virtual world normally in real-time. Therefore, time manipulation inevitably leads to a conflict between the close-coupled feedback which represents users real movements, and the desired experience of a manipulated time flow. This may lead to a negative influence on factors like realism or the level of immersion.

However, as humans normally do not experience an altered time flow in the real world at all and therefore do not have any reference (e.g. in terms of realism), we argue that users might still be accepting of such a solution when it contributes to and integrates with the inner consistency of the virtual world being presented. This effect compensates for the negative influences which seem to dominate with such a manipulation at first sight. This matches insights from the field of narrative design, for instance Coleridges willing suspension of disbelief where readers accept unrealistic premises to enjoy a story or Tolkien's importance of internal consistency [9], which states that readers are more prone to accept alien concepts if they are presented as part of a coherent narrative system. These literary concepts have proven to be transferrable to interactive media like games and now show their relevance for virtual experiences.

2 Approach

To mitigate or even avoid this influences, we aim to apply a form of visual redirection similar to previous works in the spatial domain (e.g. [1, 4–6]), but instead in the temporal domain. By applying a redirection algorithm, we also slow down the virtual user movements according to the slowed down environment, which in turn forces the user to also move slower in the real world. In our demo application, this effect can be experienced in a VR scenario with the user being tracked and slowed down while interacting with objects and moving in the virtual environment. This enables the use of slow motion in VR environments, which can be useful in gaming scenarios, but also for simulations or also analytical purposes.

3 Evaluation Results

The presented approach was evaluated in [7]. The qualitative results showed that users overall enjoy having such a slow motion technique integrated in VR applications. We found that users also adapt to the maximum speed while moving in slow motion quite fast and accurately. Due to the adaption of movement speed as well as the increase of perceived realism in some of the conditions we assume that our participants accepted the manipulation as being a restriction of the manipulated time flow. Interrestingly, we even found a slightly altered perception of time. Participants rated the time playing with manipulation as shorter, while the manipulation of environmental cues only did not result in a different judgment of durations.

Our measurements for enjoyment, presence, control and realism which were mostly constant or even increased when compared to a non-redirected baseline further indicated the feasibility of such an approach. Additionally, no increase in motion sickness was observed.

3.1 Implementation

Since our experiments were done using a multi-Kinect setup [8] and a mobile GearVR as HMD, we adapted our approach to be used in a common VR setting. In this implementation our hardware consists of an Oculus Rift and two touch controllers. Since the use of only two controllers does not allow a full body tracking, we developed a new redirection technique based a single joints instead of slowing down the angles of the whole kinematic chain. The redirection of the hands is done by calculating the neccessary translation from the last virtual hand position to the real tracked position. If the respective velocity is exceeds the maximum allowd velocity, the calculated translation vector is scaled to match the maximal velocity. This way, the virtual hands always follow the tracked controllers, but with a maximal velocity that restricts the user to move too fast. The same was implemented for the rotation as well. This implementation follows the principle of the simple low pass filter as described in [7].

Since the presented implementation ensures, that the hands always move in the direction of the controller it is possible that the virtual hands move while the real hands rest. Since we found this to be unpleasent when applied to head motions, we implemented a slightly different approach to slow down the virtual camera. While we used the translation between controller and virtual hand to calculate the velocity of the hands, we use the translation of the camera between two frames to calculate the head translation. This ensures that the virtual camera only moves when the user moves her head, too. When moving too fast, the motion is scaled down. We also do not manipulate the camera's orientation, since we found this to cause nausia and disorientation.

3.2 Demo Experience

The different hardware used for the demo allowed us to create a much more immersive environment and to include more advanced visual effects which could not be implemented for the GearVR. We implemented a VR shooter game in which the user is able to slow down the time flow. The demo scene shows the inside of a factory with three torrets as well as some barrels to get cover. The torrets are activated randomly and start shooting into the direction of the user. The goal is to dodge the bullets and to destroy the torrets by fireing back.

By pressing a button, the user is able to slow down the time. As long as the button is pressed we apply our redirection implementation on the users hands and head to force him to slow down her own movements. We can also set the maximal velocity used for the velocity low pass filter to show how different strengths of manipulation influence the game play. In addition, we included several effects like the distorting trail of a bullet known from the cinematic concept of bullet time. We also affect the audio sources as long as the slow motion is active. The scene is illustrated in figure 1. The game can also be played without the described effect and by only manipulating environmental cues. In this case, the user is able to move as fast as desired without any manipulation of motion.

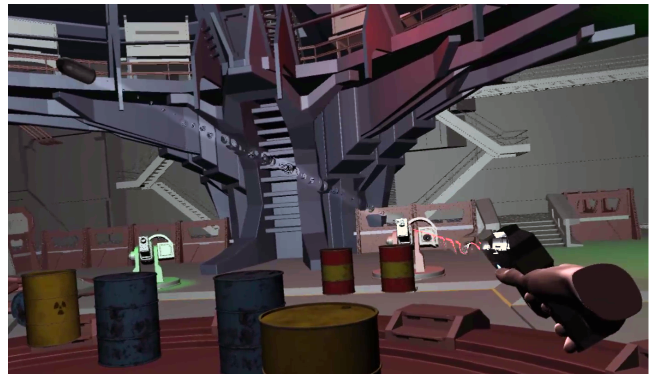

Figure 1: Screenshot of the demo application.

4 Conclusion

Slow motion itself can be easily implemented in VR by slowing down visual cues or by manipulating the audio. Though we found that such events should not only influence such environmental cues, but should also influence the user's motion. Since it is hard to force a user to move slower without any kind of physical counterpart like an exo-skeleton, we force users to adapt their motions by visual manipulation as low pass based redirection of body parts. In prior works, we showed that such a manipulation may positively influence presence, enjoyment and even the perceived realism without inducing a feeling of being in less control over the virtual body representation. With this demo we apply the concept to common VR hardware and show how such effects can be used in a shooter game.

References

[1] M. Azmandian, M. Hancock, H. Benko, E. Ofek, and A. D. Wilson. Haptic retargeting: Dynamic repurposing of passive haptics for enhanced virtual reality experiences. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, pp. 1968–1979. ACM, New York, NY, USA, 2016. doi: 10.1145/2858036.2858226

[2] D. M. Eagleman. Brain time. *Whats Next: Dispatches from the Future of Science, edited by M. Brockman. New York: Vintage Books.(Reprinted at Edge. org.)*, 2009.

[3] C. Heeter. Being there: The subjective experience of presence. *Presence: Teleoperators & Virtual Environments*, 1(2):262–271, 1992.

[4] L. Kohli. Redirected touching: Warping space to remap passive haptics. In *3D User Interfaces (3DUI), 2010 IEEE Symposium on*, pp. 129–130. IEEE, 2010.

[5] M. Rietzler, F. Geiselhart, J. Frommel, and E. Rukzio. Conveying the perception of kinesthetic feedback in virtual reality using state-of-the-art hardware. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18. ACM, New York, NY, USA, 2018. doi: 10.1145/3173574.3174034

[6] M. Rietzler, F. Geiselhart, J. Gugenheimer, and E. Rukzio. Breaking the tracking: Enabling weight perception using perceivable tracking offsets. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18. ACM, New York, NY, USA, 2018. doi: 10.1145/3173574.3173702

[7] M. Rietzler, F. Geiselhart, and E. Rukzio. The matrix has you: Realizing slow motion in full-body virtual reality. In *Proceedings of the 23rd ACM Symposium on Virtual Reality Software and Technology*, VRST '17, pp. 2:1–2:10. ACM, New York, NY, USA, 2017. doi: 10.1145/3139131.3139145

[8] M. Rietzler, F. Geiselhart, J. Thomas, and E. Rukzio. Fusionkit: A generic toolkit for skeleton, marker and rigid-body tracking. In *Proceedings of the 8th ACM SIGCHI Symposium on Engineering Interactive Computing Systems*, EICS '16, pp. 73–84. ACM, New York, NY, USA, 2016. doi: 10.1145/2933242.2933263

[9] J. R. R. Tolkien. *On fairy-stories*. Oxford University Press, 1947.