LifeTact - Utilizing Smartwatches as Tactile Heartbeat Displays in Video Games

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ABSTRACT

Wearables like smartwatches or fitness trackers are increasingly entering everyday life. This offers new and unexplored opportunities to use their unique features – like the ability to act as vibrotactile actuators – as interfaces in computer games to increase game immersion. Current tactile cues in games are mostly restricted to event based-feedback and practically exclusive to console gaming. This paper presents *LifeTact*, a system which informs players about remaining hit points through a tactile heartbeat. The Tactile heartbeat is emitted via existing wearables like smartwatches or fitness trackers. The system was implemented and evaluated in a between-subject study with gamers, who rated the system as innovative, beneficial to the user experience and immersive.

Author Keywords

Haptic Interaction; Tactile Display; Immersive Technology; Wrist-Worn; Vibrotactile Patterns

ACM Classification Keywords

H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces - Haptic I/O

INTRODUCTION

In the past, tactile feedback in video games has almost exclusively been used in the form of vibration-enabled game controllers, especially in console gaming. The function of the feedback is as diverse as games themselves, ranging from informing the player about certain events (e.g. low life) over providing feedback on user input (e.g. button presses) to providing sensory narration (e.g. accompanying an explosion) [9]. In 'classic' PC gaming, i.e. with mouse and keyboard, tactile feedback is practically absent and only available with hardware like gamepads, joysticks or racing wheels. In the last years wearables like smartwatches and fitness trackers started to enter the main stream. This offers the possibility to use their sensors and actuators to form new interactions and information interfaces for the user, like for example vibrotactile displays.

Figure 1. User playing Half-Life 2 with *LifeTact* over the smartwatch on the left wrist. The hit point display is concealed.

In this paper, we explore the possibility and feasibility to integrate existing wide-spread smartwatch-based vibrotactile feedback into video games. For this we propose *LifeTact*, a continuous tactile feedback system to display the current hit points (HP) in form of a tactile heartbeat in the First Person Shooter (FPS) *Half-Life 2* (Valve Corporation, 2004) [21].

We evaluated the effect of *LifeTact* on the user experience in a user study with 29 participants in a between-subject design. Our results indicate that users are sufficiently accurate in determining their current hit points. Additionally, users self-reported having a richer and more immersive user experience by using *LifeTact*.

BACKGROUND & RELATED WORK

In the last years there has been research on how to use dermal senses to expand our perception of reality [15], motor learning [8] or informing the user [3]. Brewster and Brown proposed the concept of tactile icons - tactons - to transfer information through the haptic channel [3]. Recent research focused on communicating distinct states with tactons, for example, *ActiVibe* [4] with 10 different tactons for progress

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completion or *RüttelFlug* [15] with 13 distinct tactons for different vertical velocities for paragliders.

In gaming contexts, researchers created accessories (see [9] or [11]) to enhance the gaming experience. Tactile feedback is either integrated in the controllers [12] or complex wearables like the ARAIG (As Real As It Gets) [20] or the Woojer [2]. Using smartwatches as tactile displays in video games seems to be unexplored yet. To the best of our knowledge smartwatch-based tactile feedback systems for gamers currently do not exist. Sra et al. have used arm-worn tactile diplays as additional interface in social mobile games [19]. They proposed exploring smartwatches as a platform to continue their research but did not investigate this yet.

INTERACTION DESIGN

LifeTact was developed as a tool to enhance the perception of player character health in games and its design follows the design principles for tactile displays proposed by Gemperle et al. [7] in being lightweight, silent and physically discrete. Additional important requirements were:

- *Robustness:* The system has to work efficiently and should not be error prone to not diminish the gaming experience.
- *Responsivity:* The system should be responsive and quickly adapt to changes in the game [5].
- *Intuitivity:* The tactile display should be intuitive [22], especially in gaming contexts.

Tactile Heartbeat Design

The design goal was to represent the hit points (HP) in a game via tactile vibration in a responsive and intuitive way, as "*health should deplete in an obvious manner, because with every hit, a player is closer to losing their life*" [17]. Nishimura et al. showed, that "*the affective feeling towards others can be controlled by presenting a pseudo tactile heartbeat as stimulus*" [13]. Therefore using a pseudo heartbeat feedback seems appropriate to increase the players perception of the characters health in games. The specific tactile design was inspired by the phonocardiogram representation of heartbeats consisting of first, second and third heart tone (see Figure 2) which is best known as audible representation of heartbeats, e.g. in movies.

The parameters of a sufficiently realistic tactile heartbeat using the vibration actuator of a smartwatch were found in an initial user testing with 5 users (30 minute sessions each). Participants were subjected to vibrotactile heartbeats with initial settings for vibration duration. These were adjusted according to the participant's feedback so that the resulting vibrations were subjectively recognizable as a heartbeat. The third heart tone was left out, because it is virtually absent from the known audible representation.

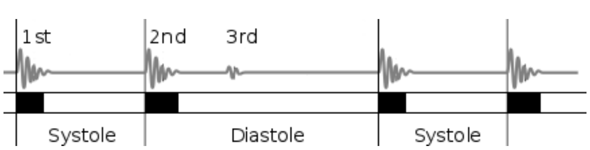

Figure 2. Phonocardiogram of a healthy heartbeat (top) (*Wiggers diagram*) with corresponding tactile heartbeat (bottom).

The final tuple describing the heartbeat for in-game representation was defined by the following formula depending on the current hit points h:

$$\begin{aligned} f(h) &= (ht_1, p_1(h), ht_2, p_2(h)) \\ &= (80, 3*h+60, 90, 6.5*h+130), h \in [1, 100] \end{aligned}$$

The parameters defining the tactile heartbeat are:

- ht_1: Duration of the first heart tone vibration
- $p_1(h)$: Systole pause
- ht_2: Duration of the second heart tone vibration
- $p_2(h)$: Diastole pause

Although the resting pulse of a healthy adult ranges from 60 to 100 [14] we chose to represent 100% of hit points (i.e. full health) with a heart rate of 45 bpm. On the other end of the continuum, 1% hit points was set to correspond to a comparatively low maximum heart rate of 166 bpm [16]. This was a suggestion in the expert workshop, which encoureged us to use artistic license to help the user differentiate high heart rates as well as give the user a very calm and collected feeling at full health.

By having a steady function for each value between 0 and 100, we can adapt the virtual heart beat's vibration pattern to represent every change of hit points, which gives the system the required responsiveness. Death (i.e. zero hit points) is represented by a pattern of five heartbeats that are slowing down and stopping completely.

Prototype System

The system consists of several software components to integrate our haptic interface into the game play (see Figure 3). First, we interface the game engine at the PC side, secondly, we access the game information from the smartphone that was then connect to the smartwatch which implements the haptic interface. The hit point values are accessed with a HP reader service via memory access once per second and then published via a small Apache http server on the PC. An Android smartphone service reads these data every 100ms and pushes them as a message to the smartwatch. The Android based smartwatch (Moto 360) calculates the heartbeat from the hit point value and displays the outcoming value via its vibration actuator. If the hit point value is the same as before the pattern continues, if the health point value is changed the heartbeat starts with the new pulse even if the old pulse is not finished yet.

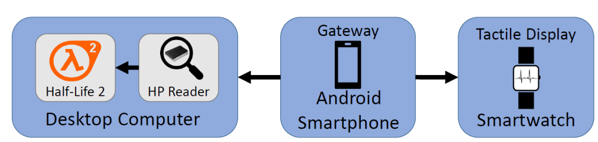

Figure 3. The system components of *LifeTact*.

Expert Workshop on Feasibility

After implementation we conducted an expert workshop (2 hours) with a game designer of a major game development company. The workshop consisted of a think-aloud session while playing Half-Life 2 with *LifeTact* followed by an unstructured interview. Overall the system was found very robust and reliable. Additionally, it was mentionend that the use of a wristband or smartwatch is in terms of wearing comfort the optimal solution for PC based gaming. The interviewee reported, that the responsivity of the system with a maximum of one second delay is sufficient for use in casual and single player games, although it might be too slow for competitive games. It was especially (and unsolicited) noted that sharply increasing or decreasing hit points with the following rapid acceleration or deceleration of the tactile heartbeat had an impressively immersive effect.

Otherwise it was mentioned that the heartbeat, which at that point used to range from 70 to 190bpm, was too fast to estimate the health when it was very low. Also the heart rate was considered to be too high which lead to us adapting the heart rate to 45bpm to 166bpm. Furthermore, upon the death of the character we implemented the already mentioned death-pattern instead of the former 0 bpm at recommendation of the interviewee. Minor criticism was mentioned regarding the commercial use of the system. The interviewee reported that for *LifeTact* to be established as a commercial system it needs improvement to make the utilization less cumbersome.

Summarizing, the interviewee stated, that for the sole purpose of helping to display hit points, the traditional Head-Up-Display (HUD) is better suited, however as a tool to improve the immersion, *LifeTact* is very helpful, among other things because of its intuitiveness.

EVALUATION

We hypothesized that using *LifeTact* instead of a traditional HUD increases the user experience in gaming because the user does not need to look at the hit points. This hypothesis is based on our own experience in developing the system and the feedback we received in the expert workshop with the game designer.

Experimental Design

The effect of tactile feedback on user experience was evaluated in a A/B/C user study with the following groups of participants (between-subject design):

- A *control group* (C-Group, N=9) played the game without *LifeTact*, only relying on the visual HUD.
- A *visual-tactile group* (VT-Group, N=10) played the game with both *LifeTact* and the visual HUD to display the health points in the game.
- A *tactile group* (T-Group, N=10) used *LifeTact* as only information display of their health points, the visual HUD was concealed (see Figure 1).

User experience was assessed with a standardized questionnaire, the User Experience Questionnaire (UEQ, [10]) on six scales. Attractiveness describes the overall impression of the system in terms of like / dislike. Perspicuity, effectiveness, and dependability measure the pragmatic quality (or usability), whereas stimulation and novelty measures the hedonic quality of the system. A custom survey with open questions and likert-scale questions was used to assess qualitative feedback about the experience while playing.

Participants

29 participants (25 male, 4 female, aged between 18 and 39 with 66% between 21 and 24) volunteered in the user study. All participants were students and young professionals with interest in games and basic knowledge in FPS gaming. The proficiency in playing FPS games was balanced between groups, i.e. each group had one or two participants with basic FPS skill, all other participants were experienced FPS players.

Task

Participants were asekd to play the first part of the Level *Route Canal* in Half-Life 2 (see Figure 1). Half-Life 2 is a single-player FPS that also contains a few puzzles and platforming sections and is widely reagarded as a milestone in PC gaming. The players' field of vision, aiming and shooting behavior are controlled by mouse movements, whereas the players' movement is controlled by keyboard controls. The duration of playtime varied between participants with an average playtime of about 10 minutes.

Procedure

Before the study started, all participants were explained the standard mechanics of the game (walking, looking around, shooting, etc.). Some participants changed the mouse sensitivity to feel more comfortable with the game. As a help, the controls and key assignments were printed on a sheet of paper and placed next to the computer. Participants of the non-control groups were fitted with the Moto360 on the right or left wrist depending on their preference and subsequently familiarized with the tactile feedback. They were demonstrated the vibrations corresponding to 100, 50 and 10 health points for about five seconds and given the respective values of the vibrations. As a very short test, the vibrations matching 75 and 30 health points were applied and participants were asked for the corresponding values.

All participants were instructed to focus on the experience of the system and not to feel pressured by taking as little damage as possible. Immediately after finishing the level, the game was minimized and the participants were asked to report the number of health points they think they had in the last instance.

Results

Intuitivity and Recognition of Hit Points

Introduced to the system, participants were quickly (within 2 minute warm-up phase) able to handle *LifeTact*, with a reasonable accuracy in identifying their hit points. Both VT- and T-Group had a mean deviation between reported and actual hit points of about 10 HP (VT-group 9.5 (SD 7.23) and T-group 7.6 (SD 7.8)) in the introduction. During the actual game, all participants felt certain about the remaining hit points. When asked how certain they felt about their hit points during the game on a scale from 1 (not at all) to 7 (very certain) participants of VT-group had a mean of 5.0 (SD 1.33) and participants of T-group had a mean of 5.6 (SD 1.7).

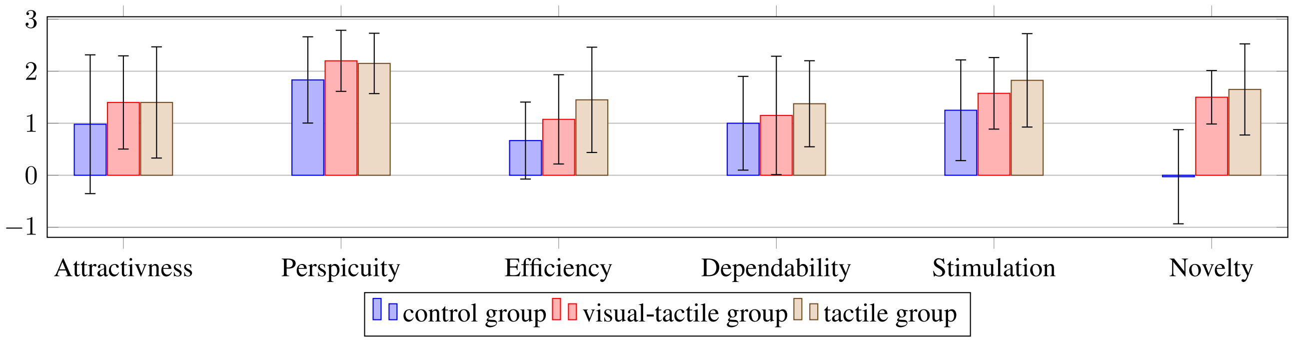

Figure 4. Mean and Standard Deviation of the UEQ separated by C-Group, VT-Group and T-Group. The scale ranges from -3 (worst) to 3 (best).

Vibration Perception

The intensity of the vibrations was perceived positively although several participants criticized the vibration intensity as too low. When asked what they felt wearing the smartwatch in the game one participant of T-Group described the vibration as *"enjoyable and not disruptive"*, while five participants described it as *"funny", "very good" and "enjoyable"* but wishing for more intense and clearer vibrations, especially in low-health, high-pulse and tense situations. When asked the same question, participants of VT-Group gave more critical feedback as compared the T-Group. One participant described the vibrations as *"clearly noticeable"*, four participants as *"slightly too weak", "too weak"* and *"[I] only felt the vibration when focussing on it"*. One participant felt *LifeTact* was *"distracting when the vibration rate is changing"*. One participant criticized the system as *"making the game too real"* and making the participant nervous.

Comfortable Wearing

The opinions about comfortable wearing during gaming varied. Three participants (two VT and T-Group each) stated annoyance by wearing the smartwatch when asked what they disliked. One participant (T-Group) attributed the discomfort to wearing the smartwatch on the 'mouse-hand' and the caused interference when using the mouse ("[It's] annoying when using the mouse") The other participants (VT-Group) attributed the discomfort to being unfamiliar with the feel of the watch and usually not wearing a watch. The remaining participants of VT- and T-Group either didn't mention the comfort at all (4T, 4VT) or described it as comfortable (2T, 1 VT), not distracting (1T, 1VT), not uncomfortable (2 T) or only slightly feeling the smartwatch (1 VT).

User Experience and Immersiveness

The results of the UEQ suggest that both groups with tactile feedback evaluated the system more positively than the control group, in particular in the dimension *Novelty* (see Figure 4). These results are supported by the qualitative feedback of the participants who stated that the system *"Works (as it should)"*. Six (3T, 3VT) participants stated that the vibrations did distract them from the game.

About half of the participants stated that *LifeTact* made the game more realistic by increasing suspense and tension and thus improving the immersion into the game. Participants using *LifeTact* described it as *"making the game more real"*, *"being more integrated into the game"* or that the *"pulse increases the excitement"*. This result points to the positive impact of the tactile feedback in giving the players an *"further kick"* and *"expanding the game with another sensory perception"*. 90% of VT- and T-Group participants reported that they would like to use a system like *LifeTact*, provided they already owned a smartwatch. Some of them restricted the intended use to single-player and non-competitive games.

CONCLUSION & FUTURE WORK

In this paper we present the design and implementation of *LifeTact*, a continous smartwatch-based tactile hit point display for games. Our work shows the possibility and feasibility of a tactile feedback system using off-the-shelf hardware in gaming to enhance the immersion and gaming experience. Study participants using *LifeTact* were able to estimate remaining hit points with reasonable accuracy and felt certain about their HP during the game. This could indicate, that while the participants may not know their exact HP, they know enough to to feel certain about their HP to play accordingly. *LifeTact* was well received by the majority of participants and the concept was recognized as being innovative and having a positive influence on the gaming experience.

We see a distinct potential for *LifeTact* or such a system in story- and experience-driven singleplayer games to enhance the players gaming experience with already existing hardware. *LifeTact* could be adapted to indicate the remaining HP in games like *Fallout 4* [18] or values equivalent to HP like *Sanity* in *Amnesia: The Dark Descent* [6]. *LifeTact* could also fit very well with projects like *Immersive HUD* [1] for Fallout 4, which allows players to disable the HUD or reduce the information shown on the HUD to allow a more immersive experience playing the game. Combined with the trend in FPS games to indicate low HP by blood splatters on the screen [23] *LifeTact* could help to create immersive UIs that use the technology the player has at hand – like smartwatches or fitness trackers. Although our system currently doesn't scale well, this issue could be improved if game developers or modders include values like HP in the existing game APIs.

In future work, the effects on immersion using *LifeTact* will be further investigated. We will also further explore the change of vibration intenstiy and other placements for *LifeTact* as well as utilizing tactile feedback to display other values aside from HP like distance or remaining time.

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