Pyramid Escape: Design of Novel Passive Haptics Interactions for an Immersive and Modular Scenario

Hugo Brument, Rebecca Fribourg, Gerard Gallagher, Thomas M. Howard, Flavien Lécuyer, Tiffany Luong, Victor Mercado, Etienne Peillard, Xavier de Tinguy, Maud Marchal

To cite this version:

Hugo Brument, Rebecca Fribourg, Gerard Gallagher, Thomas M. Howard, Flavien Lécuyer, et al.. Pyramid Escape: Design of Novel Passive Haptics Interactions for an Immersive and Modular Scenario. VR 2019 - 26th IEEE Conference on Virtual Reality and 3D User Interfaces, Mar 2019, Osaka, Japan. pp.1409-1410, 10.1109/VR.2019.8797848 . hal-02284129v2

HAL Id: hal-02284129
https://inria.hal.science/hal-02284129v2

Submitted on 8 Oct 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Pyramid Escape: Design of Novel Passive Haptics Interactions for an Immersive and Modular Scenario

Hugo Brument *[1], Rebecca Fribourg*[1], Gerard Gallagher *[1], Thomas Howard *[1], Flavien Lécuyer *[1], Tiffany Luong *[1,3], Victor Mercado *[1], Etienne Peillard *[1,2], Xavier de Tinguy *[1], and Maud Marchal *[1]

[1]Univ. Rennes, Inria, INSA, CNRS, IRISA, Rennes, France
[2]École Centrale de Nantes, UMR AAU-CRENAU, France
[3]IRT b<>com, France

Abstract

In this paper, we present the design of ten different 3D user interactions using passive haptics and embedded in an escape game scenario in which users have to escape from a pyramid in a limited time. Our solution is innovative by its modularity, allowing interactions with virtual objects using tangible props manipulated either directly using the hands and feet or indirectly through a single prop held in the hand, in order to perform several interactions with the virtual environment (VE). We also propose a navigation technique based on the "impossible spaces" design, allowing users to naturally walk through several overlapping rooms of the VE. All together, our different interaction techniques allow the users to solve several enigmas built into a challenging scenario inside a pyramid.

1 General Description

Passive haptic scenarios significantly enhance VEs [1]. However, allowing the succession of many passive haptics interactions in one scenario remains challenging due to the distinctive nature of each interaction. In this paper, we present the design of ten different 3D user interactions using passive haptics. These interactions, further described in Section 3, are the following: pushing, sliding, rotating, pressing with the foot and with the hand, throwing, plugging, rotating, joining, squeezing, identifying the attributes of an object and human feedback. They all include passive haptic feedback, be it through direct manipulation performed by the hands or the feet, or indirectly through the reuse of a single handheld prop allowing for the execution of several interactions in the VE. The main characteristic of our design is the re-usability of the same prop for several interactions as well as the use of our handheld prop to mediate the interaction with other tangible props, each constraining the user's movement and providing adequate physical feedback to the hand. In addition to the manipulation techniques, we used the "impossible spaces" design [2] to maximize the size of the VE, allowing users to navigate the VE by naturally walking through several overlapping rooms. Our different interaction techniques are embedded into an exciting escape game scenario in which users have to solve enigmas to go from one room of a pyramid to another until they finally find the exit.

2 Apparatus

Users are immersed in the VE using a head mounted display. Their feet and hands are tracked using two HTC Vive trackers and a Leap Motion. The location of each static tangible object is set and known at all times thanks to an initial calibration phase. They are fixed on the ground or a table and their position and orientation are registered using a Vive tracker fixed to a calibration prop which can be plugged onto the other props. The navigation space is 2 by 3 meters.

*e-mail: firstname.lastname@inria.fr

3 3D User Interactions

As a scenario, we propose an escape room game inside a pyramid. The user has to solve several enigmas in four different rooms inside the pyramid. We designed ten different user interactions involving passive haptics and described in this section in a chronological order.

3.1 Pushing

Users start the adventure lying down on the ground without seeing anything in the VE. They are told that they are in a sarcophagus and thus, their first interaction is to push open the sarcophagus lid in order to get out. In the real environment, they actually push a lid made of cardboard attached to a light structure surrounding them (see Figure 1, left pictures). Users are then attracted by a light emitted by a scepter that they are supposed to grab and that they will further use to interact with the VE. In the real word, the scepter is a 3D-printed object which will be the main prop used to perform physical interactions with other tangible props (see Figure 1, right pictures).

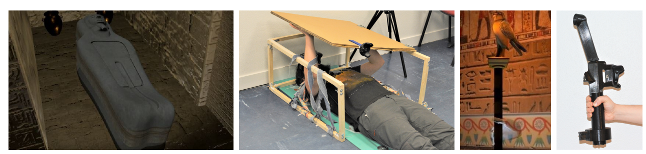

Figure 1: (Left) pushing the sarcophagus lid (virtual and real), (Right) the main prop (virtual scepter and real prop).

3.2 Sliding

With the scepter in hand, users need to find a stone where they can plug the scepter into a hole, allowing them to slide it, triggering the opening of a door to another room. The prop is made of a fixed runner and a moving part constrained along a single axis. The user is able to slide the moving part with the bottom of the scepter and feels a resisting force generated by rubber bands (see Figure 2).

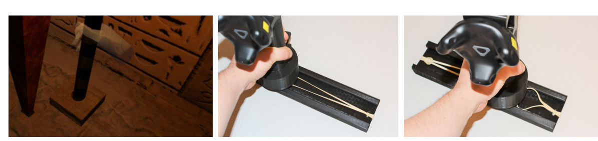

Figure 2: Sliding an object through rails: (Left) virtual environment with the sliding task, (Right) user motion with the real prop.

3.3 Pressing with the Foot

In the second room, users need to find a code on the wall that they then must enter by pressing four stone buttons located on the ground using their foot. Physical buttons are made of several layers of foam (see Figure 3). The code opens a door and presents the user with an additional element that they can join to their scepter. This element is required for further interactions in the next room.

Figure 3: Pressing the buttons with the feet: (Left) virtual representation of the feet and the buttons, (Right) real interaction with the foot.

3.4 Throwing

In the third room, users encounter three containers, including one containing fire. They must collect a fire projectile from this container using the top of their scepter and throw it into the other containers in order to kindle them. The prop for the throwing task is made of a ping pong ball held in a container and attached to a counterweight by a wire that returns the ball to the container after it is released. Users are able to pick up the ball with the spoon-like part at the top of the handheld prop, thanks to magnets that attract metal elements inside the ball. The ball is detached whenever the wire is fully stretched or the prop velocity is high enough (see Figure 4).

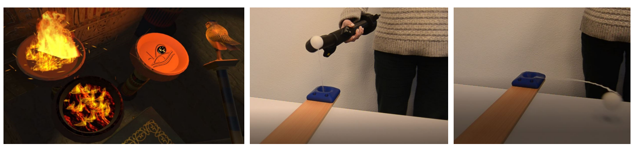

Figure 4: Throwing fire projectiles: (Left) virtual environment with the containers, (Right) details of the real prop for throwing the fire projectile.

3.5 Plugging

Once the throwing task is completed, users see some hieroglyphs on a table that they can grab with the scepter thanks to the additional joined element obtained in the previous room. The physical prop associated with the hieroglyph is joined to the scepter and then fixed to the support using magnets and variable gaps. The users are thus able to plug each hieroglyph into its corresponding location, unlocking a rotation mechanism by physically removing magnetic pins (see Figure 5).

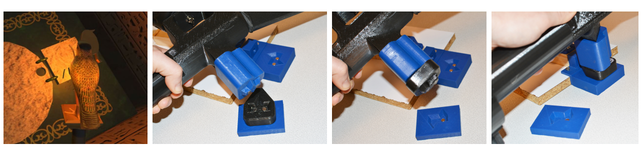

Figure 5: Plugging a hieroglyph into its receptacle: (Left) virtual representation, (Right) details of the hieroglyph manipulation.

3.6 Rotating

Users then have to plug their scepter into a hole on a circular plate and rotate it, moving a ray of light that in turn illuminates a gem once the correct number of rotations has been performed. The user can plug the lower part of the handheld prop onto a 3D-printed part fixed to a wooden bar that constrains the rotation around a screw (see Figure 6). The rotation unlocks the door of the fourth room. Before leaving the third room, users are invited to put down the scepter, freeing their hands.

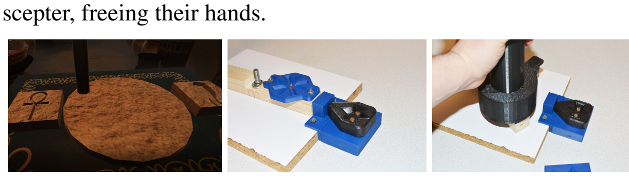

Figure 6: Rotating circulate plate: (Left) virtual representation of the circular plate, (Right) details of the rotation mechanism.

3.7 Squeezing

In the fourth room, users face a table on which there are three receptacles, each has a button in front of it. Users have to press the buttons in a certain order indicated on a surface covered by milling beetles. To see the order, users must squash the beetles with their hand, making them disappear. In the real world, their hand squeezes bubble wrap, giving them a sensation of pressure (see Figure 7, left pictures).

Figure 7: (Left) squeezing insects task, (Right) identification of three different materials.

3.8 Material Recognizing

The code indicated on the surface informs about an order between materials contained in the three receptacles. Users cannot see into the receptacles, so they have to put their hand into them to recognize each material. In the real world, users put their hand into physical receptacles that contain water, sand or water bubbles (see Figure 7, right pictures).

3.9 Pressing with the Hand

After the identification of the materials, users can press the buttons corresponding to each receptacle in the correct order. The physical buttons corresponding to the virtual ones were 3D printed and contain foam to generate a passive pressure sensation (see Figure 8). The resolution of this enigma opens the final door that frees the users.

Figure 8: Pressing buttons with the hand: (Left) virtual scene with the three buttons, (Right) details of the real buttons.

3.10 Shaking-hand Bonus

Finally out of the pyramid, the user faces a mysterious pharaoh walking towards him. When close enough to the user, the pharaoh extends his arm in the direction of the user, who can then experience a handshake with physical feedback provided by the experimenter's hand (see Figure 9).

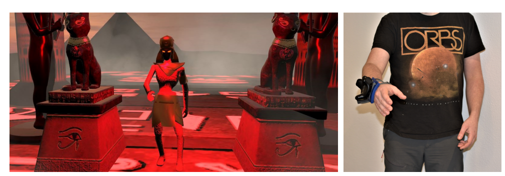

Figure 9: Shaking hands with the pharaoh: (Left) VE with the pharaoh, (Right) experimenter's hand for human-touch feedback.

Acknowledgments

Funded by the European Union's Horizon 2020 research and innovation programme grant No 801413 ("H-Reality"). The authors would also like to thank Alexandre Audinot for his help.

References

[1] B. E. Insko. *Passive Haptics Significantly Enhances Virtual Environments*. PhD thesis, 2001. Univ.of North Carolina, Chapel Hill, USA.

[2] E. A. Suma, Z. Lipps, S. Finkelstein, D. M. Krum, and M. Bolas. Impossible spaces: Maximizing natural walking in virtual environments with self-overlapping architecture. *IEEE Transactions on Visualization and Computer Graphics*, 18(4):555–564, April 2012.