A MARKERLESS AUGMENTED REALITY APPLICATION FOR TRAINING UPPER LIMB AMPUTEES

Diogo Aparecido Cavalcante de Lima†
Department of Electrical Engineering
Federal University of Uberlândia
Uberlândia Minas Gerais Brazil
diogo.cavalcante@ufu.br

Edgard Afonso Lamounier Junior†
Department of Electrical Engineering
Federal University of Uberlândia
Uberlândia Minas Gerais Brazil
lamounier@ufu.br

Bruno Guilherme Resende Vaz de Melo†
Department of Electrical Engineering
Federal University of Uberlândia
Uberlândia Minas Gerais Brazil
brunogrvm28@gmail.com

Alcimar Barbosa Soares†
Department of Biomedical Engineering
Federal University of Uberlândia
Uberlândia Minas Gerais Brazil
alcimar@ufu.br

Alexandre Carvalho Silva†
Department of Electrical Engineering
Federal University of Uberlândia
Uberlândia Minas Gerais Brazil
acs.carvalho10@gmail.com

Alexandre Cardoso†
Department of Electrical Engineering
Federal University of Uberlândia
Uberlândia Minas Gerais Brazil
alexandre@ufu.br

ABSTRACT

Amputation is a traumatic process where the person needs to start rehabilitation immediately to regain physical independence. Traditionally, rehabilitation periods last up to 12 months and have dropout rates above 35%. Initiatives to train amputees through Augmented Reality (AR) can provide more realistic and immersive experiences. This project presents a Markerless RA application for the rehabilitation of upper limb amputees. The Cylindrical Socket tracking happens in real-time through the VIVE Tracker. The application is evolving excitingly.

KEYWORDS

Augmented reality, Training; Prosthesis, Upper Limb.

1 Introduction

All amputations performed above a person's waist are called upper limb amputations [1]. Amputations can occur in total or in part [2]. Partial amputations result in a residual limb commonly called a stump [3]. This stump will be used to handle a functional prosthesis in your daily tasks [2].

Amputation can significantly restrict the performance of daily activities, as most daily actions require precise control of hand movement [4]. So, after the amputation, the user needs to start the rehabilitation process to regain physical independence and improve their quality of life [5].

However, the traditional rehabilitation process with training directly using the real prosthesis can take up to twelve months after initiation, so the process is arduous and tiring, often leading to withdrawal by the amputee [6]. Abandonment rates in the rehabilitation process of prosthesis use by amputees are above 35% [7]. In search of better results, researchers seek to use established training techniques in conjunction with new technologies. [8]

In the area of rehabilitation, we can mention Augmented Reality (AR) as a promising technology, capable of contributing to different types of training, as it can reproduce training games and simulators with 3D visualization and real-time interaction [7]. However, AR systems are not dependent on tracking techniques. Despite the current technological advances, creating applications with Markerless tracking that use the natural features of the real environment as position markers are still challenging [9].

Given the facts presented, this project aims to propose a Markerless augmented reality application for training upper limb amputees who will use prostheses.

2 Materials and Methods

2.1 Technologies used in Development

The augmented environment was developed using the Unity 3D engine version 2019.3, supported by the Microsoft Visual Studio 2019 development environment. The virtual hand modeling was developed in the 3D Studio Max 2018 software. The C# programming language was used to create the scripts of the application. SteamVR plugin and SRWorks API were also used.

The hardware needed to develop the prototype were:

- 01 – Lenovo Legion Y720 notebook with Intel Core i7-7700HQ processor, 1Tb HD, 128 GB SSD, 16 GB RAM, 6 GB Nvidia GeForce GTX 2060 Video Card.
- 01 VIVE Pro Full Kit (01 – VR Headset; 02 – SteamVR Base Station 2.0; 01 – Controller; 01 – Link Box for VIVE PRO; 01 – Cable Mini DisplayPort);
- 01 VIVE Tracker 2.0.

- 01 Cylindrical Socket (prosthesis).

2.2 Equipment Assembly

For the AR system to work, every VIVE Pro Full Kit must be connected to the computer with a minimum configuration indicated by the manufacturer. The only exception is the two SteamVR Base Station 2.0 positioned opposite each other on pedestals or fixed to a wall. The SteamVR Base Station must be at a minimum distance of 1.5 m × 2 m between them. Both must be at a 45º angle of inclination. The space between the two SteamVR Base Stations is considered the trackable space for using the application, as shown in Figure 1. The VIVE Pro Full Kit equipment together with VIVE Tracker 2.0 must be calibrated using the VIVE Pro Guide software developed for this feature by HTC.

Figure 1: VIVE Pro Full Kit equipment calibration

2.3 Augmented reality application functioning

After calibrating the equipment, we must attach a VIVE Tracker to the Cylindrical Socket, as shown in Figure 2. Thus, every time the socket is moved, the virtual hand will make the same movement.

Figure 2: Virtual prostheses attached to the cylindrical socket

3 Conclusions

With VIVE Tracker, we were able to move in Six Degrees of Freedom (6DoF). Furthermore, the use of VIVE Tracker gives the user freedom compared to other traditional tracking methods such as Marker-based ones, as the user does not need to constantly look at the marker. In this way, the user has better interaction and immersion with the application.

However, the application in AR suffers from two points of attention. The first point to mention is that the VR Headset VIVE Pro with SRWorks API by default highlights virtual objects and blurs real objects in the background, and this causes strangeness to the application user. Such strangeness is also corroborated by the low resolution of the Headset's cameras.

The second point of attention is that the application suffers from a delay, as the VR Headset VIVE Pro has a delay of 200ms. This delay makes the virtual objects always ahead of the position established by the VIVE Tracker. With the delay, the application suffers from a lack of synchronization, impairing user interaction and immersion.

4 Future Works

To continue the development of the project, some features should be investigated to improve the user experience regarding the use of the system. Among them stand out:

- Attaching new hardware (cameras) that makes it possible to decrease to a quarter of the current delay time.
- Implement opening and closing of the virtual prosthesis through myoelectric signals.
- Develop tasks for application in a system of difficulty levels.

ACKNOWLEDGMENTS

The authors would like to thank the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) for financial support.

REFERENCES

[1] Ministério da Saúde, Diretrizes de atenção a pessoa amputada. 1 st ed., Ed. Brasília: Ministério da Saúde, 2013. https://bvsms.saude.gov.br/bvs/publicacoes/diretrizes_atencao_pessoa_amputada.pdf

[2] Costa, R.M. (2017). Adaptação do usuário de próteses mioelétricas: implicações na aprendizagem de movimentos de mão. [Doctoral Thesis in Biotechnology, Health Sciences Center]. Federal University of Espírito Santo repository https://repositorio.ufes.br/handle/10/7140.

[3] Carvalho, J.A. (2003), Amputações de membros inferiores em busca da plena reabilitação (2th Ed.) Manole.

[4] Shores, J.T. (2019). Amputation. Johns Hopkins Medicine. https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/amputation

[5] Dornelas, L. D. F. (2010). Uso da prótese e retorno ao trabalho em amputados por acidentes de transporte. Acta Ortopédica Brasileira, 18, 204-206. https://doi.org/10.1590/S1413-78522010000400006

[6] Ottobock (2019). Informação para amputados - Vivendo com uma amputação. https://www.ottobock.com.br/prosthetics/informação-para-amputados/

[7] Sharma, A., Hunt, C. L., Maheshwari, A., Osborn, L., Lévay, G., Kaliki, R. R., Soares, A.B. & Thakor, N. (2018). A mixed-reality training environment for upper limb prosthesis control. In 2018 IEEE Biomedical Circuits and Systems Conference (BioCAS), (pp.1-4). IEEE Xplore. https://doi.org/10.1109/BIOCAS.2018.8584739

[8] CAVALCANTE, R. S. et al. (2019). Desenvolvimento de um jogo sério para treinamento de amputados de membros superiores. 2018. Dissertação de Mestrado. Universidade Federal de Uberlândia.

[9] Silva, H. M, Tori, R., Kirner, C. (2019). Realidade Misturada. In: TORI, Romero; KIRNER, Claudio; SISCOUTTO, Robson. Introdução a Realidade Virtual e Aumentada. Porto Alegre: Editora SBC, 2019 – p. 30-59.