Demo:Assessing Sports Related Concussion in Soccer Players Using Immersive VR Soccer

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ABSTRACT

Virtual Reality is gaining popularity due to the gaming industry. But there are many other applications of VR like training, rehabilitation, and simulation. This is our effort to combine all these application to create a technique for assessing return-to-play readiness in athletes with concussions using Virtual Reality (VR). The subjects perform various Soccer related simulations. By measuring their responses during the execution of these tasks we can asses their ability to return to the game.

Index Terms: Human-centered computing—Virtual reality; Human-centered computing—User interface programming

1 INTRODUCTION

Concussion is a type of mild traumatic brain injury(TBI). The current methods to monitor athletes with concussion include self-reported symptoms, clinician-rated balance performance, and computerized neurocognitive tests [1]. These methods are subjective and suffer from poor test-retest reliability [3]. They are often used because of a lack of better methods.

We propose that virtual reality (VR) can enhance evaluation and treatment of concussion. More importantly, similar to current evaluation methods that have enhanced sensitivity to TBI, VR can be designed with increasingly complex tasks [11] or to test multi-tasking abilities [4]. With the development of technology in full body tracking people can stimulate real world scenarios and measure movements more accurately [10]. Although visual immersion is only a part of overall experience of immersion it is an extremely important factor, and depending on the body schema the body image changes. Visual immersion can even change the space perception and perception of objects [2, 5]. Athletes are found to under-perform when they know what they are being tested for [9]. VR can capture elements of performance which athletes are unaware are being tested and prevent intentional under-performance. Further, unlike assessments that rely on expensive instrumentation or extensive training for administration, VR is relatively inexpensive, and techniques are being developed to enhance the extraction and evaluation of performance-based data [12], which will ease and enhance clinician decision-making. VR has been used to evaluate mild TBI in military personnel [8], to treat orthopedic sports injury [6], and has significant potential to evaluate and treat TBI in athletes [7].

A lot of VR applications use had-held controllers to simulate body parts. Some use hand gestures as input. Full body tracking will lead to a more immersive feeling and lead to actions more inline with the real world [10]. This **demo** demonstrates a virtual reality experience using body-tracking with Microsoft Kinect 2. **Our contribution** is a new solution that differs from existing VR applications for concussion. Currently (to our knowledge) no VR concussion solutions provide full body tracking to lead to an improved immersion experience. This is important because athletes will be the primary users of this system and having a realistic simulation allows the experience as well as the evaluation to be more effective.

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2 VIRTUAL REALITY SOCCER FOR CONCUSSION ASSESSMENT

Virtual Reality Soccer for Concussion Assessment (VSCA) is an attempt to improve existing assessment options by creating a measure that is more enjoyable, affordable, and produce results that are easier to extract and interpret. VSCA is designed to measure athletes performance on immersive, sport-specific tasks, with the goal of improving return-to-play decision making after concussion. It uses visual immersion in combination with full-body tracking to give the subject an experience comparable to the real world. Having a virtual body and the ability to interact with the surrounding objects with the whole body give the subjects feeling of virtual body ownership.

2.1 Apparatus

Minimum hardware requirements for VCSA is Microsoft Kinect 2, VR Head Mounted Display (HMD), and a windows computer with at least a NVIDIA GeForce 1060 graphics card and i7 processor. VCSA was developed on Oculus Rift S HMD (VSCA is not HMD dependent-it doesn't need specific VR controllers- but due to IR interference the Oculus is preferred). IR interference was observed between the HTC Vive and the Microsoft Kinect. Although controllers are not needed for their conventional use, the left controller is used to track the position of the body to define the center of gravity. This ensures that body doesn't move forward when looking down or crouching. The basic setup is shown in Figure 1. VSCA uses the Microsoft Kinect to track the body movements. It provides 25 tracking points which signify different joints.

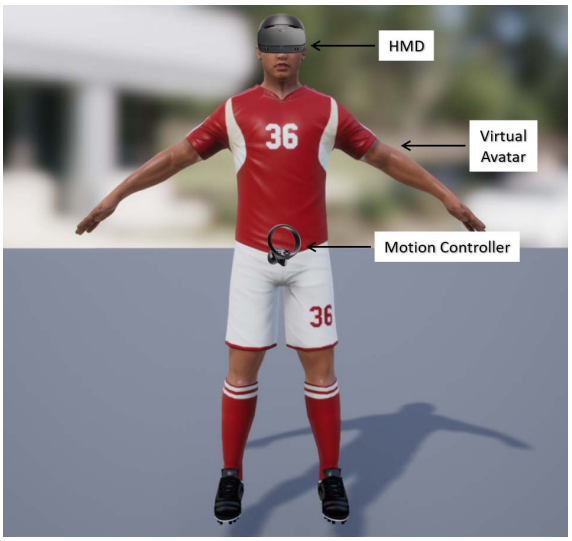

Figure 1: Virtual Avatar and HMD Setup

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2.2 Tasks

A critical component of VSCA is that it will first be tested on non-injured, competitive athletes to establish baseline performance. It is expected that as tasks complexity increases, the performance for each individual task will decline slightly, as is true in a real soccer environment. Users will perform single drill tasks, double drill tasks, and triple drill tasks.

The following list has some of the drills available in VCSA:

- **Dodge a charging player**: In this task opponents will spawn and start running at the subject. The subject has to move out of the way so as to not crash into the opponent players. There will be a player with a soccer ball and the subject has to tackle that player. This is important for Level 2 and 3 where there may be a follow-up task.
- **Shoot at goal**: In this task the subject will have a soccer ball spawn near his/her leg. The task is to shoot at the goal. See Figure 2.
- **Pass to player**: In this task players will spawn periodically, and subject's task is to pass the ball (which will spawn close to his/her leg) to the player. The position of the player is able to be changed.

Figure 2: Shoot at goal task in Virtual environment

3 Research Experiment

The experiment consists of 4 levels:

- **Practice level**: In this level subjects will perform all three tasks. For the evade task they have 2 strikes. For the goal and pass tasks they have 5 tries. This is for them to get used to the system.
- **Single task level**:The 3 tasks will be randomly presented to the subjects. In the evade tasks subjects get 5 strikes and for the goal and pass tasks they have 20 tries. The increased number of tries is because the movements is not 100% same as real world due to hardware limitations.
- **Dual task level**: The 2 combinations of the tasks are randomly selected. Depending on the task the players will be either stand close to the goal(in case the task was to evade, get the ball and then kick to the goal) or far away in the case of a pass. The important thing is that the goal task will never precede the evade task or the pass task because once a goal is scored the field resets and the subject can't have the ball in their possession again or have opponents charging at them.
- **Triple task level**: The 3 tasks will be in the order: pass to a player, the player is tackled by opponent and looses the ball so the subject has to tackle the opponent with the ball and then kick to the goal. This is to mimic a scenario found in actual soccer games.

4 Demo

The subject will put on body position tacking belt and VR headset. The height of the player will be mapped. Then a small description of the task will be displayed. Keeping in mind the time and the fact that people may want to see all tasks, subjects will be put in a 'Practice Level' and face all 3 tasks with fewer chances and in less time.

For the Demo the equipment used will be an Alienware 15 R3 with intel i7-7820HK processor, 16 GB Ram and nVidia GeForce GTX 1070, Oculus Rift S, and Microsoft Kinect 2.

Short video can be found on: https://youtu.be/3qTYalJ1mQE

5 Conclusion and Future Work

VSCA will be used to determine return-to-play readiness in athletes with concussion. Initially, we will evaluate non-injured, competitive athletes to establish baseline performance. After establishing baseline, the system will be used with high-school and university athletes with concussion. We are studying to see if it's feasible to use optical-see thru HMDs (e.g., HoloLens 2) to combine physical and virtual environments to conduct these drills.

References

[1] C. M. Baugh, E. Kroshus, J. M. Stamm, D. H. Daneshvar, M. J. Pepin, and W. P. Meehan III. Clinical practices in collegiate concussion management. *The American journal of sports medicine*, 44(6):1391–1399, 2016.

[2] D. A. Bowman and R. P. McMahan. Virtual reality: how much immersion is enough? *Computer*, 40(7):36–43, 2007.

[3] S. P. Broglio, B. P. Katz, S. Zhao, M. McCrea, T. McAllister, C. C. Investigators, et al. Test-retest reliability and interpretation of common concussion assessment tools: findings from the ncaa-dod care consortium. *Sports Medicine*, 48(5):1255–1268, 2018.

[4] O. A. Galea, M. A. Cottrell, J. M. Treleaven, and S. P. O'Leary. Sensorimotor and physiological indicators of impairment in mild traumatic brain injury: a meta-analysis. *Neurorehabilitation and neural repair*, 32(2):115–128, 2018.

[5] S. Gallagher. Body schema and intentionality. *The body and the self*, 225:244, 1995.

[6] D. R. Grooms, A. W. Kiefer, M. A. Riley, J. D. Ellis, S. Thomas, K. Kitchen, C. A. DiCesare, S. Bonnette, B. Gadd, K. D. Barber Foss, et al. Brain-behavior mechanisms for the transfer of neuromuscular training adaptions to simulated sport: Initial findings from the train the brain project. *Journal of sport rehabilitation*, 27(5), 2018.

[7] M. G. Maggio, R. De Luca, F. Molonia, B. Porcari, M. Destro, C. Casella, R. Salvati, P. Bramanti, and R. S. Calabro. Cognitive rehabilitation in patients with traumatic brain injury: A narrative review on the emerging use of virtual reality. *Journal of Clinical Neuroscience*, 2019.

[8] N. Robitaille, P. L. Jackson, L. J. Hébert, C. Mercier, L. J. Bouyer, S. Fecteau, C. L. Richards, and B. J. McFadyen. A virtual reality avatar interaction (vrai) platform to assess residual executive dysfunction in active military personnel with previous mild traumatic brain injury: proof of concept. *Disability and Rehabilitation: Assistive Technology*, 12(7):758–764, 2017.

[9] P. Schatz, R. S. Moser, G. S. Solomon, S. D. Ott, and R. Karpf. Prevalence of invalid computerized baseline neurocognitive test results in high school and collegiate athletes. *Journal of Athletic Training*, 47(3):289–296, 2012.

[10] M. Sra and C. Schmandt. Metaspace ii: Object and full-body tracking for interaction and navigation in social vr. *arXiv preprint arXiv:1512.02922*, 2015.

[11] J. A. Stephens, P. L. Davies, W. J. Gavin, S. H. Mostofsky, B. S. Slomine, and S. J. Suskauer. Evaluating motor control improves discrimination of adolescents with and without sports related concussion. *Journal of motor behavior*, pp. 1–9, 2019.

[12] Z. Yang, M. H. Rafiei, A. Hall, C. Thomas, H. A. Midtlien, A. Hasselbach, H. Adeli, and L. V. Gauthier. A novel methodology for extracting and evaluating therapeutic movements in game-based motion capture rehabilitation systems. *Journal of medical systems*, 42(12):255, 2018.