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Towards Ceramics Inspired Physiotherapy for Recovering Stroke Patients

Sándor P. Hajzer[1] & Andra Jones[1] & David E. Jones[1] & Helen C. Miles[1] & Victoria Ellis[2] & Federico V. Povina[3] & Magalí Sganga[3] & Martin T. Swain[3] & Sophie Bennett-Gillison[4]

[1]Department of Computer Science, Aberystwyth University, Penglais, Aberystwyth, Ceredigion, SY23 3DB, UK
[2]University of Wales Trinity Saint David, College St, Lampeter SA48 7ED, UK
[3]Department of Life Sciences, Aberystwyth University, Penglais, Aberystwyth, Ceredigion, SY23 3DA, UK
[4]Aberystwyth Business School, Aberystwyth University, Penglais, Aberystwyth, Ceredigion, SY23 3DY, UK

Abstract

People prescribed physiotherapy exercises can struggle to engage with exercises due to a lack of mental stimulation in the repetitive tasks. The introduction of VR to motion-based physiotherapy can be beneficial, however, currently available physiotherapy applications are focused on gaming and the gamification of physiotherapy, something that will not appeal to all patients. This project presents work in-progress towards a VR ceramics painting inspired physiotherapy application, where patients are guided to perform a series of simple motion exercises under the supervision of physiotherapists. Literature shows that art-based therapy can improve patient outcome, and ceramics involves a range of 3D movements that can be aligned with physiotherapy exercises. The work presented is intended to inform future research and development efforts.

CCS Concepts

• ***Applied computing*** → ***Life and medical sciences; Arts and humanities;*** • ***Software and its engineering*** → *Interactive games;* • ***Social and professional topics*** → ***People with disabilities;***

1. Introduction and Background

According to the UK (United Kingdom) charity Stroke Association, 100,000 people have strokes each year in the UK, and there are 1.3 million stroke survivors [Ass]. Many of these survivors undertake physiotherapy to aid recovery. Physiotherapy is complex and highly individual, but usually requires the patient to repeat simple movements that rebuild strength in particular parts of the body. Many patients struggle with maintaining motivation with these movements, but they are crucial to the recovery process. We hypothesized that pottery as a creative output may be appealing to some patients (as opposed to gamification), and so could encourage some to engage more with the physiotherapy; having a task-based approach rather than exercises purely for exercise-sake, also promoting mindfulness [AAAA*23]. By using virtual reality (VR) we could present guided tasks to support the physiotherapy exercises and to allow both the patient and physiotherapist to monitor progress or change. We chose to focus on painting, providing patients with pre-formed pots that they can add colour and patterns to. This would afford two main types of hand and arm movements: slip painting (a liquified form of clay applied to unfired pots [Whe]) and traditional painting (where paint is applied to a fired pot).

Early stroke rehabilitation that is intense, repetitive and occurs in stimulating environments results in better outcomes [TH16]. Laver, et.al carried out an experiment to see how effective VR was as a motion-based therapy on upper limb function and activity, and showed a statistically significant improvement for upper limb function and Activities of Daily Living (ADL), but were unable to show an improvement in grip strength or global motor functions [LLG*17]. VR technology may lead to new opportunities for tele-rehabilitation, which allows patients to have access to a home-based therapy following discharge from the Stroke and Rehabilitation Units [AKH*20, LAWC*20]. There are some existing VR physiotherapy applications available on the market, such as eXRt Intelligent Healthcare [eIH] and inMotion VR [VR]. While demonstrating the validity of VR in physiotherapy, these applications are focused on gamification. There are also numerous VR-based art and ceramic applications available, but none are aimed at supporting physiotherapy. Our project aims to provide a cost-effective resource that could be used by the patient in their home and would provide prescribed exercises designed to improve mobility and ADL for mild stroke patients. The system places emphasis on creating realistic, complex, and engaging experiences, that patients are likely to return to. The system will allow patients repetition of movement and duration of training which are factors that may optimise motor rehabilitation outcome, although dose-response effects and difficulty level should be assessed to ensure an optimal therapy dosing [BMS*22, DLB*09].

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2. System Developed

Our prototype system is being developed using Unity, OpenXR [Uni] and Blender and is designed to run on the Meta Quest 2 headset. These choices have been made based on cost effectiveness and our prior experience of these systems. The use of OpenXR within Unity will also help the project to be more technology agnostic. Blender is being used for the 3D development pipeline, including modelling, texturing and animating assets and a virtual potters studio. The Meta Quest 2 is a headset with hand tracking support, allowing it to be used by people who may be unable to grip or hold a controller.

The application will provide a visually calm and relaxed environment, where the patient will be sat facing a pot ready for decoration. The virtual environment is decorated to reflect the atmosphere of a modern art studio, built to be spacious and uplifting (See Figure 1). To support the patient's posture while using the application, the patient will be sat in a physical chair, mirrored as sitting on a stool in the environment, within arm's reach of all interactable objects.

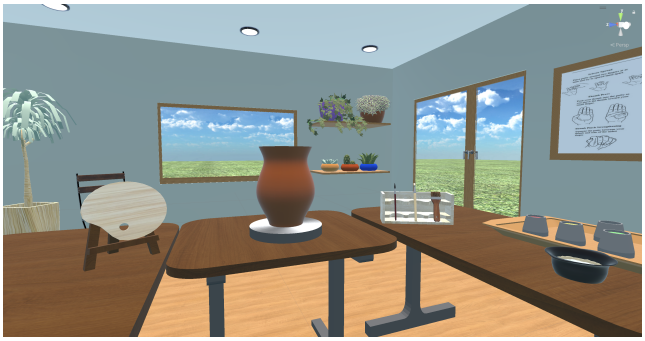

Figure 1: *Example room layout.*

The patient will be able to apply slip and paint to the pot with colours straight out of the pot or paints mixed on their palette, with a variety of brushes and their fingers. The applied paints and slip will be modelled to behave realistically, such as copious amounts of slip will cause some of it to run down. As the patient keeps painting without dipping their brush, their strokes eventually fade into a cut-off point, encourage the patient to practice their dipping motion more often. As the patient progresses with the exercises, they will be asked to follow templates to serve as guidance.

For stroke patients, one side of the body is often more affected than the other, and movement in the unaffected side of the body has been shown to improve the same part of the body on the affected side due to how the brain processes these movements [KWD11], as such the system needs to consider which side of the body is affected, and which is the patient's dominant side. The virtual environment will support exercises for both unaffected and affected side of the patient, and incorporate a 'ghost' image of the hand/lower arm that the patient can map their movements to. To further assist regaining the full range of motion, the patient sitting with correct posture is vital for these exercises. To counteract the lack of haptic feedback without controllers, some of the interactive items will have animations in response to the patient's actions, such as bristles of brushes bending against the pot.

The application is designed to provide a goal setting and progress measuring environment that will encourage the patient to return to the application and to carry on the therapy exercises. As part of this, the application will provide feedback to the patient on how well they matched the required movements. The pottery painting aspect allows creativity and free form movement to develop as the patient carries out the prescribed therapy. As the patient continues returning to the application, they will see their previously painted pots appear on the shelves and should notice an improvement in their abilities. As well as providing feedback and motivation to the patient, the application will also generate a feedback report for the physiotherapist. This will detail measures such as: session time, what side of the body was being worked on and how close the patient came to matching the movements. It is envisioned that these reports will be used by physiotherapy teams to assess recovery and design new exercises.

3. Conclusion and Future work

This paper presented work towards a VR-based ceramics inspired physiotherapy application. The application is aimed at supporting mild stroke patients in their recovery, through asking them to perform physiotherapy movements, aligned to tasks of painting and slip decorating ceramic pots. The paper introduced the core concepts and the development to date. The work presented here is intended to inform future research and development efforts, in terms of both whether the approach to physiotherapy is feasible and worthwhile, and in terms of where future research efforts are concentrated. Understanding how the technologies applied can be properly aligned with the use-case of mild stroke rehabilitation is paramount in achieving this, as well as the safety and recovery of patients. As such, input from specialists and practicing neuro-physiotherapists are sought through semi-structured interviews.

Early feedback has highlighted specific areas for considerations, such as stroke patients suffering from perceptual issues as well as muscular, meaning patients can lose the ability to identify objects and the ability to be aware of their surroundings. These issues may be addressed by a VR physiotherapy approach and providing high degree of visual stimuli. Furthermore, the brain can struggle to relearn specific movements without good posture, and measuring posture without additional sensors is a challenge for future research. In addition to feedback from physiotherapist, feedback from ceramicists will also be sought. This is to ensure that the application mimics the real-world pot decorating process. This realism is seen as key to maintaining interest and engagement, and separating the application from those focused more on gaming and the gamification of physiotherapy.

4. Acknowledgements

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