Research Proposal

Transform Interaction with Accessible Design: Emerging Rehabilitation with Functional Accessories for Users with Special Needs

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1. Introduction

New Trend of Rehabilitation in Virtual and Physical Space with Extended Reality

According to *The Growing Value of XR In Healthcare in The United Kingdom*., extended reality (XR) includes "virtual reality (VR), augmented reality (AR) and mixed reality (MR), haptics, interfaces, platforms and software," and any other immersive technologies. Although many research have been done regarding the possibilities of XR in healthcare, healthcare platform with XR for wide number of patients and potential users, especially in a non-clinical setting, is not yet well developed because of the existing ecosystems and lack of interdisciplinary collaboration. More anti-disciplinary practices are needed through the full-stack skillsets of individuals and collaborations between professionals.

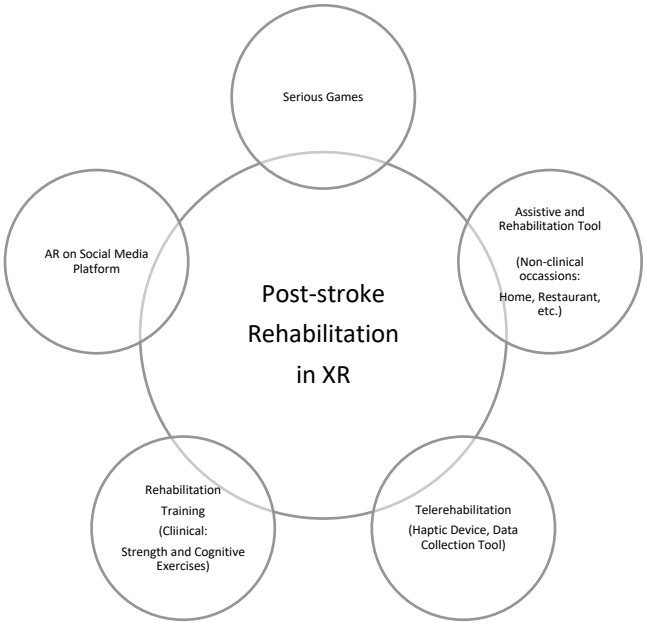


Figure 1. Connections in XR Rehabilitation

Users with Special Needs

Stroke is one of the main causes of disability around the world and the main cause of adult disability in China (Wang Y, Li Z, Gu H et al., 2020). Most of the patients suffer from hemiplegia, which hinders the work abilities and adversely affects the living quality. It also causes high financial and social burden to the society and mental health issues, so a successful rehabilitation is essential for the recovery path of post-stroke healthcare. When most of the rehabilitation tools focus on the physical rehabilitation and assistance, referring to the Stroke Association, 1 in 3 stroke survivors faced mental problems caused by post-stroke difficulties. For instance, stroke survivors suffer from depression due to the stigma of stroke and rehabilitation (Zhu et al., 2019). Due to

the impact of stroke in China, more research for accessible rehabilitation should be developed for stroke patients who live wherever in urban and rural area with personalisation in functions and even living styles.

The accessibility of stroke rehabilitation could be evolved with integration in serious games, utilisation of social media and empowerment of users. According to a report on China's internet development, 285 million users have access to the internet in rural area; the urban-rural digital gap has been narrowed by the increasing broadband coverage. Many rural internet users utilise this medium to promote agricultural products and craftsmanship (China Has 285 Million Rural Internet Users, 2020). Providing more access to online information, social media platforms can possibly empower the users with diversified functions and services via XR technologies, especially AR systems, embedded in app can deliver the interaction within the consistent and familiar interface for the rehabilitation.

2. Project Objectives and Aims

The XR stroke rehabilitation and functional accessories series does not aim to replace the clinical rehabilitation services. Rather, it aims to 1) support the clinical rehabilitation, 2) assist the learning path without the limitation of occasions, and more importantly, 3) achieve the empowerment by allowing the user to train the affected limb with the non-affected limb regardless living in the urban or rural areas with the use of well-established platforms.

3. Overview of Stroke Rehabilitation Using XR Technologies (VR / AR / MR)

According to the research related to the upper-limb rehabilitation with VR technologies, VR is promising to help engaging the patient in the intensive and repetitive recovery exercises (Bui et al., 2021). According to Adamovich S, Merians A, Boian R et al., they utilised specific device - CyberGlove and Rutgers Master LL-ND haptic device to develop a VR system for stroke rehabilitation in 2005; it shown an improvement in their impairment and learning time combining the clinical practice (Adamovich S, Merians A, Boian R et al, 2005). However, specific and advanced devices may implicit the learning cost and accessibility and affordability issues for patients. The feasibility and efficacy of the VR post-stroke training is promising, especially when it is designed to support clinical exercises, but XR rehabilitation system is not widely used in clinical or non-clinical practice while having significant advancements in technologies in these 30 years (*The Growing Value of XR in Healthcare*, 2021).

Concerning the research related to AR system and stroke rehabilitation, AR allows the user to use real-world object to interact with the virtual world, such as a "computer-generated environments (Burke et al., 2010). In research from Zeiaee et al. (2017), a rehabilitation exoskeleton is designed for VR and AR enhanced rehabilitation. It aims to create a kinematic structure that allows the stroke patients to use real data-collecting object to interact with training in AR and VR. It suggests a novel concept to integrate ergonomic design, light-weight and more degrees of motion merging both active and passive motion (Zeiaee et al., 2017). However, the compactness is still main concern for users' adherence and accessibility for production and patients.

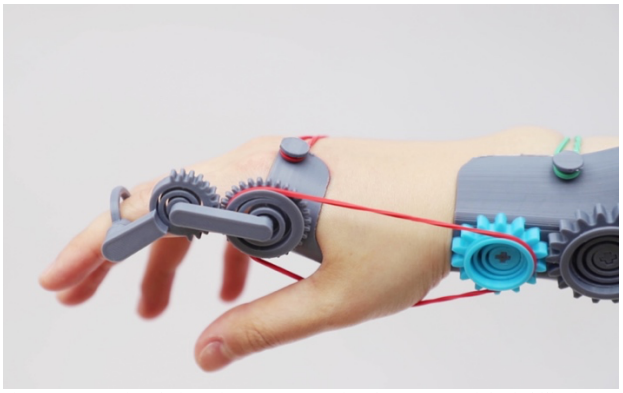
The lack of application may be caused by specific devices (i.e. Virtual Reality Headsets and non-scalable haptic device) and location (design of sensors and devices) for the XR systems used in the research. Therefore, feasibility of rehabilitation XR system will be implemented on existing platform with more accessible tools, such as mobile phones and PLA prints.

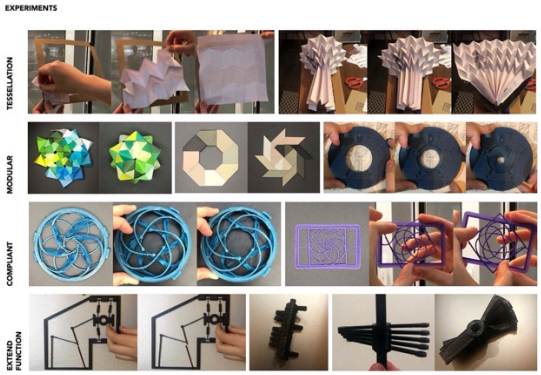
4. Research Approach

Regarding the accessibility and sustainability not only environmentally, but also economically and socially, the research will create series of XR rehabilitation in the form of interactive filters, serious games and accessible haptic device with additive manufacturing. Quantitative and Qualitative research will be used to examine the effectiveness of the tools and designs.1) Quantitative: As the series will be published online, the number of impressions rate, opens, captures, saves and shares will be recorded to examine the reaching out rate to the stroke communities and general public. I will seek collaborations with Dr Tijana Vojinovic, physiotherapists and

stroke patients for collecting exercising data to examine the rehabilitation efficiency on their improvement of motor impairment. 2) Qualitative: Consultation with engineer, physiotherapist and psychologist to gain significant feedback on the workability and design. In the first stage of design and development, I will recruit 6 stroke survivors as volunteers or contributors to share their impressions and suggestions on the basic interaction and design.

Referring to my on-ongoing collaborative research and artistic practice project REHAP: Mono-material Rehabilitation Tool with Dr Tijana Vojinovic (project details: http://janetchoi.xyz/rehap.html), the accessibility and sustainability of rehabilitation technologies are sometimes neglected in the existing design and research aspects. In the research workshop, contributors include patients and care givers, they suggested the personalisation of modular rehabilitation tool would be ideal for empowerment and it could become a stylish wearable for identities with colours, materials and functionalities for limbs.





Picture 1. On-going design of REHAP: 3D printed mono-material rehabilitation tool concept with Compliant mechanisms
Picture 2. Experiments on transformable design with origami and parametric design with 3D printing and flexures

Although VR and AR systems are used to develop different rehabilitative strategies, they are not widely used in clinical or non-clinical practice although many research suggested the advantages of VR to the enhancement of the effectiveness in rehabilitation (Kiper et al., 2018). The project aims to connect XR, includes AR, and stroke rehabilitation with more accessible design through the means of social media and online platform (i.e. Facebook / Instagram Stories Filters, Tiktok / Douyin, VR/AR/MR website, etc.) in an lower cost and requirement of device / platform regarding technical specification, so as to 1) enhance the patients' adherence, 2) improve the stigma of stroke rehabilitation, 3) look for ways to design and manufacture more accessible and personalised haptic devices, 4) develop cognitive and strength self-training with additive manufacturing (i.e. FDM 3D Printing).

5. Implication

Art and Science, Design and Engineering, and Aesthetics and Functionality are anti-disciplinary studies that require all-rounded research and skills as well as collaboration and communication among professionals (i.e. designer, design technologist, engineer, physiotherapist, neuroscientist, etc.). I will seek for collaboration and consultation from physiotherapist, bioengineer and psychologist for building the exoskeleton haptic device with compliant mechanisms.

Concerning the implementation, in the first stage, Spark AR, PXAR studio will be used for the development of the interaction on Facebook/Instagram and Douyin/Tiktok respectively. These programs will utilise visual programming and javascript, which create immersive interactive experience. I had relevant experience in using Spark AR and patches for making interactive promotions via connecting the song and user via Instagram stories filters. In order to raise the awareness, Douyin / Tiktok utilised the short-video platform for charity marketing, which aims to encourage people with disabilities to share their experiences (*Disability Pride Month: Share Your Experience on TikTok*, 2021). The XR Rehabilitation series has the eagerness to change the definition of

rehabilitation tools. Instead of a medical device, the haptic device will be used in both functionality and aesthetics, which could be used for collection of data in body tracking and personalisation of expressing the patients' identity in the form of stylish wearables.

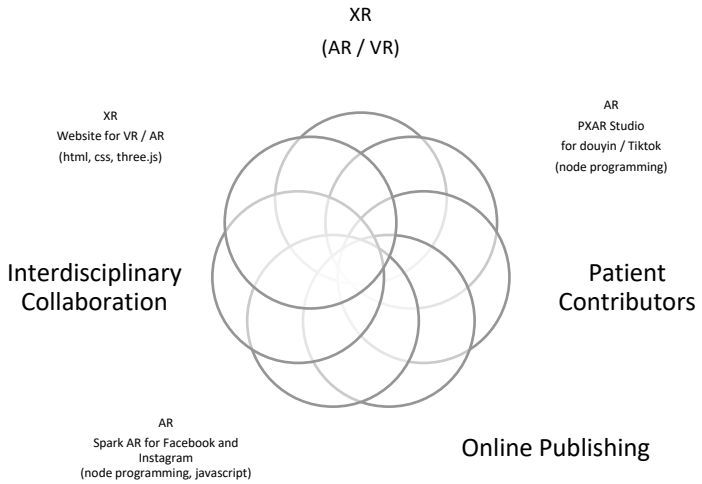


Fig 2. Implementation of XR for Rehabilitation with Existing Platforms

6. Significance of Further Research

A successful XR healthcare system could imply a significant change in the ecosystem of assistive and rehabilitative technologies and the collaboration crossing industries (i.e. apparels and textiles, game design and social media). With the development in XR and accessible rehabilitation, not only do the stroke patients can have a more immersive experience which could enhance the adherence, the other stakeholders in different industries can also be advantaged. The extent of functional accessories, which were served as fashion wearables like sunglasses, can be explored with more personalised design for users with special need to encourage discussions among different industries from rehabilitation technologies, psychology and fashion design.

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