The use of total immersion in the rehabilitation process

Zastosowanie totalnej immersji w procesie rehabilitacji

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Abstract
The popularity of immersion, understood as absolute engrossment in a virtual world, has been growing year by year, due to new hi-tech sound, image and data-processing technologies. Man, because of human nature, is attracted to immersion as a way of experiencing new environments, which are often very different from those offered by the real world. Thanks to immersion in a virtual world, one can step into any desired computer-generated reality. This technology has found its use in the process of motor rehabilitation, likewise, psychological therapy. Total immersion in a virtual world creates the possibility for guided rehabilitation, utilising the appeal of am imaginary environment. Patients become more engaged and motivated to take part in the laborious and painstakingly long process leading to the recovery of their motor functions. Cooperation between physiotherapists and psychologists with engineers has resulted in the creation of new software solutions, and improved equipment, which can be tailored to meet the needs of patients with various mental problems or physical disfunctions and disabilities.

Streszczenie
Popularność immersji czyli zanurzenia w wirtualnym świecie każdego roku wzrasta za sprawą nowoczesnych technologii dźwięku, obrazu i przetwarzania informacji. Człowiek ze względu na swoją naturę sięga po immersję aby doznawać nowych, często tak różnych od realnego życia przestrzeni. Dzięki zatopieniu w wirtualnym świecie może przenieść się w każdą wyimaginowaną komputerowo rzeczywistość. Tą technologię zaczęto implementować w procesie rehabilitacji ruchowej oraz psychologicznej. Korzyści wniknięcia do wirtualnego świata poprzez zastosowanie immersji, dają możliwość prowadzenia ukierunkowanej rehabilitacji, wykorzystując atrakcyjność wyimaginowanej przestrzeni. Pacjenci stają się bardziej zaangażowani i zmotywowani do żmudnego, długotrwałego procesu usprawniania. Współpraca fizjoterapeutów i psychologów z inżynierami owocuje nowymi oprogramowaniami, udoskonalonym sprzętem, który można dostosować pod różne dysfunkcje i niepełnosprawności chorych.

All over the world, the process of constant improvement is underway in all areas of life. New ideas, technologies and processes are being implemented into the life of society every day. Rehabilitation, currently experiencing its heyday in terms of development of new trends and techniques, has also begun to implement available technologies to maximise its therapeutic effects. The use of immersion as an element allowing the patient to fully and consciously enter the rehabilitation process, seems to be a very interesting idea. The notion of immersion is closely related to the virtual world, where both mind and body are engulfed in a computer-imagined reality which, once the user surrenders to it, takes dominance over the real world. Immersion has become very attractive, hence the widespread interest in computer games allowing players to experience its full poten-

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tial. It often provides a possibility to step into the position of a game character and make it alive through the user's presence. The user's movements become the movements of the avatar. The player feels engrossing control over her/his character and the computer-created space deceives the senses and mind, creating the impression of having been transferred to another world, much more interesting and colourful than plain reality. Complete submersion into the virtual world has been defined as total immersion.

Experts in computer games published on the bezschematu.pl portal identify the following types of immersion: Tactical immersion, requiring the involvement of attention and skill in order to properly perform an action is typical for arcade or action games. Strategic immersion requires the involvement of intellectual resources and prediction of the consequences of the player's decisions. Narrative immersion consists in making the player invested in the plot of the story s/he is being told. Spatial immersion gives the player a sense of total presence in the virtual world[1-3]. Designers of games based on immersion and virtual reality develop a featured world meant to stimulate as many of the player's senses as possible, making the game both compelling and engaging. The computer-created space must be a realistic representation of the real world in many aspects, but it must also require the player's concentration and evoke willingness to explore it - in order for the player to fully experience and consciously immerse her/himself in this world. This mechanism is best described in terms of escapism, i.e. the escape from reality and everyday routine into the realm of fiction and illusion[1].

For most players, this is nothing but a pleasant getaway, but many people may find it to be much more. Patients who are bedridden or paralysed, who suffer from social anxiety or mental illnesses, may see virtual reality as an opportunity for new experiences, often definitely more positive than what they have to face each day when struggling with their illness[1,4]. There is a whole range of technological solutions, specially adapted so that each recipient may experience immersion to a full extent. Special glasses (so-called VR goggles) enable the display of images with great picture quality and high resolution, which translates into the number of visible details. The display inside the glasses, typically of OLED class, allows for highly accurate colour replication. At present, the quality of the computer-generated imagery, in real time, is very close to photorealistic quality. Numerous sensors placed within the glasses (gyroscope, accelerometer and magnetometer) are supported by high-quality processors that process the sensor data and instantly transfer movements of the user's head into the virtual reality[5]. Through the installed manipulators, hand movements may be transferred into the world of the game with great precision. When implementing virtual reality into rehabilitation, the manipulators and glasses are equipped with additional sensors. They make the mirroring of hand or head movements so precise that it is possible to perform computer-based analyses reflecting progress in the rehabilitation process. The entire experience is made whole by surround sound effects. Such a set allows its user to fully experience total immersion[6].

A team of software developers, graphic designers and musicians makes it possible to recreate practically any environment and craft it into a perfect imitation of the natural world. The virtual world that is to a large extent interactive, operated either using the above-mentioned controllers or in a very intuitive way, may be controlled with precision, hitherto also unprecedented by patients with reduced mobility. The above technologies make it possible to transfer a patient in the course of rehabilitation, suffering from various motor disorders and deficits, into any desired virtual environment, without the barriers and limitations affecting a patient in the real world[7]. There may be no doubt that the possibility to conduct therapy in a virtual forest or on a sandy beach will foster the rehabilitation process and positively influence its outcome. For a patient, picking flowers on a sunlit, colourful meadow is a definitely more pleasant option than performing alternating flexion and extension of the upper limbs in an exercise room. Currently, physiotherapists working together with engineers of the latest technologies are creating systems to support the process of rehabilitation of lost function or improvement of a given parameter. Carefully programmed rehabilitation models are receiving a new dimension, in which the patient pursues a therapeutic goal aided by an exciting and engaging scenario[8,9].

Obviously, the fact that computer games may be harmful, due to the violence they contain or age-inappropriate content, must not be overlooked. They may cause addiction leading to isolation from the real world. Nevertheless, a properly selected game, combined with restrictions on playtime, may induce very positive effects. Such a game may, in a non-invasive way, transfer the player into an attractive reality and convey any desired content, from teaching logical thinking or motor coordination, to improving perceptiveness or implementing learning through play. Thus, it may serve not only as entertainment, but also have a therapeutic function. In numerous scientific reports, the positive impact of rehabilitation conducted in virtual reality is clearly shown. This form of rehabilitation has found its use in the therapy of patients with neurological and motor deficits, older patients and those suffering from mental disorders or internal diseases[10-13].

Total immersion could not exist without the special equipment engaging all the senses (vision, hearing and kinaesthetics)[4]. The market offers various solutions, mostly deriving from the entertainment industry, which has had a huge budget at its disposal for years. However, from year to year, we can also see the growth of the therapeutic and rehabilitation services market, offering utilisation of state-of-the-art technologies. One of the first devices on the market providing immersive virtu-

al reality was the Samsung Gear VR. Released in 2015, it was a real technological novelty, offering new sensations and an opportunity to experience the virtual world. The goggles used in this device must be connected to a Samsung smartphone with sufficiently high resolution, which means that not all models are supported. Without a compatible smartphone, the goggles are useless. Image quality is also dependent on the smartphone model. The smartphone acts as a display and provides the computing power necessary to run the launched applications. Moreover, the goggles do not have their own power supply and operate using power from the attached smartphone. Owing to this solution, the headset is fully independent and may be used anywhere. The device features a built-in gyroscope and accelerometer, therefore, certain functions responsible for tracking head movements run through the goggles. The camera allows for a 90-degree field of view. The device is additionally equipped with a touchpad for easier operation and the goggles are fitted with a small fan, forcing internal air circulation to prevent the lenses from fogging. The Oculus VR application required to operate the goggles is automatically installed once the smartphone has been connected.

Not long after the release of the Samsung headset, the market was virtually inundated with devices providing immersion in virtual reality. In 2016, three major corporations released their own devices: HTC Vive, Oculus Rift and Sony PlayStation VR. The PlayStation headset is fully functional with the PlayStation 4 game console and consists of several elements. One of these is a special module, connected to the game console, which takes over a part of the calculations, relieving the console's computing power. To operate, the goggles also require the PlayStation Camera, which is not included in the set[14]. The remaining systems utilise tracking technology: the HTC Vive uses a scanning laser and light-sensitive LEDs, while the Oculus Rift is equipped with cameras tracking infrared LEDs on its controllers. They

utilise, respectively: two Lighthouse stations emitting IR lasers and an IR camera. Both the Oculus Rift and the HTC Vive must be connected to a computer with high computing power. Oculus VR recommends using a computer with at least 8 GB of RAM, a CPU equivalent to Intel Core i5-4590 and a GeForce GTX 970 graphics card. In all the three models, the video is displayed separately for each of the lenses. The HTC Vive and the Oculus Rift have comparable parameters. Both devices use an OLED display with the resolution of 1080 x 1200 per eye, with the frequency of 90 Hz and a 110-degree field of view. The companies use both Fresnel and traditional lenses. Sony Play-Station also uses an OLED display, but the resolution is lower, at 960 x 080 RGB, the width of the field of view is similar, at 100 degrees, but the resolution is higher – 120 Hz. All the described devices are equipped with a built-in accelerometer and gyroscope, but the Oculus Rift headset also has a magnetometer and the 6 degrees of freedom (6DoF) feature. Each of the above models is fully functional with two touchpads enabling control over the applications and the avatar. The PlayStation VR utilises standard controllers, but a number of games require special PS Move controllers. HTC developed its controllers in collaboration with the Valve Corporation. They have several buttons, a trigger, a pad, grip buttons and sensors that detect the position of the accessories thanks to the laser beams from the Lighthouse stations[15]. The Oculus Rift also developed special Oculus Touch controllers. They work similarly to the HTC controllers, based on motion as well as touch, and are also equipped with buttons, a trigger and sensors. However, the Oculus is also compatible with the basic controllers for Xbox One.

The newest and most sophisticated headset model for immersive virtual reality available commercially is the HTC VIVE Pro[16]. Its frequency and field of view are comparable to the HTC Vive, but the new version has been fitted with the AMOLED display and the resolution is significantly higher, at 1440 x 1600 per eye. The

headset has built-in sensors: Steam-VR tracking, an accelerometer, a gyroscope, a proximity sensor and an interpupillary distance (IPD) sensor. The goggles work in the same way as the earlier version. A new feature is the Intel WiGig Wireless system, i.e. a wireless connection which allows for full, 360degree movement. In addition, a dedicated foam goggle insert has been designed to further block the access of external light, thereby augmenting immersion. The device is designed to function with the same system requirements as its older version, but its designers recommend using the GeForce GTX 1070/Quadro 5000 or the AMD Radeon Vega 56 graphics cards. The goggles and earphones are Hi-Res certified, which guarantees real excitement, allowing for even deeper immersion in the virtual world. The HTC Vive Lighthouse sensors and controllers are required to enjoy the full potential of the goggles, but the Pro version is compatible with the HTC Vive sensors and controllers.

Total immersion is one of the most advanced and engaging technologies used in virtual reality. With each passing year, this phenomenon is gaining importance not only in the entertainment industry, but also in therapy and rehabilitation. Its essence can be found in the possibility of increasing therapeutic efficacy through complete mental engagement of patients in the course of their rehabilitation. There is overwhelming scientific evidence confirming the benefits of supplementing traditional rehabilitation with various virtual reality activities[17-19]. The development of virtual rehabilitation is inevitable and Poland also wants a part in it, not only by purchasing ready equipment, but also by developing its own solutions. An example is the research grant of the National Centre of Research and Development (NCBiR) No. POIR.01-02.00-00-0134/16, to be implemented between 2018 and 2020, the aim of which is to develop a virtual game supporting the therapy and rehabilitation of stroke patients[5]. This project is primarily focused on achieving complete isolation of the patient from hospital reality and conduct-

ing rehabilitation in a Virtual Therapeutic Garden. There, immersed in beautiful surroundings, enhanced by the sounds of nature and soft music, the patient sets off on a journey deep into her/his mind to strengthen motivation for the rehabilitation process, overcome depression and reduce stress levels. The project's assumptions, developed by Dr. Joanna Szczepańska-Gieracha, a psychotherapist with many years of experience in work with people having disabilities, are based on the belief that a serious problem in the rehabilitation of chronically ill people is the high risk of depression, decreased motivation for rehabilitation and a sense of low self-efficacy in the process of physiotherapy[20]. Therefore, the primary objective of the device, developed using the total immersion phenomenon and the assumptions of Erickson's psychotherapy, is to activate a patient's psychological resources so that s/he can participate in the process of rehabilitation in an active and engaged manner.

Following the growth of new technologies, one can notice the development of many interesting projects and find a number of ready-made, tried and tested technological solutions.

Below, some are listed:
- https://vrtierone.com
- https://appliedvr.io
- https://www.prosoma.com
- http://www.tomorrow.pro
- https://lojke.pl
- https://www.sparx.org.nz
- https://www.crunchbase.com/hub/virtual-reality-startups

The awareness of various solutions may help people involved in procuring equipment for modern rehabilitation departments in hospitals and clinics, as well as private offices. In order to improve the effectiveness of undertaken therapies, to increase the competitiveness of rehabilitation facilities and reduce the risk of burnout among staff, it may be worth turning to new technologies and treating them as a welcome solution, not as a threat. There is no way of avoiding progress or the increasing interference of technology in our lives, thus, we should try to make the most effective use of the benefits they offer.

Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgement

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