Understanding How Users Engage in an Immersive Virtual Reality-Based Live Event

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Abstract— ***Virtual Reality combined with social functioning is a lucrative business direction. Due to COVID-19, a need for better social interaction is identified urgently both in education institutes and the business sector. In this paper, we will show two business cases where social functioning is needed. The first one illustrates how the business sector can use Virtual Reality Social Platform (VRSP) in remote events. As a case study, we have selected Spinverse's Summer Day organized in Microsoft AltspaceVR. The second business case, in turn, classifies requirements for Virtual Reality Social platforms. This has been studied in close cooperation with XR Presence. Results show that current technologies offer many features to be used, but at the same time, there are needs for further development. In addition, more studies are needed in technology acceptance, usability, user experience, and business impact.***

Keywords: Virtual Reality, Social Functioning, Virtual Reality Social Platform, Human Computer Interaction, XR, Covid-19

I. INTRODUCTION

Virtual Reality (VR) has existed in research and development since 1966 [1, 2]. Advances in digital technologies have made VR today accessible and applicable not only in research but also in applications, including education [3], medical [4], entertainment [5], and business [6]. According to Jerald J. [7], VR is defined as "*a computer-generated digital environment that can be experienced and interacted with as if that environment were real*". In VR, users experience immersion and presence in a simulated world with the help of hardware (e.g., headsets, sensors, and gloves) and software (e.g., 3D application) [8]. The major components of a VR system contain input devices (e.g., controllers), output devices (e.g., head-mounted display), and graphical interface software (e.g., Unity3D). With the success of VR commercialization, there are several VR devices available today in the market, including Oculus by Facebook, Microsoft's HoloLens, and HTC Vive.

In recent years, people's interest in VR in terms of hardware and software have become increased. Thus, their interests in Social VR have also emerged [9]. This concept is explained by Wang [10] that social VR relies on VR-based technologies that enable users to experience multi-dimensional interactions in a simulated and immersive digital environment without a need to meet each other physically in the real world [11]. It is an emerging social method, particularly in cyberpsychology and related areas. According to the existing literature, social networking is one of the important parts of people's social activities. Hence, with the advances of technology, people have used such up-to-date tools and technologies in their social activities, as they are no longer satisfied with face-to-face communication in the real world constrained by space [11]. Also, it is important to take into consideration that the way people socially communicate and connect in the real world has recently changed due to the new challenges exposed to the world (e.g., pandemics). Hence, the role of emerging technologies (e.g., VR and conferencing tools) has become essential in people's day-to-day communication.

This paper addresses social VR from the e-discipline of Cognitive info-communications (CogInfoCom), which investigates the links between the research areas of info-communications, informatics and cognitive sciences, which, among various other fields have emerged as a combination of these sciences. CogInfoCom intends to provide a complete view of how brain processes can be merged with info-communications devices for the cognitive capabilities of the human brain [12].

II. VIRTUAL REALITY SOCIAL PLATFORMS

A virtual reality social platform (VRSP) allows its users to host or join multiplayer instances in which users of this platform can socialize and interact with their environment and each other. All participants of a session are placed in the same 3D digital environment. While they are called VR social platforms, users without VR equipment can also access all its features using the desktop, or sometimes the mobile device mode, which features adjusted controls and user interface to match their device.

All VR social platforms feature pre-existing 3D environments, but some allow users to upload their content and host social sessions instead. All platforms also enable their users to customize their Avatars, which function as their visual

representation, to a limited extent to maintain the integrity of the platform's overall art style. An exception in this practice of user customization is VRChat which allows users to upload and use their custom avatars.

According to Perry [13], the rapid emergence of Social VR applications in recent years has suggested that shared virtual environments represent one of the promising areas of development, particularly in social communication and networking. Generally speaking, social VR has created opportunities for users to meet and interact with others (e.g., friends, peers, and strangers) in a shared, collaborative, and immersive digital environment. Microsoft AltspaceVR indicates that social VR seems to be a promising medium for users to communicate with others virtually and remotely, as well as it extends existing social communication channels of the real world [14].

AltspaceVR is a VRSP by Microsoft centred around the creation of live virtual events. It is very accessible as it can be used in VR, desktop and mobile for free by creating a Microsoft account. A big emphasis is put on user-created content as AltspaceVR allows users to upload their 3D worlds in which they can host their events. In these events, users can gather, talk, collaborate, and interact which each other and the environment in engaging ways using many of AltspaceVR's built-in social features. These features can include microphones, web projectors, minigames, and other interactive features. Events can have up to 50 users at all times per instance, but multiple instances of the same event can co-exist, raising the number to well over 1000 users. Users in separate instances cannot interact, but certain users can be "mirrored" by the world's moderator over all the cases so everyone can see them.

Furthermore, and based on the work of McVeigh-Schultz et al. [15], it is described that social VR generally allows users, who are geographically separated in the real world, to meet and communicate with each other using realistic avatars, as they are in a face-to-face communicative mode. The authors also explain that in social VR communication, users can make eye contact and manipulate virtual objects that they can see in that virtual environment [15]. Compared with traditional non-digital or non-immersive VR communications, the way people connect with others has changed to a more exciting, interactive, and engaging mode with the help of immersive VR-based technologies [16]. Also, as Moustafa and Steed [17] stated, social VR can fully engage and immerse users in real-time, and their embodied interactions in such an environment are comparable to face-to-face communication in the real world. Furthermore, it provides a broader range of communication modes, including bodily gestures, voice, and facial expressions [17].

III. HUMAN-COMPUTER INTERACTION IN VIRTUAL REALITY SOCIAL APPLICATIONS

As social VR has become a trend, particularly in Human-Computer Interaction (HCI), how people engage in such immersive virtual environments has also gained significant attention from researchers in the related areas. In Hudson et al. [18], it is mentioned that in contrast to desktop-based computers and mobile devices, virtual reality-based tools and devices can evoke more positive emotional reactions and higher levels of psychological and behavioural engagement of users. In the existing research, there can be seen a noticeable number of academic studies, particularly in how players engage in non-immersive VR games (e.g., VR games that use a flat-screen), including engagement in exergaming [19], learning [20], and gameplay [21]. According to Pyae et al. [22], engagement in a digital game or a virtual environment refers to *"a quality of user experience characterized by the depth of a user's investment when interacting with a digital game or a virtual environment*". Wang [21] stated that VR and its immersive nature could make users engage significantly in new, innovative, and active ways that are unlikely in other technologies.

Furthermore, an immersive VR environment can create the deep emotional responses of users that affect many aspects of their cognition and psycho-physiological states such as engagement, mood, and performance [23]. As stated by Shin [24], in an immersive VR environment, users can experience a sense of physical presence and engagement dimensions of presence that may not differ from real-world conditions. In the existing literature, there can be seen some studies concerning user's engagement in such immersive environments as immersive VR-based exercises [25], educational training [26], and healthcare [27]. The current research has shown that as social VR-based events are becoming a trend recently, users' engagement in such immersive environments has become an interesting and important topic for researchers and practitioners, particularly in HCI and VR.

In recently, VR has become an alternative social platform for users to meet and communicate with others for different purposes such as business meetings and seminars, collaborative learning, social gaming, entertainment, fitness activities, and religious gatherings. One of the most well-known social VR applications is Microsoft AltspaceVR, primarily targeted to create events in a virtual platform [28].

With the power of immersive VR technologies, in AltspaceVR, people can create and attend virtual events such as music live shows, business meetups, learning classes, and so forth. For instance, in AltspaceVR, we can create a virtual academic conference for researchers from different geographical locations. MaxWhere has also been used for virtual conferences such as CogInfoCom. MaxWhere is a VR educational platform, initially released in 2016. It is user friendly and allows information to be shared quickly and easily. The digital content in the MaxWhere virtual spaces is laid out in 3D space through a collection of Smart Boards that help users interpret the content and navigate in a more effective way than the traditional (non-3D) approaches. [29]

AltspaceVR extends the functionality of MaxWhere by providing the option to the users to use an immersive head-mounted display or their personal computers to engage with the system and attend the conference. Furthermore, it can utilise its functionality on a personal computer where the system is already installed. Similar applications in the market alternative to AltspaceVR, including Facebook Spaces, VRChat, and Rec Room, respectively [30].

The existing literature has shown the promises of social VR using immersive technologies for people's communication and social interaction in a virtual platform; however, to the best of our knowledge, the research is still limited in how users socially interact and communicate with others in an immersive virtual environment particularly for social aspects (e.g., social events). Also, the current research is still limited in how users engage in immersive VR-based social events (e.g., conferences, entertainment shows, and learning). Hence, to bridge these gaps, we intend to conduct an exploratory study in this research to understand how users engage and socially connect in an immersive VR-based social event. It is worthwhile to explore this research area in terms of people's social connectedness and engagement in immersive virtual social events because it can contribute to designing user-friendly immersive social VR applications for users and enhance the existing social VR applications. Also, in this study, we are interested in understanding user's perceptions of adopting immersive VR systems (e.g., AltspaceVR) in their social interaction and engagement.

IV. RELATED STUDIES

Although limited, the existing studies of social VR applications have helped us understand the promises of such technologies for people's social communication and engagement. For instance, in Gunkel et al.'s [9] study, the authors mentioned that VR applications had gained significant attention from users in recent years, and consequently, users' social and communication experiences in VR have also become more relevant. Their study conducted a study with 91 participants by using four use cases (e.g., education and gaming). They, in their research, identified two essential factors for VR social experiences: interacting within the experience and enjoying the experiences that can be considered when designing VR for social experiences. Page [2] explored whether social VR is a good medium to support distributed groups of users by conducting an exploratory in-the-wild study. In their study, the authors used Samsung VR headsets to understand how existing social groups from different geographical locations use VR for collaborative activities. Their study's findings suggest a strong propensity for users to feel present and engage with group members in the study while bringing group behaviours into the virtual environment. The authors also report that users' experiences in different emotional states in VR are similar to what they would experience in the real world. Also, in Hudson et al.'s [32], the authors investigated how social interaction impacts users' experiences in a VR-based underwater seascape exploration by conducting focus-group discussions that revealed three categories: immersion, interaction with the virtual environment, and social interaction. The authors conducted a survey study with 234 respondents, and their findings showed that the three variables had a significant role in users' satisfaction and loyalty intentions. Although these studies have highlighted the importance of users' social experiences in such immersive environments, it is vital to explore this area further to have more insights into designing and developing immersive social VR systems for users' social connection and communication.

V. CASE STUDY: SPINVERSE SUMMER DAY

Most of the virtual experiences built by Turku University of Applied Sciences (TUAS) have focused on virtual training and are exclusively available in VR. Recently we decided to shift some of that focus towards multiplayer social applications as they are a fast-growing market with much potential and are not distant from our VR development since they are also primarily available in VR.

The Spinverse event space was built on the TUAS AltspaceVR modular environment template. Using this template of prebuild rooms and structures, we can form any type of environment we want for indoor, outdoor, serious or casual use. As this event was linear, the space was made quite simple with only a lobby, the big main hall and the Auditorium, where the concert took place, all placed in a straight line. Fig. 1 shows a screenshot from the SPINVERSE social event in the AltspaceVR platform.

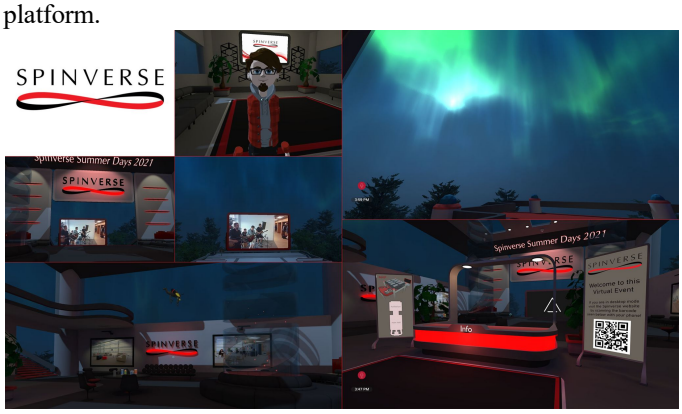

Figure. 1. SPINVERSE social event using AltspaceVR platform

As this event was aimed to be a concert, the most focus was put on the visuals and the general feel of the space. This was primarily achieved by switching from daytime to nighttime with northern lights and lighting up the interior with smooth hidden lights in the Spinverse colours. Other interactive features requested during development, such as drinks in bottles and cans the users could pick up, drink from, and throw around or a flying camel the users could teleport on briefly, allowed for more fun interactions suitable for such an event.

When it comes to virtual events, it is essential to promote not only the event but the technology as well. Not many people are familiar with virtual environments or with the platform the environment will be hosted on. A user must know what to expect to build interest. Curiosity for a new experience can work for something easily accessible, but it will not motivate them to go through the process of joining such an event. Proper instructions or live instruction video sessions simplify the process so that anyone can follow simple steps or instructions if they are willing. Their willingness is equal to their enthusiasm and anticipation for the event, which is generated by good promotion. The most considerable risk of lacking promotion can cause a deficiency of participants, which brings down the social atmosphere of the event as users have less opportunity to socialize.

Considering the effort one must put to join such a virtual event, if users are offered an inferior yet more accessible

alternative, many will lean into that. If the same event is streamed on YouTube and Teams at the same time, users may lean onto these familiar platforms and miss out on a truly unique experience. The organizers must try to familiarize the users with the new platform and excite them for the VR event. If a handful of users join the environment before the event, they can express their excitement to others and get them to also attempt to join.

A questionnaire was administered to organizers and participants of the summer day, which addressed the following questions: For organizers, provide your experience while setting up the VR based event platform for the summer day's social event. For remote and on-site participants, did you use the VR based event platform during the summer days? If yes, how was your experience? If not, please provide the reason why you did not use it.

The reflections are as retrieved from organizers, and the participants are as follows:

Reflection from Organizers When analyzing the reflections, our findings broadly indicate that the concerns perceived by organizers were related to setting up the virtual event with VR, lack of familiarity with Virtual Reality devices and environments, difficulties on acquiring VR devices, cost, planning- when to introduce VR during the event. For example, one individual from the organizer's group (O1) indicated, "While planning, I had a challenge understanding setting up the virtual event with VR. I did not know whether I have to install the application on the VR or mobile device". Similarly, another organizer (O3) mentioned, "I never used the device before the event and had no clue how it will work, and others will use". Similarly, another organizer (O2) reported: "Since the event was planned both on-site and remote, it was hard to plan when and how to introduce VR to event participants".

Reflection from remote and on-site participants We labelled the participants' received reflections in the following categories: positive, negative experience, and why they did not use the VR.

After analyzing the sets of reflections, we found that not all participants were immersed on the same level during the event. For example, one of the remote participants (RP1) mentioned, "It allowed me to experience the different world, i.e. watch concert via VR device". The same participant reported, "I like the experience of the northern lights on the virtual environment".

On the other hand, participants who participated in the summer days remotely had difficulty setting up their accounts, as they had no prior experience with VR-based events. Additionally, the participant's unfamiliarity with virtual events influenced their use of a VR-based event platform for the summer day's social event. One remote participant (RP2) pointed, "We were told to join the event at 17.30, and however, the agenda provided at the events page was not as descriptive as I would have liked. At the same time, there are multiple ways to attend the same event at the same time, e.g. Teams. Rather than setting up a new account, it was much easier to use the familiar ones and join the event". Another aspect that participant highlight is personal situations. Remote participant (RP3) pointed, "I did not even try the VR-platform in the summer days, as my day consisted in working in the housework's right away after the culture workshop because I had just arrived at the cabin one day before. Then I had to drive for at least 1,5h + 1,5h back to get to the closest decent restaurant for the Summer Day's dinner... my cabin is that far away from civilization". Day's dinner... my cabin is that far away from civilization".

VI. EXTENDED REALITY (XR) BUSINESS NEEDS

We have cooperated with XR Presence's representatives for years. During 2021 we have worked closely to identify needs for Virtual Reality Social Platforms (VRSP). Next, the main findings are analyzed:

This research started by testing various VRSPs to find pros and cons. A successful business in this field requires the right skill sets and/or subcontracting models. Current platforms such as Microsoft AltspaceVR have limitations, for example, in data gathering and data integration. Having defined our technology with an appropriate back-end system, including cloud services, our focus will be on security issues, GDPRs, and standards-based on the data to be collected.

Furthermore, we have to focus in the design phase on system architecture, 3D asset libraries, and 3D implementation of the premises. At the same time, from the business perspective, we have to solve the challenge of integrating with the corporate strategy the chosen technology infrastructure, and we have to understand which kind of editing, admin, and end-user tools we need to develop.

This research has to carefully consider what development tools such as Unity or Unreal Engine can meet all the business needs. With the chosen tools, we have to efficiently design and implement environments (including photorealistic 3D graphics and/or 360 pictures), interiors, artwork, colour schemes, corporate image, ad contents and functions, and advertisements. Digital media should be able to be visualized in video format, animations, slide shows etc.

VII. SOCIO ECONOMIC IMPACT

The value and need of the VRSPs specified above by XR Presence extend beyond the current market trends and opportunities. Covid-19 will remain in global history not as a deadly virus but as the inflexion point on the maximum utilization of the technology in professional, personal, social, and also cultural activities [33] Therefore, what needs to be analyzed is not the new markets that can be reached with the virtual social spaces as blue oceans but their sustainable, social and economic impact that leads into Green and Pink Oceans [34, 35].

VRSP can be considered a sustainable technology as it reduces travel carbon emissions, utilizes best the available human time, reduces the waste operations resources and increases productivity [36]. Therefore, VRSP can lead to green oceans where sustainability and profitability can be directly aligned with social and economic benefits and impact on the people and the economy.

On a similar note, VRSP can also be considered as a social technology as it provides the base for effective adaptation of the social-oriented United Nations 2030 sustainable agenda composed of 17 development Goals adopted by all UN Member States in 2015 and set out a 15-year plan to be achieved achieve [37], [38] (Fig. 2).

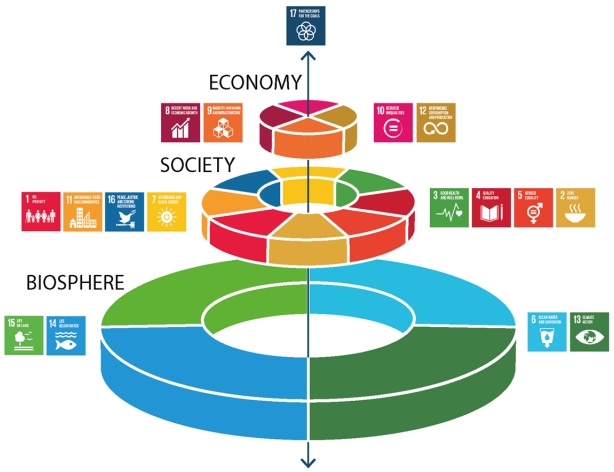

Figure 2. Categorization of the UN SDGs [39]

The 2030 UN agenda focuses on the premise that sustainability and sustainable growth have a social, economic, and environmental aspect. Specifically, the ecological and social impact of the VR Social Platforms can be related with the following UN SDGs: SDG-4' Quality of Education' via affordable and accessible training around the clock; SDG-5' Gender Equality by helping women participate in activities when this would not have been possible in a physical space; SDG-8' Decent work and economic growth by providing virtual working spaces to those who can't access the physical ones; SDG-9' Industry innovation and infrastructure' similar to SDG-8 by providing innovative infrastructures accessible to all; SDG-10 'Reduce inequalities' by reducing financials, social, racial, lifestyle and other types of discrimination through the use of avatar technology; SDG-4' Quality of Education, by providing interactive spaces for virtual conferences, seminars or even academic lecture halls.

The combination of the sustainable and the social dimension of the VR Social Platforms indicate the social impact of the technology on society and the economic opportunities that derive for all involved. Users are benefited from the utilization of their time, while the technology providers are benefited from the offering of the technology. This win-win situation between the society and the economy indicates the potential of the VR Social Platforms to serve as an alternative reliable, and effective environment for professionals and social meetings [40]. Furthermore, its environmental and social dimensions can generate a snowball effect with more technologies to enter the market soon due to the global geo-entrepreneurship movement [41].

VIII. AREAS OF FURTHER RESEARCH

This research can be extended by integrating technologies developed and being developed and experimented in other VR and XR projects of the TUAS Future Interactive Technologies Research Group. Furthermore, an analytical comparison can be conducted between the Altspace VR platform and the VRSP by Microsoft on the possibilities of desktop VR and classic immersive VR applications.

Some of the technologies that can be integrated into the VR Social Platforms and extend their effectiveness beyond the marketing, promotion and communication events are Hand and Finger Tracking, Eye and face tracking, Big Data Analytics, Neural Networks, Natural Language Processing, and other AI applications.

Specifically, the integration of Eye tracking can indicate several behavioural characteristics and feeling that derives from the time and attention and the interest given to a specific object or person [42]. Similarly, face tracking enables new modes of interactivity. Facial geometry location is the basis for classifying expressions and understanding human behaviour and feelings deeper than what eye-tracking currently offers.

Hand tracking is the first step for gesture recognition. Hand and finger tracking contribute to analyzing body language, which is related to the freedom of movements and the overall behaviour a person has in a virtual space [43]. Haptic illusion and gesture recognition can also be integrated to maximize the VR experience. Haptic illusion has also been widely used to meet the compact-sized requirement of wearable haptic devices and contribute towards a more realistic approach on the VR distinct characteristics of interaction, immersion, and imagination [44].

The integration of the above technologies with further body tracking technologies, including skeleton tracking, can optimize the avatar's movement and immersion level.

Research is being concerted on the above areas, and the results will be gradually reported.

CONCLUSION

Virtual socials spaces attempt to satisfy the need people have for social interaction during casual or professional meetings. They don't intend to replace meetings, exhibitions, or concerts in the real world but to offer a unique experience that can be more accessible and safer. With the appearance of Covid19, many events were cancelled, and people had to stay inside. This created the need for digitalized alternatives promoting a new market of services and products that can outlast Covid19 and co-exist with their real-life counterparts.

The case study presented in this paper indicates that virtual events can work well under the right conditions, but there are efforts to be made by both parties involved.

The technology providers of the virtual environment must have a good understanding of the platform they are called to develop to best transform the clients' requests into reality. They must also provide a development agenda and inform the client of the possible limitations of the chosen platform, and suggest interesting and engaging alternative features. It is necessary to train the client on how to enter the virtual space and use all of its existing features. If the client wants to test features that are inaccessible to them due to the lack of a specific device, then

this device should be provided. While the client is hosting the event, the provider can offer better technical assistants to the participants. A representative from the development team needs to be available to support those who need help but can't reveal confidential information.

On the other hand, the client that requested the virtual environment must first realize what their aim for this environment is. If it is intended to entertain or if it must facilitate a professional activity, the client's primary goal is to express it well to the architects and designers of the environment and request any feature they needed to be present. Afterwards, considerable emphasis must be placed on the promotion of both the environment and its features as well as the technology used to access it. If it is a VR exclusive event or if the event is hosted on a platform the user could be unfamiliar with, user manuals and technical assistance must be provided to all the participants to make it easy for them to join and enjoy the experience. These informational materials can be requested from the provider, but it is up to the client to distribute them to the users as they are responsible for the event's success.

The technology to create such ideal events exists but a good balance of work and effort from both parties must be achieved to deliver promising results. Understandably, the design, development, organization, and promotion of such events are different from traditional social events, but this is one of the hurdles any blooming market must surpass. This technology can be applied to a great variety of markets, and as more events are organized and more people are introduced to unique, interesting, and engaging virtual experiences, its applications can extend even further.

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