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This paper discusses how the metaverse should augment the humans with disabilities

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The metaverse is a new paradigm made possible by emerging technologies like virtual reality, augmented reality, and blockchains. Humans with disabilities should not be excluded from the metaverse and should have equitable access to it. However, it is unclear which options humans with physical and cognitive disabilities will have in the current metaverse to use and represent themselves – and feel included. Our research seeks to determine how humans with disabilities should be augmented in the metaverse, as well as whether the current metaverse permits such augmentations. If not, what features should be added to make the metaverse more accessible and inclusive? In this regard, we have begun to investigate one of the most well-known decentralized metaverses, namely Decentraland.

CCS CONCEPTS • Social and professional topics ~ User characteristics ~ People with disabilities • Human-centered computing ~ Interaction design ~ Empirical studies in interaction design

Additional Keywords and Phrases: Metaverse, Augmented Human, Human Augmentation, Rehabilitation

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1 INTRODUCTION

The metaverse is a new paradigm defined by Matthew Ball in 2020, going beyond virtual reality (VR) or augmented reality (AR) due to the features below. According to Ball [1], the metaverse should be:

- Persistent
- Synchronous and live
- Open to everyone without any cap on concurrent users
- With a fully functioning economy and direct ownership of assets
- An experience spanning the digital and physical worlds

- Interoperable
- Full of different experiences created by different types of contributors

Therefore, Ball underlined that metaverse should also be open to humans with disabilities, who are different contributors. However, Ball did not explicitly mention disability and did not detail how accessibility and inclusion should be achieved.

In this paper, we first discuss related work. Then we present our findings from studying the search results related to disabilities on the Decentraland metaverse [2], and finally, we discuss our vision for future work and recommendations for a more inclusive metaverse.

2 RELATED WORK

Although the metaverse goes beyond VR, most current metaverse implementations are based on VR. Users evolve with avatars in 3D virtual worlds. For example, Decentraland is currently a 3D virtual world where users can join lands with avatars through a Web browser and desktop application. Decentraland fits Matthew Ball's above definition because it uses cryptocurrencies and non-fungible tokens (NFTs) to buy and sell lands, wearables, and objects such as NFT paintings. The users directly own their assets because of the use of these cryptocurrencies and NFTs on top of blockchains, Ethereum and Polygon so far. Facebook, now called Meta, has launched its own metaverse [3], where assets such as artist creations start to be bought and sold. Facebook emphasizes the possibility of carrying out remote VR work meetings, which is an extension of its existing digital workplace platform for businesses.

However, Meta's metaverse does not run on a decentralized blockchain such as Decentraland, which was the first one running on a blockchain, i.e., Ethereum. Assets on a public blockchain such as Ethereum are directly owned and controlled by the users without intermediaries. Thanks to thousands of peers, a public blockchain is decentralized, running thanks to thousands of peers [4]. Thus, the persistence of a public blockchain is higher than one of a centralized party that can go bankrupt or be dismantled due to legal issues. Another difference between Decentraland and Facebook Meta metaverse is that Facebook Meta metaverse can only be accessed with Facebook's dedicated VR head-mounted display (HMD), further limiting its openness and interoperability. A study conducted in 2020 found that VR systems still have an accessibility problem: "people with disabilities often can not use it" [5]. Even though Decentraland has been around for a few years and has hosted important events, it is still a long way from widespread adoption. Facebook Meta metaverse has just started to try to attract more contributors thanks to a content monetization scheme. Both systems have to deal with spam [6] and copyrights infringements. The following table summarizes how well Decentraland and Facebook Meta metaverse addresses Matthew Ball's metaverse definition.

Table 1: Decentraland and Facebook Meta metaverse according to Matthew Ball's metaverse definition

metaverse	Persistent	Synchronous	Open	Asset ownership	Spanning experience	Interoperable	Different contributors
Decentraland	Strong	Yes	Strong	Strong	Weak	Strong	Medium
Facebook Meta	Medium	Yes	Weak	Weak	Medium	Weak	Weak

However, it has been found that current VR systems have accessibility problems [5]. Access to standard Web pages has greatly improved since the World Wide Web's inception, but advanced Web interfaces for accessing 3D worlds are still in their infancy. For example, accessing virtual worlds with HMD remains difficult for people with vision impairment.

A survey of VR for people with disabilities [7] introduced a taxonomy of the potential benefits of such systems when the users can use HMD:

- VR for rehabilitation
- VR for skill learning
- VR-based e-learning
- VR for real-world training
- VR for entertainment

3 STUDY OF DECENTRALAND SEARCH RESULTS RELATED TO DISABILITIES

The Decentraland Web interface already necessitates some effort to be used and it has no unique accessibility feature. At the beginning of a session, the users can choose the appearance of their avatar. Different parts of the body can be personalized, ranging from the head to the upper body, lower body, shoes, and accessories. Contributors can create and sell special accessories and clothing known as collectibles. Hence, users with disabilities may choose whether to represent their disability. For example, they may wish to portray themselves as using a wheelchair. For this reason, we investigated whether wheelchairs were available in Decentraland's current accessories market. Unfortunately, as shown in Figure 1, no wheelchair was available. That is, until 2022, it is not possible to represent an avatar in a wheelchair. Similarly, the search term "prosthetic" yields no results. At this time, a user who wanted to represent an arm or leg prosthetic could not do so. Nonetheless, it would be easy to create such a wheelchair or prosthetic collectible because Decentraland already has the features in place to do so. As a result, one of the first recommendations we could make to improve Decentraland would be to create a few collectibles related to disabilities that users with disabilities could choose from if they so desired. Of course, if users do not want to display their disability, they can choose an avatar without disability.

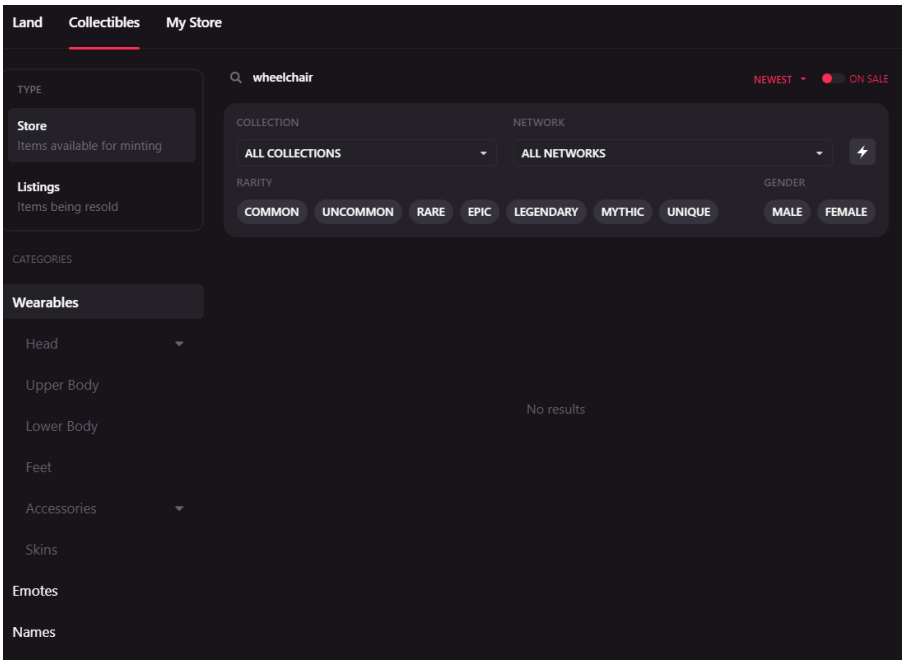

Figure 1. "wheelchair" search result on Decentraland collectibles

The OpenSea marketplace is another place where collectibles sold for Decentraland can be found. OpenSea is the leading NFT marketplace. Decentraland collectibles are linked to an NFT. An NFT is a digital token that serves as a digital certificate of ownership for a digital asset such as a collectible or an artist's digital image. Despite being the largest NFT marketplace with over 80 million NFTs, a search for "wheelchair" yielded only 825 NFTs. More specifically, in the collectibles category of Decentraland on OpenSea, which is stored on the Polygon blockchain, which has lower fees than Ethereum, a search for "wheelchair" in the 728 000 NFTs in this category yielded no results, as shown in Figure 2.

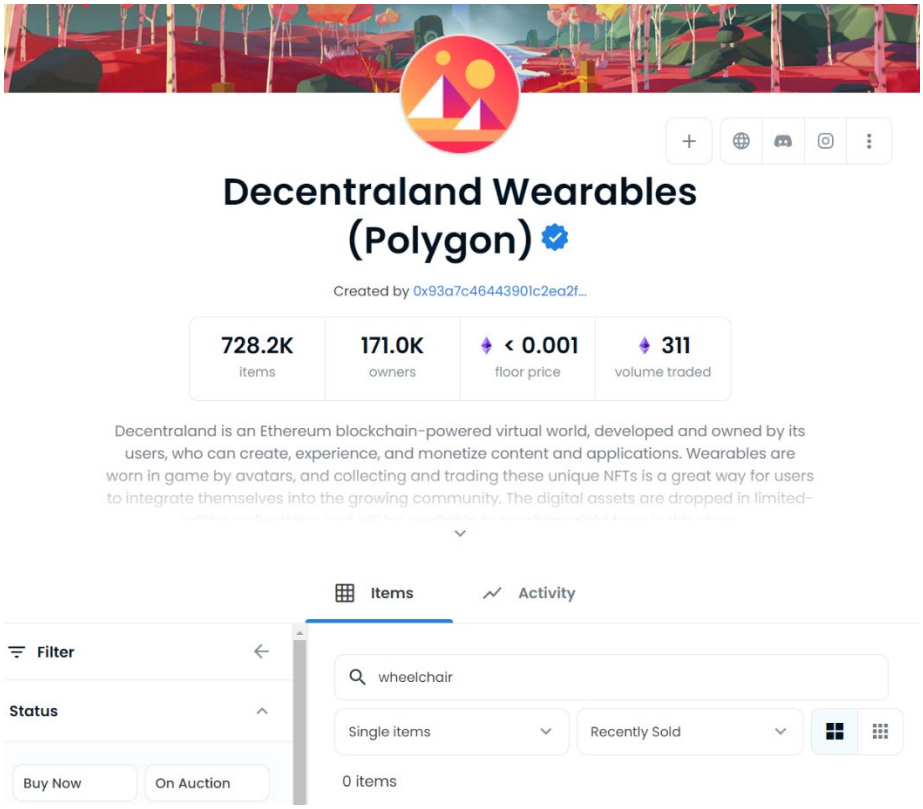

Figure 2. "wheelchair" search result on OpenSea Polygon Decentraland wearables

Among the 825 NFTs that mentioned “wheelchair” in OpenSea, many of them were part of several collections of NFTs related to wheelchairs. 4 artists explicitly mentioned in their profile that they were using a wheelchair as shown in Figure 3. Following is how they introduced themselves on their OpenSea profile also shown in Figure 3:

1. “My name's Pop. I'm Artist on wheelchair after accident age 20 years old 2012. Because accident at my neck spinal cord injury.”
2. “Hi, I'm Daria and I'm an artist on a wheelchair”
3. “the creator of this collection, i am suffering of Duchene Muscular Distrophy and all pictures are made from my feelings!”

4. “The author is not always a wheelchair user, but a disabled person with SCI. I hope that a social model of disability will be realized.”

One artist who presented images of astronauts in wheelchairs did not explicitly mention using a wheelchair but he appeared using it in one of his NFTs displayed on OpenSea. Another author was not an artist but he was documenting his love for his wife with photos of them that were turned into NFTs. Although the above findings do not answer how many users with disabilities would like to represent themselves on wheelchairs in Decentraland, it shows that a few of them who are also artists like to emphasize that they use wheelchairs.

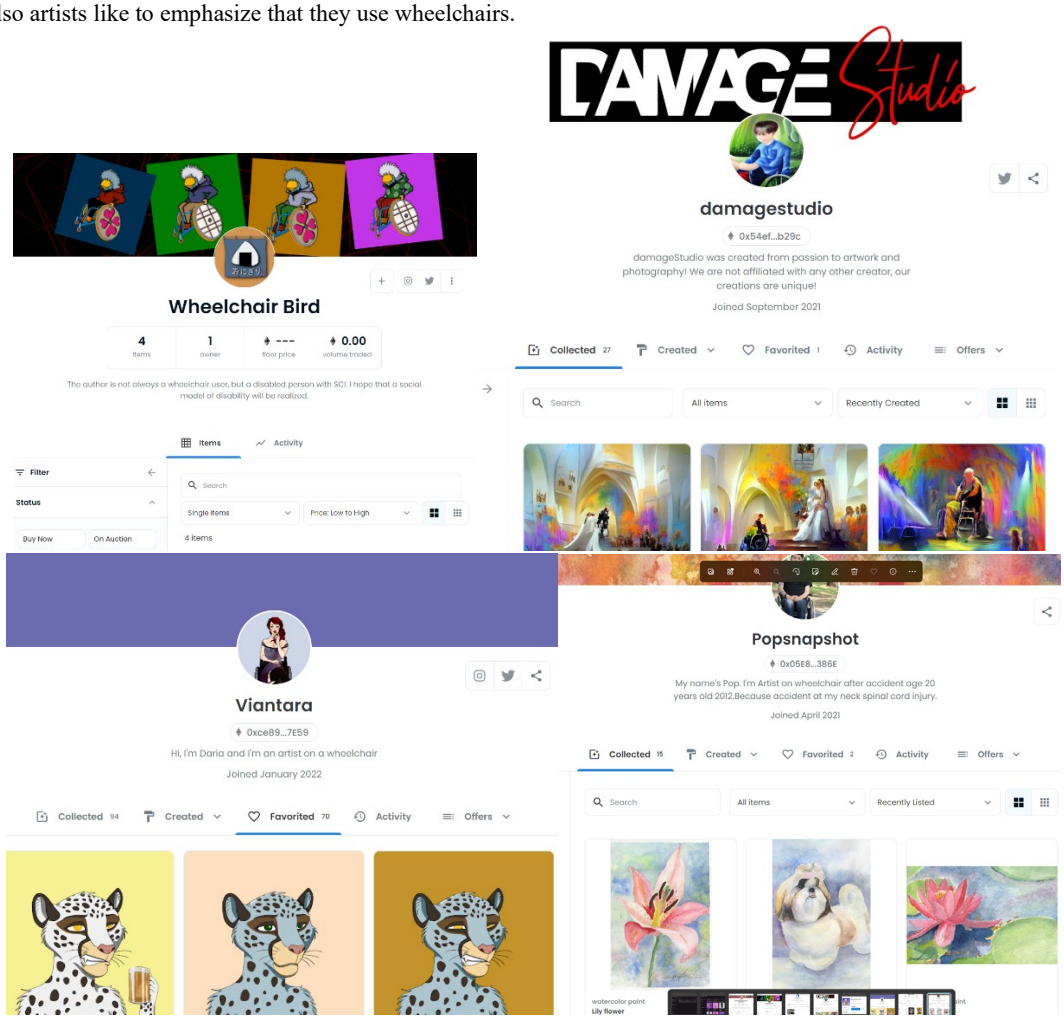

Figure 3. 4 OpenSea artist profiles mentioning they use a wheelchair

The 4th quote above introduces another role that the metaverse could have for users with disabilities, the role of socialization. Traditional VR before the metaverse is not a place where other users join. It may be a game that the user plays but it is not open to other users who could join. One of the new characteristics of the metaverse is to be always on with people who can join and leave at any time. metaverse is a new opportunity for socialization with VR or other digital

interfaces (Web, AR…). We would then extend the taxonomy of the benefits of VR for users with disabilities to the following taxonomy of the benefits of the metaverse, which includes VR, for users with disabilities:

- metaverse for rehabilitation
- metaverse for skill learning
- metaverse-based e-learning
- metaverse for real-world training
- metaverse for entertainment
- (NEW) metaverse for socialization
- (NEW) metaverse for earning revenues

The last category in the above bullets points, namely "metaverse for earning revenues" can be achieved thanks to the selling of metaverse assets such as art items created by artists with disabilities as NFT, which can be displayed in art galleries or spaces in the metaverse. New economies with augmented humans in the metaverse can exist, e.g., as envisioned in [8]. In play-to-earn games like Axie Infinity, NFTs and tokens have helped poor families to increase their revenues [9]. Other play-to-earn games are thus possible in the metaverse. We even found in the 825 NFT that mentioned "wheelchair" in OpenSea, a few sellers who weren't really artists but who created NFT to support their sport for people with disabilities. In Figure 4, we see that Nicolas Brignone, a French para-sport athlete, created NFTs on OpenSea to fund the purchase of a new wheelchair. Another seller was the rugby league, which created NFTs to support their rugby on wheelchair tournament, as shown in Figure 5.

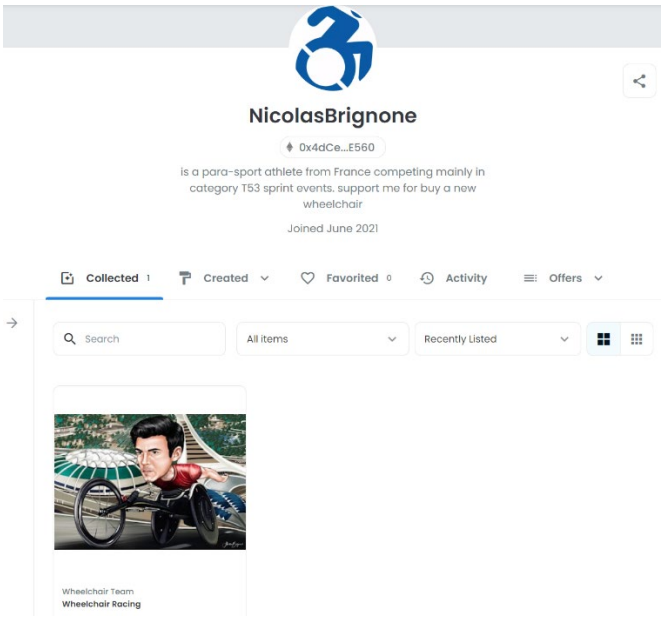

Figure 4. French athlete on wheelchair using NFTs on OpenSea to support him

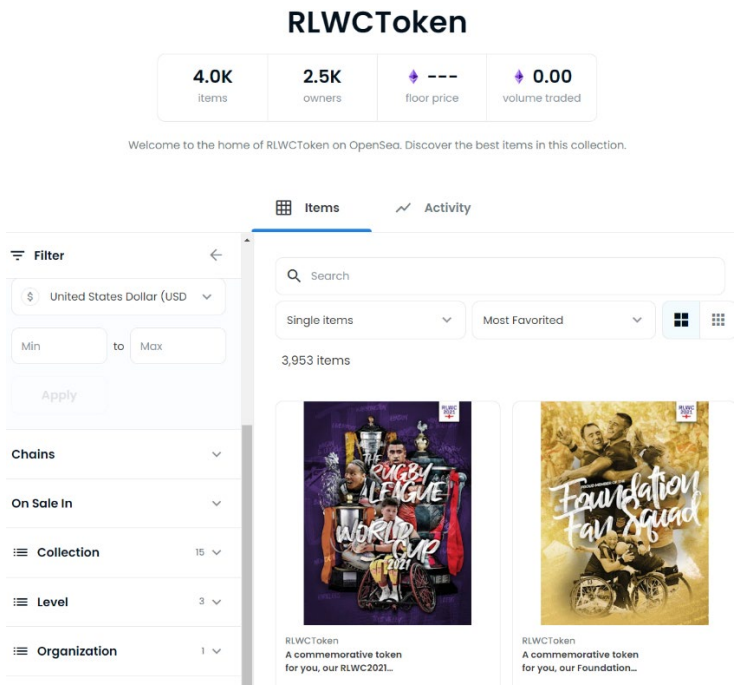

Figure 5. Rugby league selling NFTs to support rugby on wheelchair tournaments

4 CONCLUSION AND FUTURE WORK

We have underlined in this paper that humans with disabilities may also be augmented thanks to the metaverse. However, the current metaverse, especially with VR, has not yet addressed accessibility and representation for humans with disabilities. Prior to elaborating guidelines and making practical recommendations, we would like to conduct a survey to learn more about what humans with disabilities think of the metaverse and how they would like to be represented in the metaverse. Then we will be able to make preliminary design suggestions to better align the metaverse with the needs of people with disabilities. Those initial design recommendations will need to be refined following empirical trials with VR and AR in real-world settings with users with disabilities.

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