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Trends in Intellectual Property Research

Patent Spectrum of Human Digital Twins

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Abstract: Although no "absolute" definition exists, a human digital twin (HDT) may be defined as a virtual physiological copy or counterpart in digital world of a real person existing in the physical world having active connection between the human and his corresponding twin in metaverse. The current study aims to explore the intellectual property rights (IPR) challenges of HDTs. Previously discussions on HDT have mostly focused their potential use in health system for predictions of diseases nearly ignoring the patent associated with them. Current study highlights patent landscape analysis of HDT indicating current trends in HDT patents and future scenario of this technology.

Keywords: Human Digital Twin; Intellectual Property Rights; Data; Privacy.

1. Introduction

The emerging digital technologies are changing our ecosystem rapidly and affecting all spheres of life including legal domain. One such infant technology is that of a human digital twin (HDT). Currently no accepted definition of human digital twins (HDTs) exists and the same is true regarding their identity, personhood, and intellectual property (IP) and data related issues. A HDT may be defined as a virtual reflection of a human, updated from real-time data by simulation and machine learning. The HDTs are true "digital copies", i.e., "duplicates" of real persons, which can interact with reality as well as their counterpart real persons. As parents think that their children will be more brilliant than they are and do way better in life, likewise it can be hoped that HDT will make the world better that we could not. HDT is a subcategory of the digital twin and is a twinned entity the human. It is a real-time mirroring computerized system of a human agent, able to simulate or emulate his characteristics and behavior in context[1]. The functioning of an individual's body depends on systems (neuro, blood etc.), subsystems (respiratory, vestibular, endocrine, locomotor, digestive, etc.), organs (eyes, heart etc.), influenced by surrounding conditions (temperature, vasodilatation, hydration, etc.) and regulated by brain.

The concept of HDT appeared in 2016 for the health sector, as a sophisticated simulation of the human body (Blake, 2016). Hafez defined the HDT as a "human-specific smart machine dedicated to aligning human objectives with the smart machines supporting her" (Hafez, 2020). Zibuschka *et al.*, (2020) defined the HDT according to the cloud-based-cyber-physical system (C2PS) reference architecture for DT (Alam & El-Saddik, 2017).

HDT is the subject of an anonymous blog at humandigitaltwin.com[2] dated from May 2020. The author refers to having a human model including any sort of data related to a person and its experience, that could be clustered according to six dimensions: physical, cognitive, emotional, social, occupational and financial. Avenga Labs refers to HDT as digital twins of people, which are digital representations of humans as

[1] https://www.scitepress.org/HomePage.aspx (Accessed 15 October 2023).

[2] https://www.humandigitaltwin.com (Accessed 15 October 2023).

complex physical objects[3](Another company, Proglove, advertises largely the HDT, presented as the digital counterpart of the human worker and introduced also as the missing representation of humans in Industry 4.0 Digital Twins[4].This is referred also by the Picavi company in the logistics sector, as a representation of a human being resulting from the tracking of its activities[5].

Two allied concepts of HDT are Personal Digital Twin (PDT) and Virtual Human (VH). The PDT concept was introduced in 2020 (Saracco *et al.*, 2020) for personalized healthcare during the Covid-19. The PDT is defined as a "representation of various aspects of a person that might include the movement of the person, the interactions that person has in physical space with other people, and her health status". Burden and Savin-Baden, (2019) define VH as "Software programs which present as human and which may have behavior, emotion, thinking, autonomy and interaction modelled on physical human capabilities".

The digital twin was first used by NASA for virtual clones of physical structure in physical space while Naudet and colleagues (2021) introduced the concept of the HDT in 2019. The HDT may have different meanings and different starting points for various domains. Despite replica of its physical human, it can't be labelled as digital twin as there is only one brain and an extensive sharing of data. The human digital twin cannot claim the data and can't make decisions. The privacy, rights, regulations, and ethics of HDT are quite challenging. One person exists at multiple places simultaneously only in stories or maybe only if his/her body travels at the light of speed (when matter converts into energy). The twinhood concept, although seems very interesting due to long standing presence in biology, art, and culture, is not complete at least virtually. Cybersecurity risks can arise due to connection with the internet. It's the right time to start discussion on the patent landscape for HDT. IP can be one of the main challenges for HDT after 2050 due to key role of AI, data sharing and allied tech advancements. This study aimed to analyze the patent trends, identify the key market players, the main areas of HDT invention, and future perspectives in this field.

2. Patent Landscape of HDT

The HDT being high-tech require continuous innovation. The key yardstick of innovation cycle is the patent document which indicates the recent trends in HDT technology, geospatial analysis of market players and their growth potential (Burhan *et al.*, 2017). Patents are litmus test of innovation. Patent analysis helps gather trends in technology and predict technological advancement (Abbas *et al.*, 2014). Since an applicant discloses complete technological information to get protection from state, information disclosed in patents is reliable. HDT is a complex matrix of data and is infinite, and ever evolving. IP will therefore determine how HDT is created, and its behavior throughout its life. Despite a growing discourse on HDT, relevant IP portfolio has not been explored yet. This is an obvious gap in the literature especially considering that IP law and regulation are fundamental for any invention.

Patents indicate research and development (R&D) regime and innovations in a specific field (Ernst, 2003; Hufker & Alpert, 1994). They also suggest the market leaders of a technology helping understand their potential (Pejic-Bach *et al.,* 2019). Patent analysis suggests trends, the novelty, quality of patents, technological demands and gaps in states granting patents (Abbas *et al.,* 2014). This analysis can help understand the situation of competitors and potential areas of R&D activities in each region. To the best of our knowledge, no study exists corelating patents and HDTs. Current study indicates the prospects and demand of HDT.

[3] https://www.avenga.com/magazine/human-digitaltwins/ (Accessed 15 October 2023).

[4]https://itsupplychain.com/human-digital-twin-thedigital-counterpart-to-the-human-worker/ (Accessed 15 October 2023).

[5]https://picavi.com/en/human-digital-twin-productiveonboarding-for-new-employees/ (Accessed 15 October 2023).

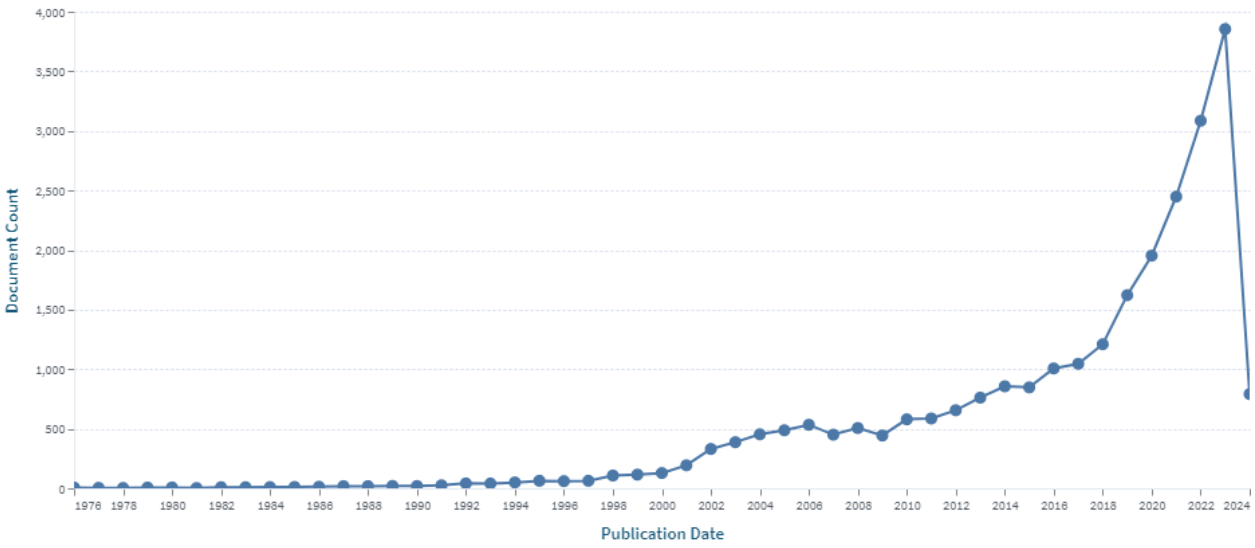

Figure 1. Dynamics of patent activity of HDT over time[6].

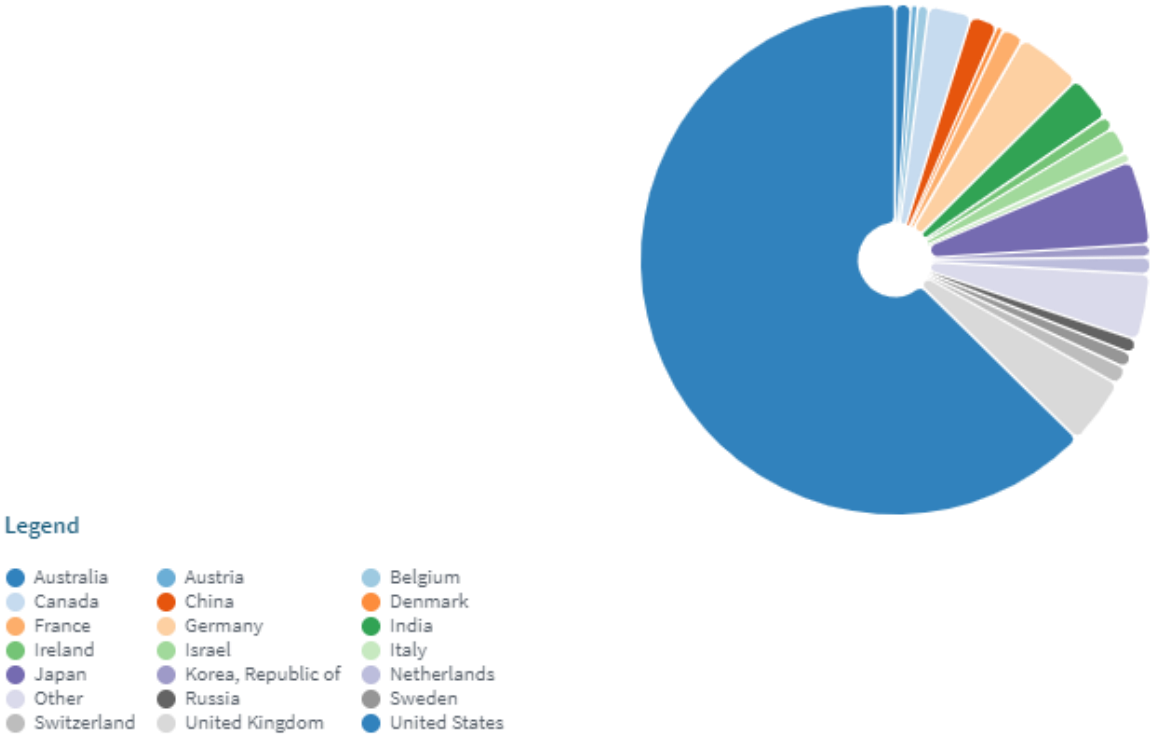

Figure 2. Top inventor countries[7].

[6] https://www.lens.org (Accessed 20 December 2023)

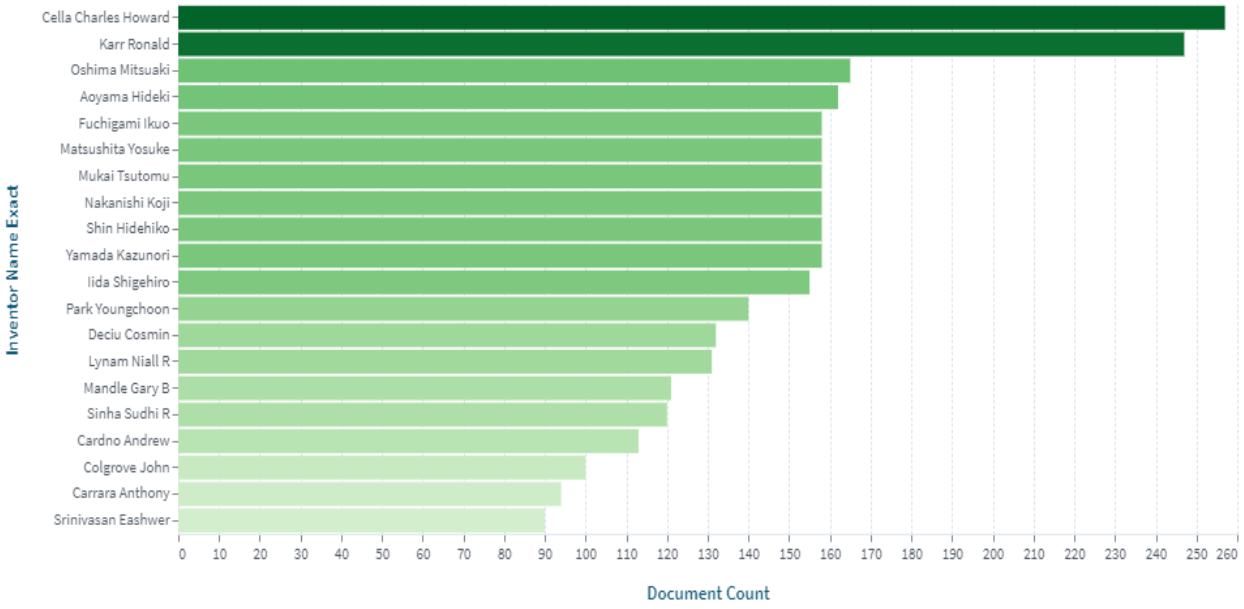

Figure 3. The inventors with the largest number of patents (https://www.lens.org).

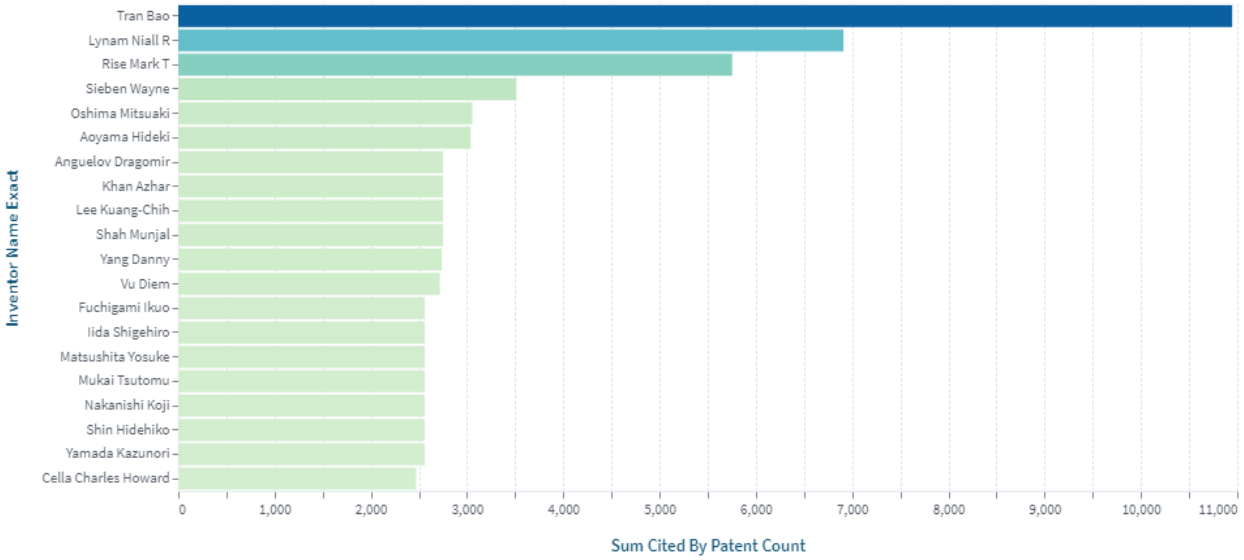

Figure 4. Most cited patents (https://www.lens.org).

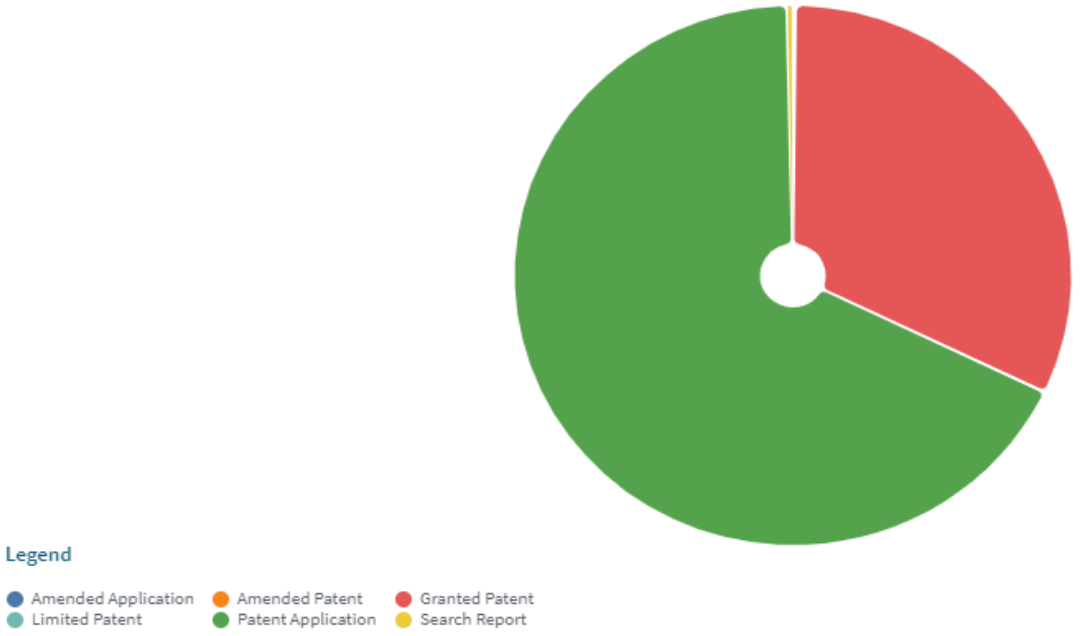

Figure 5. Patent application types (https://www.lens.org).

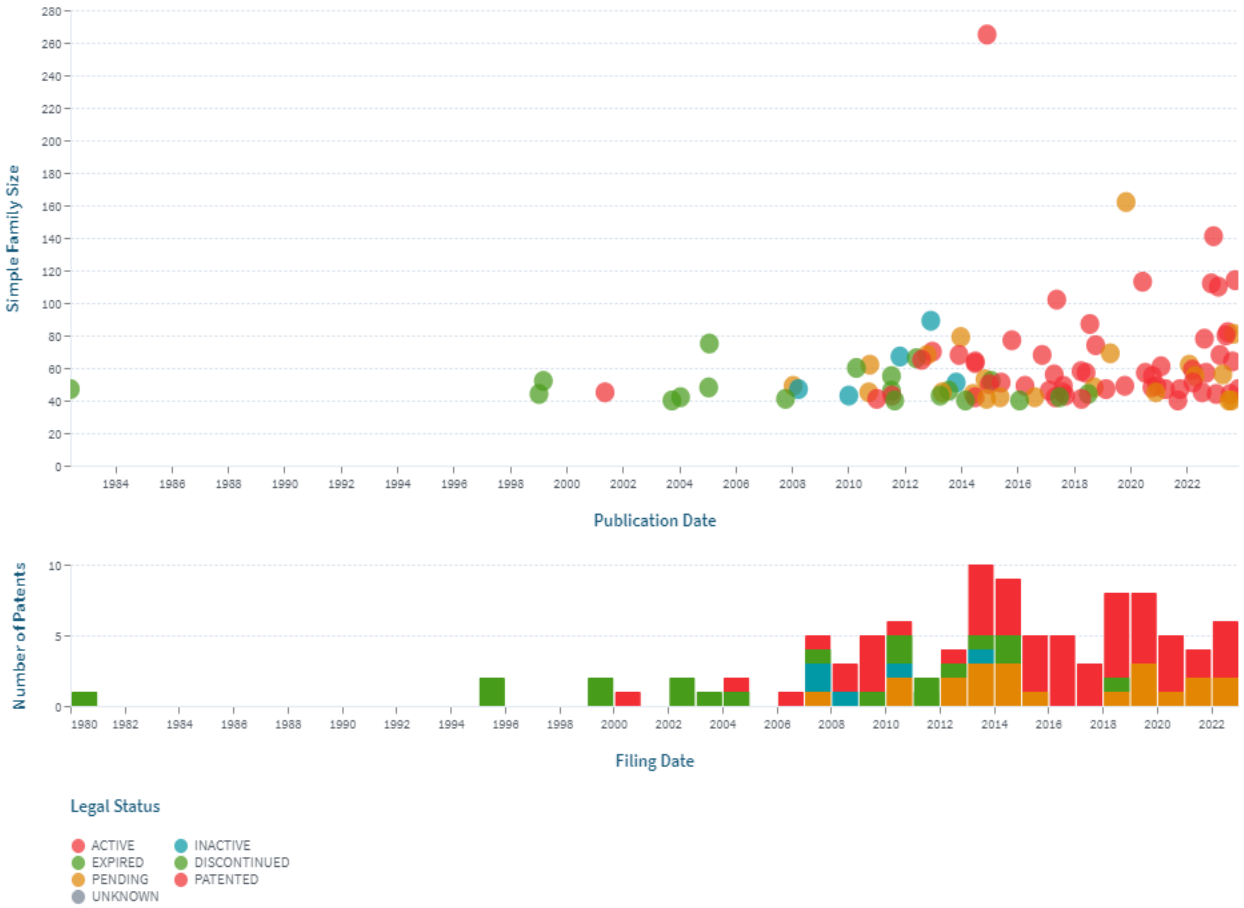

Figure 6. Patent applications by legal status (https://www.lens.org).

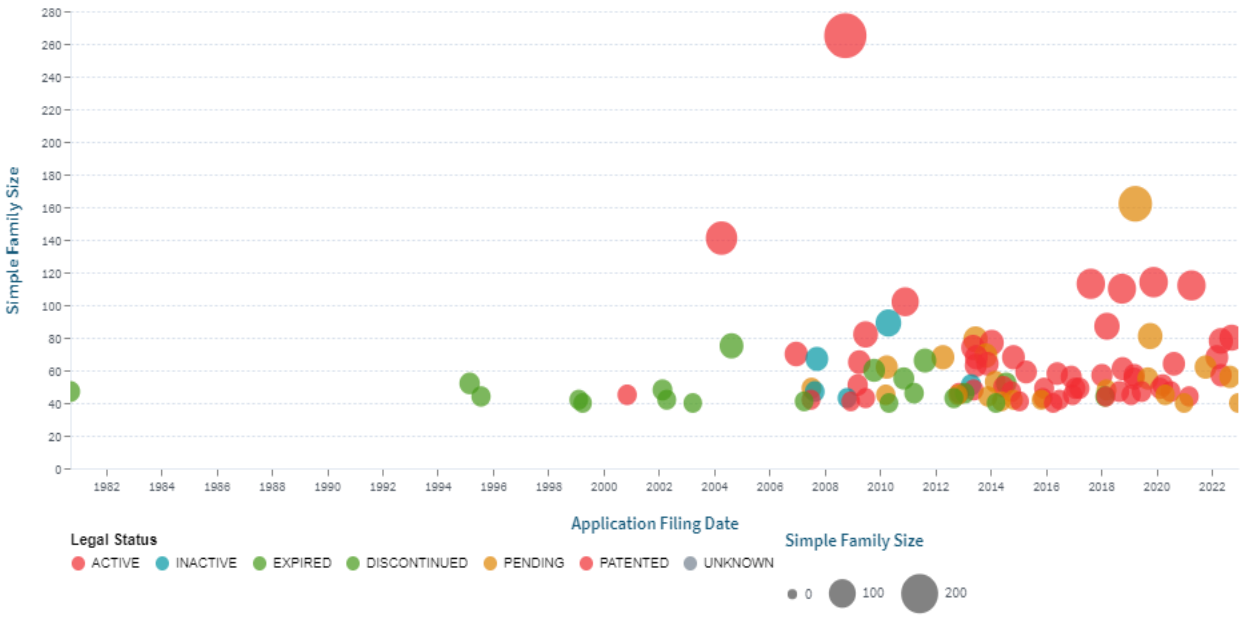

Figure 7. Temporal evolution of most protected patents(https://www.lens.org).

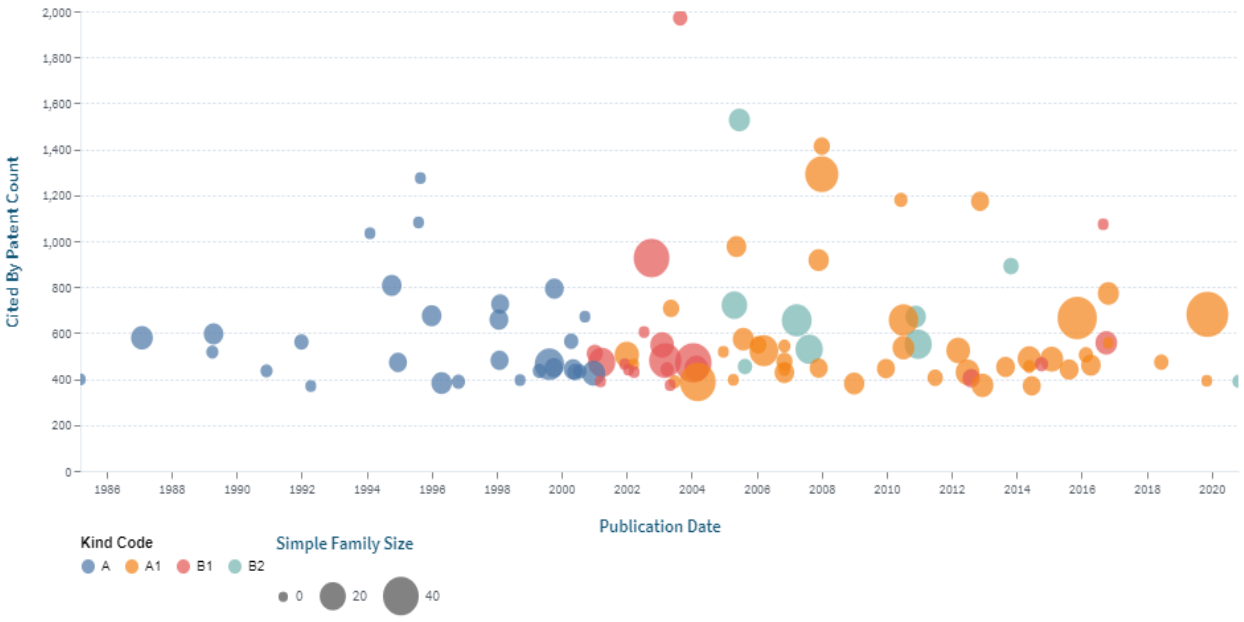

Figure 8. Temporal evolution of most cited patents over time (https://www.lens.org).

A search by "Human Digital Twins" indicated 25924 patents, with 10309 simple and 8642 extended families[7] (Figure 1). Most of patents are from USA, EU and China. A significant increase in the number of HDT patent applications can be observed from 2018. Less patent applications were filed before 2020, and then exponential increase is observed from 2020 till now. Each document contains details of territories where HDT is protected, priority dates, expiry dates, preferred embodiments and freedom-to-operate. United States, European Union, Canada, Australia, and China are the top patent offices which granted patents[8] (Figure 2). A stable increase in the dynamics of applications and granted patents during the period of time between 2018 and 2020 can be observed. The patenting landscape presents a strong indication of the continuous efforts of scientists in the field of HDT. The leaders in the number of patents issued are the United States, the European Patent Office, Canada, Australia, and China, which together account for more than 50% of the total number of patents around the world.

A patented invention can be the work of more than one inventor. It was found that the majority of the HDT patents granted have more than one inventor (Figure 3-4)[8] and there are even patents with more than 50 inventors. Patent application types and legal status is shown in Figure 5-6[8]. Similarly, most protected and most cited patents have been shown in Figure 7-8[8].

Patents are perceived and experienced by corporations and users very differently. Lens being a public resource for global patents and scholarly information is a platform for innovation cartography. The time-consuming nature of patent filing combined with narrow protection can make patent an insufficient form of protection for HDT. The law is ill-equipped to deal with questions and challenges raised by the linking of the organic, biological person with synthetic, inorganic data of HDT. This patent analysis indicated the concentration areas of HDT highlighting gaps for the future technology design by corporations. This analysis will serve an important reference for patent layout for future studies on HDT. HDT stakeholders are much diverse than similar technologies of this era. Since all patents are not available in electronic databases so our search was limited to those available at the time of our search in Lens patents. Accordingly, our findings are not based upon a complete record of all HDT patents. However, our search is wide enough to offer an overview based on a most comprehensive sample size that could be accessed at the time.

3. Conclusions

Current study has certain limitations. In this paper the patent data were from the Lens database. However, including data from major patent offices (POs), like Europe Patent Office (EPO), China National Intellectual Property Administration (CNIPA), Japan Patent Office (JPO), and WIPO, can improve the reliability of the results. Different patent formats, languages, and classification systems used by different POs are a challenge in identifying HDT patents. Further, innovations do not always occur as patents. Sometimes companies prefer not to disclose invention but keep it as trade secret making it difficult to observe technology trends and developments by patent analysis.

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[7] https://www.lens.org

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