Social Issues with Digital Twin Computing

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Abstract

This article introduces the social issues with Digital Twin Computing to bring about new digital societies—a fusion of the real and virtual. Issues are presented as those of the three elements of data, autonomous agents, and virtual societies from the perspectives of security/privacy and ethics/laws. Essentially, social issues entail the human quest to freely engage in activities in both the real and virtual to achieve more comfortable and affluent lifestyles.

Keywords: security, privacy, ethics

1. What are the social issues with Digital Twin Computing?

NTT laboratories are conducting research and development of Digital Twin Computing (DTC) to achieve new digital societies that fuse the real and virtual. Social issues with DTC entail ensuring human activities are not hindered in either the real or virtual or discovering such hindrances in advance. Humans now live in both real and virtual societies. We, NTT laboratories, believe a stress-free combination of activities in both these societies will expand human activities and bring about more comfortable and affluent lifestyles. If there are inconsistencies between the real and virtual, for example, activities in the virtual that are not recognized in the real or activities in the virtual that become uncontrollable and destroy real activities, etc., such inconsistencies could become sources of stress and anxiety for individuals and society. The essence of social issues with DTC is how these inconsistencies (which we call *disconnected parallel worlds*) can be foreseen. We believe that the DTC vision we have put forth will become socially stable by developing technologies to prevent such inconsistencies or limit the damage they cause.

2. Components of DTC

To achieve new digital societies with DTC, we adopted the concept of digital twins. A digital twin is "a mapping process that accurately represents in cyberspace the shape, state, function, etc. of a real-world object (thing)" [1]. Virtual societies are created by gathering digital twins. To address the social issues with DTC, we perceive DTC as having three elements (**Fig. 1**).

- Data
- Autonomous agents consisting of data and interaction functions
- Virtual societies consisting of collections of digital twins

Data express people and objects. In contrast to conventional digital twins that have been developed for objects, DTC focuses on digital twins of humans. We believe that digital twins must be used for general purpose as well as express complex content because we expect each digital twin to work in a broader social context rather than just as a solution to a problem. The goal of this idea is expressed as *reproducing human internalities* in our DTC vision.

We presume that digital twins are autonomous agents, in other words, systems that operate autonomously. This is because we assume that digital twins will represent and strengthen human activities in virtual societies. We believe that digital twins will need

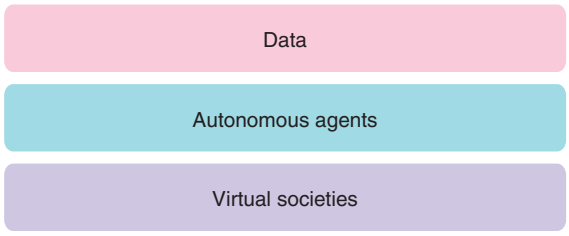

Fig. 1. Elements of DTC.

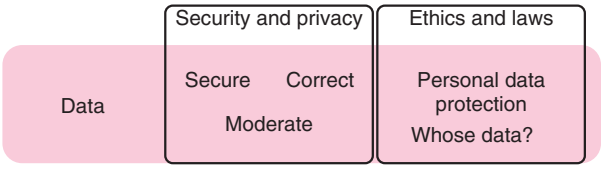

Fig. 2. Data of digital twins with DTC.

to be able to interact with each other (using functions called *operations*) and, at least in part, will inevitably need to be able to interact autonomously. Digital twins will also carry out simulations and other calculations and actively feed the results back to the real targets. Therefore, they will bridge the gap between the real and virtual. Not only can digital twins be viewed as autonomous agents but also as part of cyber-physical systems when viewed together with real humans or objects that have received feedback. We are also studying the generation of digital twins with properties that do not exist (called *derivative digital twins*) by other digital twins. This is a challenge.

A collection of digital twins and their activities is called a *virtual society*. DTC will provide environments where digital twins can be placed and operate. Digital twins are autonomous agents that hold data for people and objects internally, thus can form some kind of society. This will not just entail the aforementioned digital twin interactions. We believe that by giving the operating environments of digital twins or derivative digital twins high level functionality or even linking them with external applications, it will be possible to create various virtual societies.

3. Considerations of social issues

As explained above, the goal of DTC is to create new digital societies that combine the real and virtual and avoiding the creation of inconsistencies between these two domains, in other words *solving parallel-world problems*, is a social issue.

What are the approaches for solving parallel-world problems? There should be approaches for monitoring and controlling all digital twin activities in the environment provided by DTC. We do not deny that these approaches could be used in dedicated and closed services that use digital twins, but we will not take these approaches. Instead, we believe that each element of DTC will follow conventional data processing and computing rules and that by harmonizing the whole, we can avoid creating disconnected parallel worlds.

Accordingly, we will study each DTC element—data, autonomous agents, and virtual societies—as issues to debate. We will attempt analysis from the technical (security/privacy) and rule (ethics/laws) perspectives. Although, the technical perspective focuses on information security [2] and privacy frameworks [3], we will address broader concepts. Obviously, the rule perspective must follow current laws; however, we will also address ethics and laws without making strong distinctions between them.

4. Data issues

The data for digital twins assumed with DTC will have the following properties (**Fig. 2**).

- Data will express humans and objects
- Personal data will be included
- A wide scope will be described to address general problems
- Details will be described to address complex problems
- Sensors will be used proactively
- Data from a variety of sources will be integrated
- Data may also be generated from other digital twins

A digital twin is a *lump* of data. Because we are proactively thinking about digital twins of humans with DTC, a large amount of personal data will be included. Moreover, because we want to achieve more advanced computing with digital twins, we aim to make digital twins be general-purpose as well as be able to express complex content. When expressing human internalities, digital twins will consist of sensitive personal data that must be handled carefully.

We also take a proactive approach to generate data in DTC. We are studying fusing and using sensor and capture data, measurement data from wearable devices, and behavioral data from the Internet from the real

world. We are also studying not only the simple accumulation of data but also data generation (derivative digital twins) by other digital twins.

From the above, we assume the following issues.

4.1 Security and privacy issues

As mentioned above, a digital twin is a lump of data, thus requiring information security. Of course, this will entail discussions about the basics of security—confidentiality (free of information leaks) and availability (available when required). Therefore, how will the integrity of a digital twin be perceived? If we simply think of it as data integrity (accurate and without omissions), then solutions are easy, but digital twin integrity becomes an interesting issue when thinking of it as the integrity of objects and humans in digital space; a little beyond the scope of information security. Ultimately, the question of integrity is whether all the data required to solve a problem is described with a digital twin. Another idea recommended in the context of data privacy is called data minimization, which is the pursuit of moderation in the handling of data. The goal is to simultaneously pursue moderation and precise collection of data.

4.2 Ethics and law issues

Since digital twin data are also personal data, it will be necessary to comply with privacy and data protection regulations, and consistency will be required even if these personal data are not subject to regulation. The main point of this issue is the nature of the design objectives, i.e., regarding how and to what extent the person (subject) of the digital twin can understand the generation of the digital twin and its purpose.

Such digital twin data can be generated from sensors installed by other people or data from other digital twins, which would make the digital twin a collaborative work so to speak. Thus, the issue here is whose data are they?

5. Issues with autonomous agents

Digital twins assumed with DTC are autonomous agents and will have the following properties (**Fig. 3**).

- Digital twins are systems that operate autonomously
- They have functions called operations and interact with other digital twins
- They can generate new digital twins (derivative digital twins)
- They comprise virtual societies

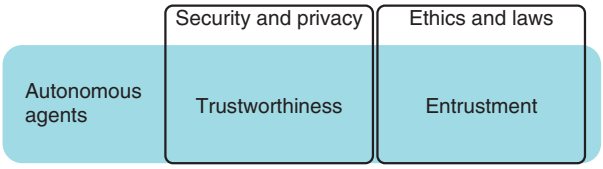

Fig. 3. Autonomous agents with DTC.

- Unified with the real, they become part of cyber-physical systems

A digital twin is also a software system that expresses a target human or object as data. This software has functions called operations and operates autonomously by interacting with other twins. The range of autonomy will gradually be implemented from here on, although one currently planned capability is the generation of digital twins with properties that do not exist (derivative digital twins). Digital twins will form virtual societies. They will also feed data back to real entities and become part of cyber-physical systems through unification with the real.

From the above, we assume the following issues.

5.1 Security and privacy issues

As with many other systems, we believe the expectation for autonomous agents will be their trustworthiness. Naturally, this means operating as expected (or enough to believe it so) at any time. Trustworthiness is a concept that includes a number of requirements that is not discussed in detail here, however, in this case it is characterized by authentication and authorization (information security), artificial intelligence (AI) malfunction, physical safety (cyber-physical systems), etc.

5.2 Ethics and law issues

The first issue is to entrust work to a digital twin. The presence of objective judgments is a clue to this. This is likely to involve transparency and explainability often discussed in the context of AI ethics. The second issue is the social framework of entrustment. This involves considering whether the autonomous agent is a tool, representative of a human, the self of a human, etc., and delving deeper into the relationship between the autonomous agent and the law. A derivative argument of this issue is whether it is even ethical to use a digital twin. This problem is like that of being allowed to use your smartphone to study at home but not in an examination room. The third issue is of whether the work is one that a twin must not be

made to do, aside from breaking the law. For example, in the case of derivative digital twins, if another person creates a digital twin of someone else, how will it be interpreted? Are there digital twins that are appropriate to create or those that should not be created (including the data-related issue of who owns the data that are created)?

6. Issues with virtual societies

Virtual societies conceived with DTC are collections of digital twins and their activities, as discussed above. Virtual societies may be achieved through linkages with external applications or be thought of as cyber-physical systems through linkages with actual humans. Although there are conceivably many variations of virtual societies and many subjects responsible for them, the following two general issues (**Fig. 4**) are discussed in detail.

6.1 Security and privacy issues

With virtual societies, trustworthiness is typically expected to be the same as with autonomous agents, but cybersecurity measures are more important. A major additional issue is that of ensuring consistency. Consistency means that there are no contradictions between the state of a digital twin and that of its subject. Since there can be more than one digital twin, this also includes consistency between digital twins. For example, if twin A sells a belonging of a subject, and at the same time twin B has it destroyed, consistency will cease to exist (transaction management). The first question in a virtual society is to what extent transaction management is required and is key to solving parallel-world problems.

6.2 Ethics and law issues

An important issue with a virtual society consisting of autonomous agents is the design of the rules of the society. This is the problem of how to constrain the free behavior of agents. Examples of this could include distribution of limited resources (ensuring fairness) or the necessity of basic prohibitions (e.g., the elimination of discrimination). There is also the issue of whether to allow rules to override individual protections when it is in the public interest, for example, to respond to disasters or pandemics.

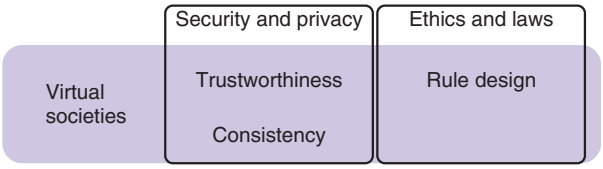

Fig. 4. Virtual societies with DTC.

7. Future developments

This article described the aims of DTC and discussed the social issues that should be addressed to achieve those aims as those of the three elements of data, autonomous agents, and virtual societies, and described them from the perspectives of security/privacy and ethics/laws. By continuing to think about these issues, we believe new digital societies that combine the real with the virtual are achievable.

References

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