# Human Digital Twins for Well-being

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**Abstract**

NTT is researching digital twin technology that reproduces not only the outer states, such as appearance, voice, and movement, but also the inner states, such as values and thoughts, of humans. To actualize a future in which human digital twin technology contributes to the well-being of people and society, it is necessary to examine the ideal path of technology evolution from a broad interdisciplinary perspective. This article introduces research activities to pursue well-being as the Grand Challenges of Digital Twin Computing, i.e., Another Me and Mind-to-Mind Communication.

*Keywords: digital twin, well-being, Self-as-We, Another Me, Mind-to-Mind Communication*

## 1. Toward a human digital twin for well-being

A digital twin reproduces physical entities, i.e., humans, objects, and the environment, on a computer as twins in the digital world on the basis of data collected about such entities. NTT is engaged in research and development for the actualization of various digital twins and their applications from human communication to simulation of cities and transportation [1, 2]. A human digital twin should have not only an external model of a person's face, body, voice, and movement but also an internal model of a person's personality, values, and knowledge. When one hears this, they may be afraid that others would look into their inner self to exploit them or that their existence could be replaced with their digital twin.

To eliminate the possibility of adverse effects caused by the unethical use of human digital twin technologies and pursue ethical advances in such technologies to contribute to the well-being of people and society, NTT has established two Grand Challenges, i.e., Another Me and Mind-to-Mind Communication [3]. A human digital twin should not be used to substitute its original person but facilitate that person's connection with other people and create new opportunities through deep understanding of that person, which would expand the possibility of self-realization and achieve a well-being society based on strong solidarity and altruistic coexistence.

This concept is similar to the Self-as-We theory proposed by our joint research partner, Professor Yasuo Deguchi of Kyoto University. In the Self-as-We theory, a "self" does not mean "I" as an entity that thinks and therefore exists here and now but means "we" that includes all persons who share a purpose or behavior and also objects that support it. Therefore, the "we" that I belong to, i.e., the "self," will change in various ways depending on what goals I am working toward and what activities I am engaged in. A human digital twin that deeply understands the person serves as a bridge that connects that person and others, enabling that person to discover a new self and aim for a better "we" that is open to diversity.

The Grand Challenge Another Me is based on the concept that the digital twin of me that precisely reproduces the outer and inner states of me performs various activities autonomously on behalf of me in the same way as how I would do in those activities (for example, one's digital twin will make friends autonomously in cyberspace), and that by giving feedback with a sense of reality to me, I could expand opportunities in my life, leading to personal well-being such as self-realization.

Mind-to-Mind Communication contributes to a society full of diversity where people can mutually respect each other as well as a society full of creativity in which people's ideas are combined by understanding each person and preventing miscommunication

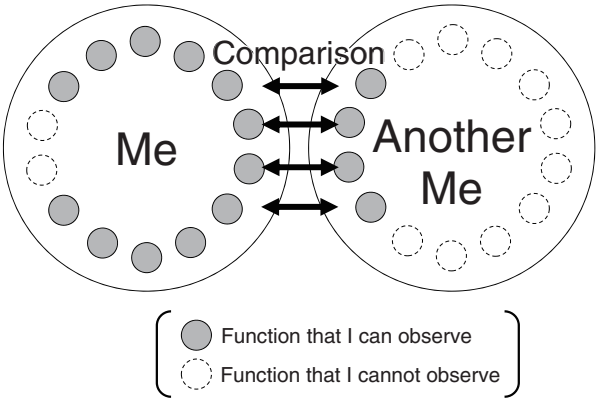



Fig. 1. Functional I.

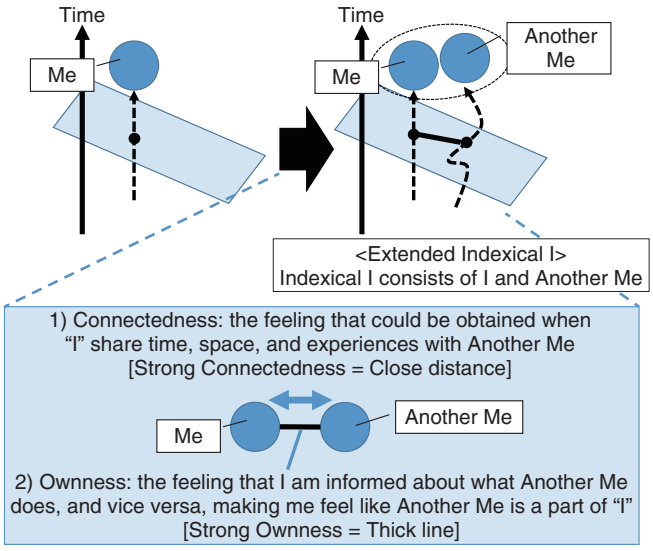



Fig. 2. Indexical I.

(discrepancies in intentions between information sender/recipient) and discommunication (a state in which information transmission itself is missing).

The following is a discussion on well-being in the context of Another Me and Mind-to-Mind Communication.

## 2. Another Me: another way of being self

Another Me is not an expansion of a uniform person through impersonal artificial intelligence (AI) but an expansion of a person's temporal and spatial potential while maintaining the diversity that each person has. However, depending on the situation in which it is used, there is a possibility that Another Me would replace its actual person, thus degrade the irreplaceability and dignity of that person. What is the desirable position of Another Me in a society that enhances well-being? To answer this question, we are conducting joint research with Professor Yasuo Deguchi and Associate Professor Takuro Onishi of Kyoto University from a philosophical perspective.

After many discussions through collaboration of philosophy and technology, we concluded that Another Me, as an existence having high I-hood but not "I" itself, can be positioned on two axes. The first axis is Functional I (**Fig. 1**), which represents the similarity of what Another Me and "I" can and cannot do. Functional similarity is necessary to allow Another Me to act on behalf of "I." The other axis is Indexical I (**Fig. 2**), which highlights an aspect of "index" that refers to "I" on the basis of certain evidence or a clue found in Another Me that evokes the sensation of "I'm in this now." We discussed that indexicality can be expanded with the Self-as-We theory. If we think "I" and Another Me as a "self" on the basis of this theory, through the sense of "acting and experiencing together with Another Me," we can feel "I" in Another Me. The Indexical I is thought to consist of two further elements. One is "Connectedness," which is the feeling that could be obtained when "I" share time, space, and experiences with Another Me, and the other is "Ownness," which is the feeling that I am informed about what Another Me does, and vice versa, making me feel like Another Me is a part of "I."

To enhance the well-being of Another Me through the expansion of human temporal and spatial possibilities, we believe it is important to enhance both the Functional I and Indexical I elements of Another Me both technically and design-wise (**Fig. 3**).

## 3. Two communication challenges of Mind-to-Mind Communication technology

**Figure 4** shows two communication issues that Mind-to-Mind Communication technology needs to overcome. Figure 4(a) shows a communication scene in which you and your partner have different purposes, backgrounds, and sensibilities. In such a case, communication may not be established in the first place, and discommunication may occur. The purpose of Mind-to-Mind Communication technology is to understand the general meaning. In other words, the goal is to convey, even if vaguely, that there is a

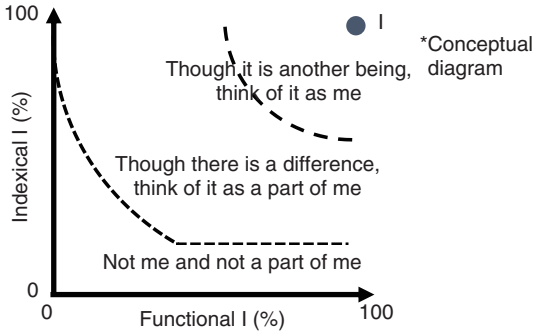
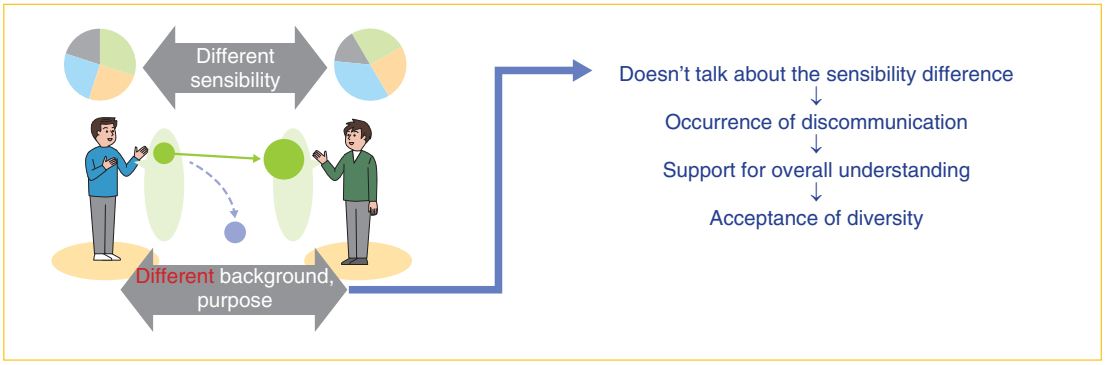
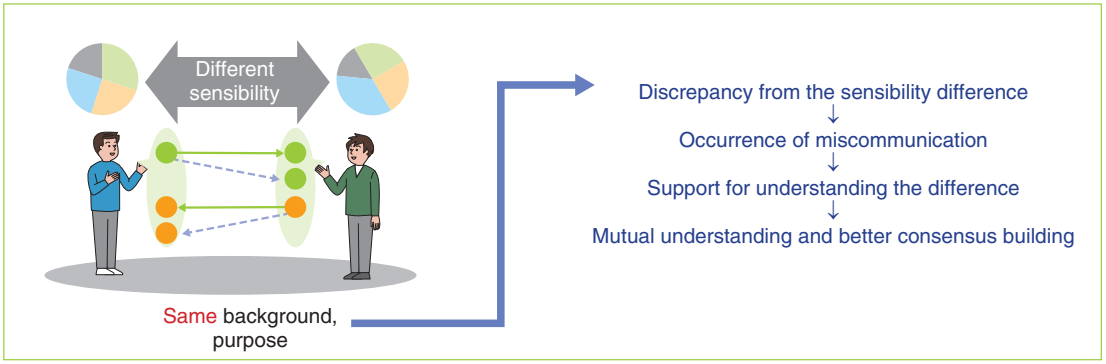



Fig. 3. Proportion of Functional I and Indexical I.




(a) Resolution of discommunication and diversity inclusion




(b) Resolution of miscommunication and mutual understanding

Fig. 4. Challenges of Mind-to-Mind Communication and their effect.

sensibility different from one's own. Even if we do not understand the details of sensibility, if we can sense and recognize that there are various sensibilities, it will promote understanding and acceptance of diversity. Figure 4(b) shows a scene with a common background and purpose and different sensibilities. This occurs often in everyday life. Differences in sensibility lead to miscommunication and misunderstanding. However, if two people with different sensibilities can understand each other for the same

purpose and form a consensus, it will lead to better consensus building and, in turn, increased creativity.

As a use case to promote specific technological development aimed at overcoming discommunication and promoting the acceptance of diversity, we are working to support communication for people with mental disabilities and in minority groups in the workplace. In particular, we are building prototypes of support systems targeting the problem that occurs when each person has a different sensibility, erroneous assumption, and misunderstanding, which could cause problems in the workplace and limit the person's opportunity for active contribution. To visualize and understand well-honed sensibility and enhance creativity beyond differences in sensibility, we have started to convert sensibilities between professionals, such as Shogi (Japanese chess) players and Formula racing teams, and analyze the dialogue and movement between players with different expertise to improve the performance of the individual players. In Shogi, there are no unstable factors for movement due to the environment, and the excellence of agreement and conclusion can be objectively evaluated through recent AI. Because, in many cases, a Formula team deploys two cars with the same conditions in each competition, two drivers with the same conditions and a well-honed sensibility interact with each other from nearly the same environment, allowing them to compare utterances. Although we have only just begun, we are also working to encourage creativity by studying the sensibilities of professionals.

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