Co-creation in Man-Machine Interaction

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Abstract

The purpose of our research group is to realize a "Co-creation System" [1][2]. *Co-creation means co-emergence of real-time coordination by sharing cognitive space and time. Human communication with emergent reality like this needs two kinds of processing at the same time* [7]. *One is explicit communication such as the exchange of messages and the other is implicit embodied interaction such as sympathy and direct experience. Using this dual-processing complementarily, we are developing co-creative man-machine interfaces and interactive media* [3-6][8]. *This new technology will be effective for recovering human linkage, social ethics and mutual-reliability that has been lost in the IT society.*

1. Introduction

As the background to this research, we have already pointed out the serious limitation of intelligence realized in artificial systems. Human intelligence can be classified into two different categories: "search" and "emergence." A searching algorithm based on "completeness" of intelligence has been widely used in IT systems to find the best solution. This kind of intelligence is applicable to definite situations in which every state can be previously defined (Fig.1a). However, in indefinite situations, such as the system including human behaviour and social communication, searching algorithm cannot be used. In such unpredictable conditions, another type of intelligence is required and intelligence with emergence is essential for overcoming the limitation of the conventional approach.

2. Incompleteness and Co-creation

In the present IT systems based on the framework of searching, the relationship between humans and artificial systems is a one-sided transfer from the system to human. As a result, the size of the information space prepared in the artificial system becomes extremely large and the human becomes very passive on the other side. This is a problem of design principle based on intelligence with completeness. On the other hand, Japanese culture has very different traditional background, i.e. emergence in real-time. Our cultural backgrounds think that artificial systems should be incomplete, but this is a kind of active "incompleteness" to realize an emergent reality with humans (Fig.1b). Due to this incompleteness, coordination between the system and the human is co-created in real-time.

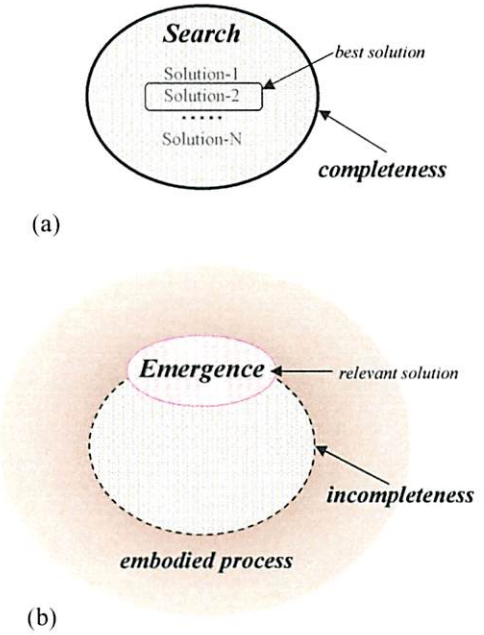


Figure 1: Search and emergence

In this process, embodied interaction plays an essential role in realizing a "relevant" function with real-time coordination. The stone garden Ryoanji temple in Kyoto is a famous example. There are 15 stones in this garden,

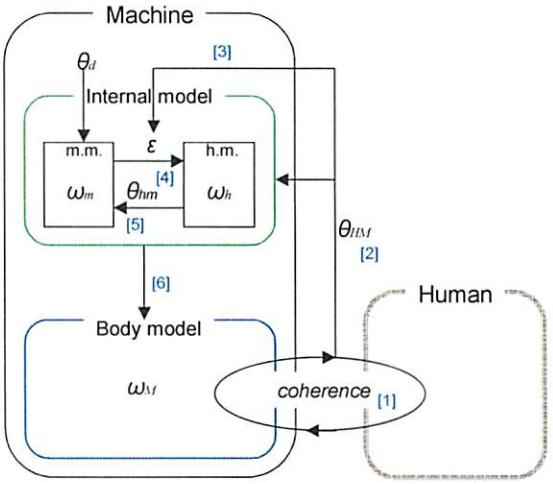
Figure 2: Japanese stone garden

however you can never see all stones at the same time (Fig.2). Some stones are always hidden by other stones. This is a kind of active incompleteness. So if you want to get a whole image of the garden, you have to walk around in the garden as part of the garden. Then you will be able to co-create the whole image including you as part of the garden. This is the design principle of the co-creation system that is based on active incompleteness and embodiment. However, how to realize such process in an IT system is still an open question.

3. Dual-dynamics Model

To achieve this target, the design principle of the co-creation system should be established. In our research group, "duality of self" was proposed as a hypothesis for realizing co-creation [1][2]. This hypothesis assumes that our human intelligence is composed of two different processing modes. One is the process of "explicitness" and the other is "implicitness." This explicit part is concerned with self-consciousness and realizes intelligence with completeness. In other words this intelligence is our causal operation in formal logic. On the other hand, the implicit part is concerned with embodied process with active incompleteness. This realizes the interaction between the system and the indefinite actual world. Here, the interface between these two processes emerges by "mutual constraint." We regard this emergence as a co-creative process of intelligence. Recently we showed experimental data concerning this hypothesis [7].

From this hypothesis, we have already proposed a model of co-creation (Fig.3) [3][8]. This "dual-dynamics model" is composed of two sub-models. One is an internal model to show the explicit process and the other is a body model to represent the implicit process. Since the synchronization phenomenon of the body motion is widely observed as a typical dynamics of the embodied process, a nonlinear oscillator and mutual entrainment are used to show the dynamics of a body model that can be embedded as a part of the indefinite world. This is a kind of mathematical expression of the active incompleteness and temporal coherence can be self-organized in such open space. On the other hand, the internal model is a coupled nonlinear oscillator as closed space to represent the process based on completeness. By the mutual constraint between these two sub-models, an emergent process of intelligence is simulated.

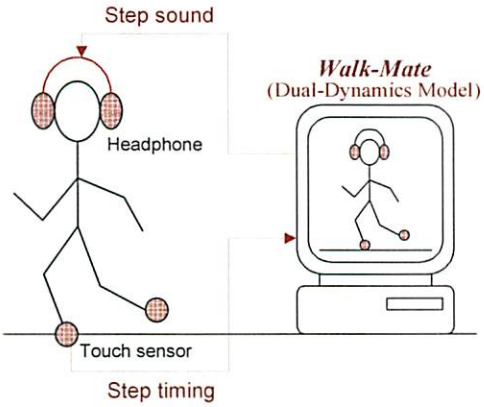


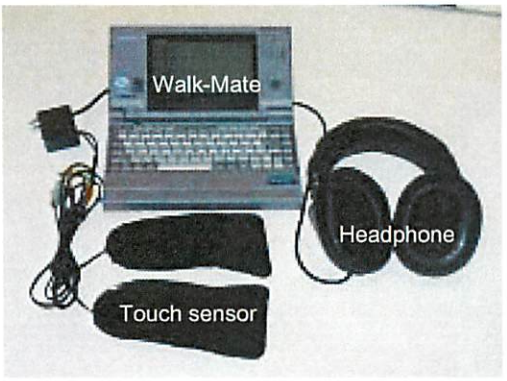
1. Self-organize coherence between human motion and body model
2. Get the organized coherence as phase difference θ_{HM}3. Modify the internal model parameter ε such as $min(\theta_{HM} - \theta_d)$
4. Search ω_h such as $min(\theta_{HM} - \theta_{hm})$ under the fixed ω_m in internal model
5. Search ω_m such as $min(\theta_d - \theta_{hm})$ under the fixed ω_h in internal model
6. Change ω_M in body model corresponding to searched ω_m
7. Back to 1

Figure 3: Dual dynamics model

4. Co-creation in Man-Machine Interaction

This model was represented as part of the co-creation process between human and machine [4][5]. The rehabilitation process of human walking was used as an





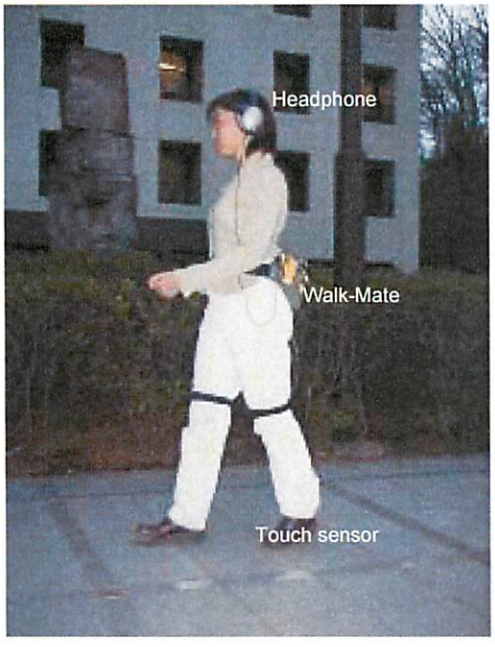


Figure 4: Walk-Mate

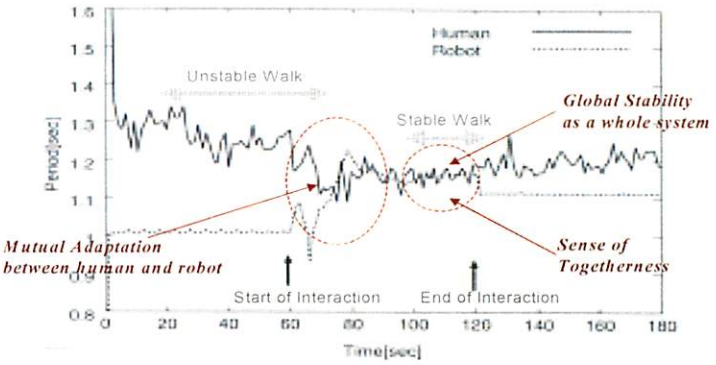


Figure 5: Co-creation process

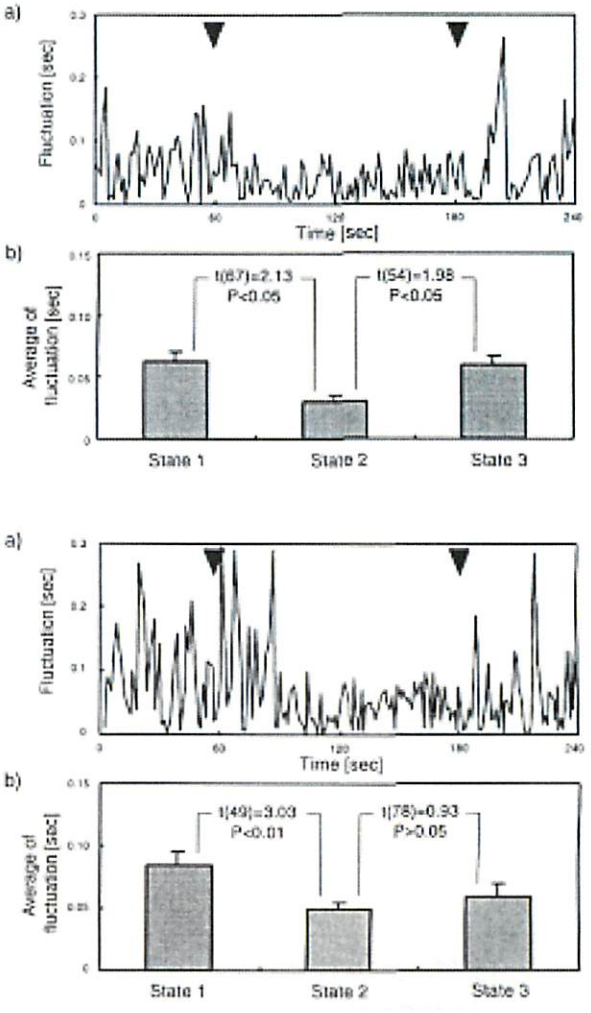


Figure 6: Co-creation process

example because coordinated walking between two persons is widely observed in rehabilitation for elderly people to redevelop their walking ability. Our dual-dynamics model is realized in a personal computer as a virtual walking robot and footsteps are exchanged between the robot and human walker (Fig.4). The footstep of the robot is transmitted to the human by headphones and the footstep of the human is feed back to the robot by a touch sensor. Everyone has had this kind of experience when walking with another person. In such situation, temporal coherence of footsteps between two persons spontaneously appears. This co-creation robot was named "Walk-Mate."

To evaluate the effectiveness of this system, interaction process between Walk-Mate and a human with walking impairment was analysed [6]. As a result, three characteristic properties were observed (Fig.5). The first is mutual adaptation between the human walker and Walk-Mate. The periods of their footsteps mutually coincided with each other after the start of interaction. This is a kind of co-creation dynamics in walking motion. The second is the emergence of global stability including both the dynamics of the human and the Walk-Mate. Fluctuation of the footstep period due to the walking impairment was significantly decreased in this co-creation process. The third is the sense of togetherness emerging through this process, suggesting this process also realizes the emergence of our mental connection. Recently, similar results are widely obtained from various patients (Fig.6). These results show that our proposed framework could be effective for establishing a co-creation process between humans and artificial systems.

5. Conclusion

In this way, we are developing co-creation systems in a man-machine interface. In the next step, this technology for a co-creative interface should be extended to a network system to support co-creative communication in human linkage. On the Internet, exchange of explicit information is very easy but the implicit process cannot be shared there. This means there is no co-creation on the Internet. As such network system has penetrated into daily life, relation-building problems, such as mutual reliability in a virtual community and togetherness between remote places has become an important subject. This co-creation technology has the potential for overcoming the problems of the modern network society.

References

[1] Miyake, Y. (1997). Design in Life (in Japanese). *Gendai Shisou*, 25(6), 301-317.

[2] Shimizu, H., Kume, T., Miwa, Y. & Miyake, Y. (2000). Ba and Co-creation (in Japanese). Tokyo: NTT Publisher.

[3] Miyake, Y., Miyagawa, T. & Tamura, Y. (2001). Man-machine interaction as co-generation process (in Japanese). *Transaction of SICE*, 37(11), 1087-1096.

[4] Muto, T. & Miyake, Y. (2002). Analysis of co-emergence process on the human-robot cooperation for walk-support (in Japanese). *Transaction of SICE*, 38(3), 316-323.

[5] Yamamoto, T. & Miyake, Y. (2002). Analysis of interaction between player and listener in music live performance (in Japanese). *Transaction of SICE*, 38(9), 800-805.

[6] Takanashi, H. & Miyake, Y. (2003). Co-emergence robot Walk-Mate and its support for elderly people (in Japanese). *Transaction of SICE*, 39(1), 74-81.

[7] Miyake, Y., Onishi, Y. & Pöppel, E. (2002). Two modes of timing anticipation in synchronization tapping (in Japanese). Transaction of SICE, 38(12), 1114-1122.

[8] Miyake, Y. & Miyagawa, T. (1999). Internal observation and co-generative interface. *Proc. of 1999 IEEE International Conference on Systems, Man, and Cybernetics (SMC'99)*, Tokyo, Japan, pp. I-229-I-237.