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Human Augmentation Platform (HAPF) Using 6G Network

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ABSTRACT

We introduce the Human Augmentation Platform (HAPF), a platform enabling social implementation of human augmentation as a potential use case for 6G towards a well-being society. HAPF absorbs physical differences between the subject of an action and the target to transfer human behavior precisely and efficiently from one to another.

1 Introduction

Human Augmentation (HA) [1]-[3], which enhances human abilities in terms of physical capabilities, perception, cognition, and presence, is a promising technology addressing various social problems toward a well-being society [4][5]. By making practical use of HA, various values and solutions can be pursued to address social problems.

The outbreak of SARS-Cov-2 (COVID-19) and its successive social transformation have changed our way of living in terms of both work style and lifestyle. For instance, telework has become commonplace, and taking workcations (working remotely while integrating leisure elements of a vacation) and having multiple residences in various regions have gradually become socially accepted. With advances in technology toward ambitious goals, eventually most work will be location free [6]. In addition, people can enjoy any professional service regardless of the location. For this reason, not only traditional communication modalities, i.e., visual, auditory, and textual information-based telecommunications, but also additive modalities, e.g., those involving the other senses, must be considered in next generation telecommunication services as in HA use cases.

A combination of HA and the sixth-generation mobile system (6G) will yield high affinity and provide added value and solutions to those problems and opportunities [7]. In use-case implementation of HA, such as remote operation and / or sensing of tangible (real) objects, i.e., augmentation of human presence, 6G will be beneficial due to its low latency data transmission feature since transmission latency over a mobile network is targeted to be shorter than that of the human nervous system. The user can perceive the existence of a distant object via 6G with a sense of realism.

Regarding the practical aspect of HA, a variety of component technologies such as artificial intelligence, robotics, electronics, augmented reality, virtual reality, and brain-machine interface (BMI) are being studied and developed [8]-[12]. For instance, augmentation of physical capabilities, an approach for sensing human-body information mainly from the brain and muscles such as brain waves and myoelectric activity used in actuating actual muscles and exoskeleton, has already been practically employed. One typical application is a myoelectric prosthetic hand [13].

On the other hand, integrating these component technologies covering four categories, i.e., physical actions, perception, cognition, and presence, onto a unified platform to connect devices for HA over the Internet has not been investigated to the best knowledge of the authors. In addition, in practical implementation of such a platform, a use case covering the issue of mutual adaptation between entities of interest must be addressed.

In this article, we propose the concept of HA using 6G, a potential use case for 6G to address social problems for sustainable development goals (SDGs). The Human Augmentation Platform (HAPF), which is designed as a framework and a toolkit for HA application development, is introduced. The platform is capable of absorbing differences in physique between the subject person of action (subject) and the object person (target) to transfer human behavior precisely and efficiently from the subject to the target. The rest of this paper is organized as follows. Section 2 describes the concept of HA using 6G. Section 3 follows with a description of the proposed HAPF and its technical features. Finally, Section 4 summarizes this article.

2 HA Using 6G

2.1 Concept

This section describes the concept of HA using 6G to actualize a new style of human communications in the 6G era. The aim of this concept is to connect people beyond space and time limitations. By reducing the perceived distance among people, regardless of the

distance in physical space or time, HA using 6G will help people to enjoy value-added communications. Specifically, not only by sharing the user physical ability but also by sharing his/her perception and emotion with anybody on the globe, richer communications that cannot be established through only conventional visual, auditory, and textual information will be possible. Thereby, such an unprecedented communication style will further promote mutual understanding of people towards a well-being society.

Toward this goal, extremely low latency is a key requirement among the major 6G system requirements [8] for HA as indicated in Fig. 1. If network latency in the order of milliseconds is achieved, it will be shorter than the approximately 20-ms response time of the human nervous system, which is the time for any information conceived in the human brain to be conducted to a peripheral nerve [18]. In other words, the 6G network will respond as fast or even faster than the human nervous system.

2.2 Five Target Capabilities

The five target capabilities of HA using 6G are given hereafter.

(1) Ubiquitous body

The first target capability is a ubiquitous body. When an extremely large number of massive sensors for the five senses are connected to the HAPF, sensory perception information will be available across the globe in real time, leading to actualization of the ubiquitous body.

(2) Sharing skills

The second capability is sharing skills. HA using 6G could enable people to share their skills by transcending the limits of language-based communications. Capabilities for sharing skills that are handed down by relying on verbal communications or experiences and skilled techniques are needed, and this capability will contribute to improving the efficiency of such skill transfer. For instance, skills of a professional sports player can be transferred to a child trainee even though they have totally different physiques.

(3) Feeling communication

The third capability is feeling communications. In the context of approaching a well-being society, it is inevitable that technologies will be developed to enable very sophisticated communications with realistic senses of presence and atmosphere to achieve a much deeper mutual understanding. Since conventional telecommunication technology has focused particularly on visual and auditory information, a realistic sense of presence or atmosphere including emotional atmosphere has relied only on those modalities. Feeling communications will be a means to compensate for the lack of communications conveying a much more realistic sense of presence or atmosphere.

(4) Perception sharing

The fourth capability is perception sharing. Perception sharing means not only sharing the five senses (visual, auditory, tactile, gustatory, and olfactory sensory perception) but also amplifying those sensory perceptions as well. Technologies for visual and auditory sensory perception have achieved a certain level of maturity; however, those for tactile, gustatory, and olfactory sensory perception are still gradually emerging with advances in various sensing and stimulating techniques. Such multi-modal communications have the potential to enrich interpersonal communications and foster tighter bonds between people.

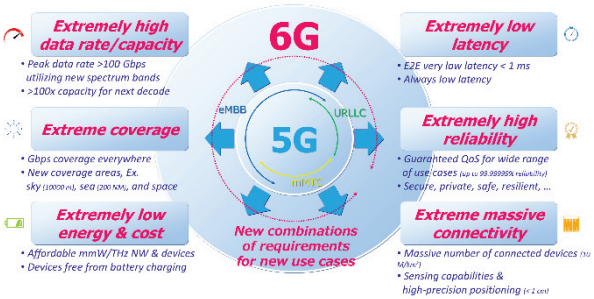

Fig. 1 6G system requirements

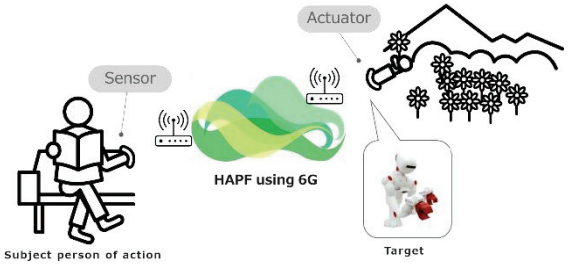

Fig. 2 Human augmentation using 6G network

(5) Telepathy and Telekinesis

The last target capability of HA using 6G is telepathy and telekinesis, the ultimate form of telecommunications. By enhancing the above-mentioned HA capabilities using 6G combined with emerging BMI technologies, telekinetic actions could be performed remotely, and even thoughts and emotions could be shared telepathically.

3 HAPF

3.1 HAPF Overview

This section presents an overview of the HAPF, the world-first platform for HA. The HAPF was designed to optimally transform, transfer, and share sensing data of human activity to a target (not limited to a human) in a distant place utilizing the high-level capabilities of 6G. Figure 2 shows the basic operation of the HAPF system. A series of sensor devices related to the captured action of the subject transmits the captured data to the target through the HAPF. The target is stimulated by actuator

devices that reproduce the intended action using some stimulus signals, e.g., myoelectricity stimulation in real time resulting in the sharing of actions. As the initial goal, we implemented HAPF to actualize the ubiquitous body and sharing skills capabilities among the five target capabilities of HA using 6G as mentioned in Section 2.

In the design of HAPF, we considered functional requirements for connecting bodies to share motion between the subject and target. For example, if the sensed human action is directly applied to the actuator, some burden may be imparted to the target and the action may not be fully shared due to a difference in physique such as the angle of motion. Therefore, a conversion capability for the sensed motion data to adapt to the target actuator device and body part must be equipped in the HAPF to address such problems.

3.2 Key functionalities

The HAPF comprises the following four main functionalities as shown in Fig. 3.

(1) Physique Transformer

The HAPF is equipped with a physique transformer that absorbs the difference in physique between the subject and target. For instance, the transformer makes possible the sharing of natural action between a human and a robot that is totally independent of their size and skeleton by transforming and adjusting the sensed data based on the body data stored in the HAPF. Another example is that precise action can be reproduced based on a rough action by the subject utilizing the adjustment capability of the transformer.

(2) Network Connectivity via API

The HAPF provides an application programming interface (API) to the sensor and actuator devices that are connected via a mobile network. Sensors and actuators can be located in any location.

(3) Recording of Action

The HAPF is equipped with a recorder unit to record motion data captured from a sensor device. This makes it possible to reproduce motion of a person recorded previously using accumulated records of his/her acts.

(4) HAPF SDK and Inter-connectivity of Devices

An HAPF software development kit (SDK) provides HA application developers with the necessary means to connect their own variety of sensors or actuator devices with the HAPF via the API. This capability also provides opportunities to interconnect those devices and services with ease.

3.3 Use Case Example

Let us consider a sports lesson in which information on physical movement and kinetics is received from an instructor in a remote location. We can potentially learn more efficiently by feeling the instructor movement and directly moving our body than only by listening to instructions and watching his/her movement. Another

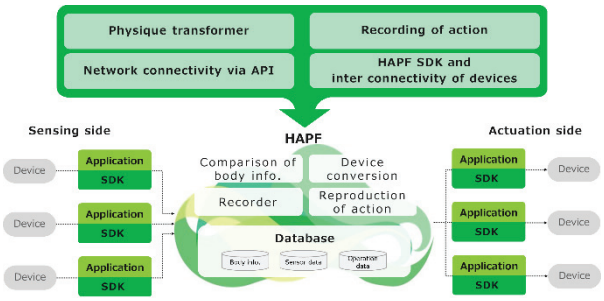

Fig. 3 Human augmentation platform

example is an application to address social problems such as labor shortage and skill inheritance in which skilled technique is needed. Owing to the recorder in the HAPF, such master craftsmanship can be reproduced and handed down, and is not bounded by time.

4 Summary

This article presented the concept of HA using 6G, a potential use case for 6G to address social problems such as inheritance of work skills and skilled labor shortages. Design of the platform is addressed with the five target capabilities actualizing the concept of HA using 6G. The proposed HAPF is capable of absorbing differences in physique between the subject and the target to transfer human behavior precisely and efficiently from one to another while not being bounded by time. As sensing and actuation technologies mature, the HAPF will contribute to addressing social problems and actualizing a well-being society through implementing a variety of use cases utilizing the features not only of sharing human acts but also of transmitting emotion and sharing of the five senses.

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