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Telerehabilitation Based on Markerless Motion Capture and IMT-2020 (5G) Networks

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Abstract

Eldercare programs such as health consultations and physiotherapy that improve the well-being and extend the life expectancy of people in rural or sparsely populated areas is a socially important though costly problem. We ran a pilot project to test the effectiveness potential of telerehabilitation using markerless motion capture technology integrated in a fast and low-latency IMT-2020 (5G) mobile network. Accelerating technological innovations and the surge in advances of telehealth will greatly impact conventional home visit or outpatient rehabilitation services, working in concert with or even supplanting them, given the potential lower cost and better utilization of time.

Keywords:

Telemedicine, Telerehabilitation, Health Services Accessibility

Introduction

With its population rapidly aging and declining numbers, Japan is a forerunner within the Asia-Pacific region and a signal of what is to come in many countries throughout the world. Despite ongoing challenges however, the trajectory of pursuing innovative models of integrated eldercare in the face of economic constraints within Japan holds great promise in its trasferability to similarly ageing societies. In recent years, information and communication technologies have made remarkable progress and innovations in medical and healthcare fields, the telemedicine system is rapidly improving to provide the same quality of medical care in sparsely populated areas as available in urban areas, in less restrictions on location. This is expected to reduce regional disparities in healthcare[1]. Telemedicine and healthcare systems will also be pivotal in the transformation of the healthcare system from the current centralized system to a decentralized one, which will be accelerated by the COVID-19 pandemic situation [2].

Currently, telemedicine is generally practiced by the standard video meeting technology of wired or IMT-Advanced (LTE) networks. In order to realize *telerehabilitation*, however, it is imperative to take quantitative measurements such as of joint angle and muscle force without touching the patient as well as to have real-time direct communication for consultations, treatment and therapy sessions. Further, ease in transmission of optimal quality images is essential[3].

Here we report a demonstration experiment in which industry, academia, government, and the private sector collaborated to conduct telerehabilitation, using two novel technologies: markerless motion capture and IMT-2020 (5G) networking, to serve super-aged persons in a depopulated and mountainous region.

Methods

The experiment was conducted in Shinshiro City, Aichi Prefecture, Japan, which has been designated as a depopulated region by the Ministry of Internal Affairs and Communications.

Five volunteers with a history of hospitalization in Shinshiro Municipal Hospital (SMHp) within one year were enrolled in this study. A markerless motion capture system (Simi Motion Analysis, Simi Reality Motion Systems, Germany) and a 4K resolution camera for remote diagnosis were installed in the Tsukude Clinic (TsCl), approximately fifty minutes drive from SMHp, and a newly laid commercial 5G/LTE network backbone (NTT Docomo, Japan) was used.

A physiotherapist working for SMHp remotely inspected the volunteer's posture, walking speed, and joint positions measured using markerless motion capture, as well as gait weight bearing balance monitored by an insole pressure sensor (eRubber shoes, Toyoda-Gosei, Japan) while they performed physical therapy tasks. During the tasks, each participant was accompanied by a nurse wearing a head-mounted camera who recorded them performing muscle strength training of the lower limbs and walking training in the parallel bar. Video of the participant's physical training was recorded and streamed through the network and monitored in real time by a physical therapist at SMHp while gait, walking speed, and joint positions were calculated using the markerless motion capture system and dynamic gait loads attained by insole sensoring were displayed simultaneously.

Sufficiency of video quality and latency were evaluated by both 5G and LTE backbone and 4K, 2K and HD video resolution settings – 5G/4K, LTE/HD,2K,4K. Physiotherapist and participants were asked to evaluate the program by means of a qualitative questionnaire, while quantitative changes in motor movements were measured. Details are shown in Fig.1.

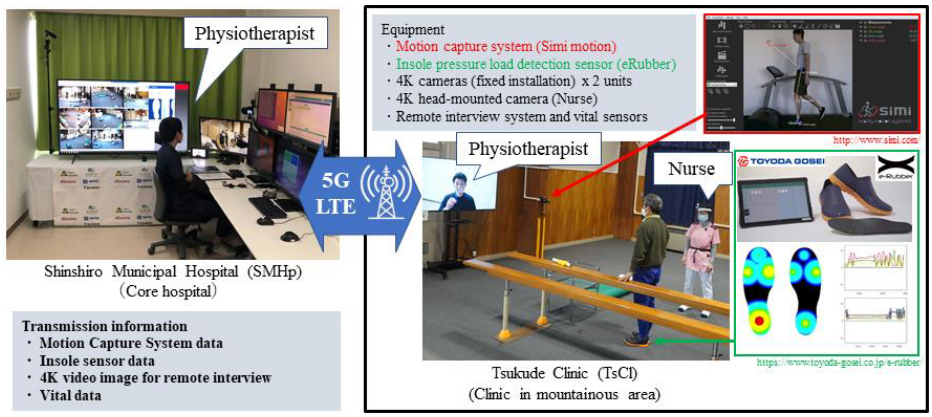

Figure. 1 Experimental configuration

Results

For the comparison among four backbone and resolution settings, six out of seven participants answered that the quality was "Good" for 5G/4K resolution. For LTE communication, the three groups were similar, except for a single "Bad" response in the LTE/2K setting. As for the latency, five out of seven respondents answered that the latency was "Acceptable" for 5G/4K setting. In LTE, the higher the image quality to be transmitted, the lower the acceptance rating, and only one person in the LTE/4K setting responded with "Acceptable." As for participant acceptability, two answered "Very anxious" at the first place, but they responded with "Generally reassuring" after the experiment. For the comparison questionnaire between on-site / remote, two preferred "On-site rehabilitation" at the first place but changed to "I will rather do it remotely" after the experiment.

Conclusions

We demonstrated telerehabilitation for remote consultation using a 5G communication system in an aging population of a rural, depopulated, mountainous area. Using 5G communication technology, we confirmed that multiple high-definition images can be transmitted with lower latency in telerehabilitation compared to LTE communication systems. We also confirmed that a motion capture system improved the subjective evaluation of the program.

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