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論文要約

Thesis Outline

With the invention of immersive technologies such virtual and augmented Reality, human perception space is shifting beyond their surrounding physical environments and many efforts have been put into increasing visual immersion and we have witnessed rapid increment in graphical fidelity and realistic physics computation. However, translating the sense of touch and weight into virtual spaces is still lacking. Loss of weight perception in virtual environments can mean the loss of critical information and at the same time the learning ability to perform tasks with accuracy. Then, how can we perceive weight from objects that we cannot physically interact with? A robust weight perception usually requires the combination of somatosensory and visual information. However, throughout our daily lives, there are situations where somatosensory information is not available, such as when avoiding a falling or incoming object.

There have been researches showing that haptic sensation is not the key element for weight perception. Visual cues, regardless of the existence of haptic sensation, could lead to the understanding of an object's weight. A classic example is the size-weight illusion which refers to the phenomenon when the larger of two objects of equal mass is perceived as weighing less than its smaller counterpart.

Our first study on virtual weight perception show a contradicting finding in that not all humans share the same motion-weight pairing. A virtual environment where participants control the steepness of a slope was used to investigate the relationship between sliding motion and weight perception. Our findings showed that distinct, albeit subjective, motion-weight relationships in perception could be identified for slope environments. These individualistic perceptions were found when changes in environmental parameters governing motion were introduced, specifically inclination and surface texture. Differences in environmental parameters, combined with individual factors such as experience, affected participants' weight perception. This phenomenon may offer evidence of the central nervous system's ability to choose and combine internal models based on information from

the sensory system. The results point toward the two possibilities: 1) relationship between muscle activity and virtual weight perception and 2) controlling human perception by presenting strong sensory cues to manipulate the mechanisms managing internal models.

Seeing objects in motion can also invoke motor responses such as muscle activation and arm movements which can result in the increase in muscle tension and joint torques. This means that without physically touching an object, we are capable of perceive and react to predicted weight. Therefore, arm movement and force can be the primary method of giving input in the virtual spaces where sensing an object haptically is not possible. We conduct another to determine if we can control muscle activation level without physical interaction and proposed an advanced security system where we developed a 4-digits numerical password system on an iPad using an EMG sensing device attached to the user's flexor carpi radialis for muscle activity sensing. While the result is positive with high accuracy, it also shows the ability to control muscle accurately without interacting with physical objects, which allows us to adopt EMG as a tool to verify if controlling virtual weight perception is possible.

Can virtual weight perception in human be controlled? We verified this possibility by designing a new human computer interaction which utilizes muscle activity to enhance perception. A virtual environment where participants control the placement of an object with different muscle stiffness states is used to investigate whether virtual weight perception can be controlled. Our findings showed the relationship between physical weight perception with virtual weight perception. Low stiffness allows greater sensitivity compared to high stiffness. This can be relate to the physical state of numbness and greater resistance which makes weight differentiation more difficult. Also, weights perceived in low stiffness are mostly perceived as heavier than weights perceived in high stiffness and vice versa. This experiment also hints us at how we can control weight perception.

The study helps improve our understanding of brain mechanism involving weight perception and hints us at the possibility of controlling or correcting perception via parameters like motion and muscle stiffness. The knowledge can be used and applied in many cases. For example, we can use this knowledge to counter perception illusions such as size-weight illusions both in physical and virtual environments. The examples of security applications and HCI for virtual weight perception raised as a part of this study may be only a fraction of what is possible.