MagTacS: Delivering Tactile Sensation over an Object

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ABSTRACT

A system that can deliver tactile sensation despite an object existing between an actuator and human was developed. This system composed of a control part, power part, output part, and coil. The control part controls the overall system using a microcontroller. The power part generates electric current to create a magnetic field. The output part delivers high energies to the coil. The coil generates a time-varying magnetic field to induce current flow within the body. Through the tactile sensation recognition test, delivery of tactile sensation was confirmed in the air even an object existed between actuator and human skin.

Author Keywords

Tactile sensation; time-varying magnetic field; magnetic stimulation

ACM Classification Keywords

H.5.2. Information interfaces and presentation: User interfaces: Haptic I/O.

INTRODUCTION

Contact-type methods that require physical contact between the actuator and skin are mainly used in haptic fields to present tactile sensation. Mechanical methods such as DC motor, servo motor, piezoelement, and von-frey filament, electrical methods using electrostatic or electric stimulation, and thermal methods using peltier element and foil are currently used to present three types of tactile sensation which are vibration, pressure, and thermal sensation [1].

However, the contact-type method can fundamentally present tactile sensation only when skin is contacted in which it is insufficient to be used in fields that emphasize user experience (UX) such as virtual or augmented reality and 3D or 4D interaction systems. Therefore, devices that present noncontact-type tactile sensation with methods using focused ultrasound and air-spray have been developed to improve the drawbacks of contact manner [2,3]. However, these methods have limitations such as short traveling distance, requirement of several ultrasound transducers, and occurrence of noise. Recently, a method that presents tactile sensation using laser has been developed [4]. This method radiates pulsed laser directly on the material attached on the skin surface for the human body to sense stress waves that are generated by thermoelastic effect as tactile sensation.

However, these noncontact-type tactile sensation-presenting methods have a common disadvantage that delivery of tactile sensation is difficult or impossible if an object is in between the actuator and human. In this study, a technique was developed which can present tactile sensation using time-varying magnetic field that is generated from electric coil despite an existing object.

BASIC PRINCIPLE OF MAGNETIC TACTILE STIMULATOR

All human body activities are controlled by electrical or chemical reactions. These reactions occur inside the human body, but similar results can be artificially generated outside the body by inducing equivalent or similar reactions.

Researches that induce tactile sensation by directly applying electric current to skin are being performed. On the contrary, the method proposed in this study uses an electric coil that is separated in a certain distance from the human skin to generate time-varying magnetic field. This magnetic field make a current flow by inducing electric field within the human body. This current can elicit a tactile sensation by activating nerve cells or mechanoreceptors of the skin. The schematic diagram of magnetically induced tactile sensation is shown in Fig. 1.

DEVELOPMENT OF MAGNETIC TACTILE STIMULATOR

The actual image of the magnetic field based tactile stimulator is shown in Fig. 2.

The developed system is composed of 4 parts including the control part, power part, output part, and coil part. The control part controls operation of the total system using a microcontroller. The power part generates high DC (direct current) voltage to generate magnetic field and the energy is stored in the capacitor. The output part delivers high voltage and current to the coil in short time by using a silicon-controlled rectifier (SCR). The coil was made in a disk shape by winding copper wire and the size is 13 cm in diameter. The size of the total system without the coil is 60 x 30 x 20 cm^3 (W x L x H).

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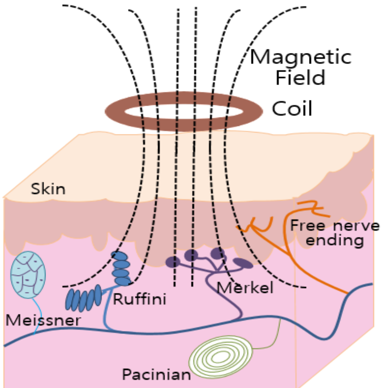

Figure 1. Schematic diagram of tactile sensation induced by magnetic field.

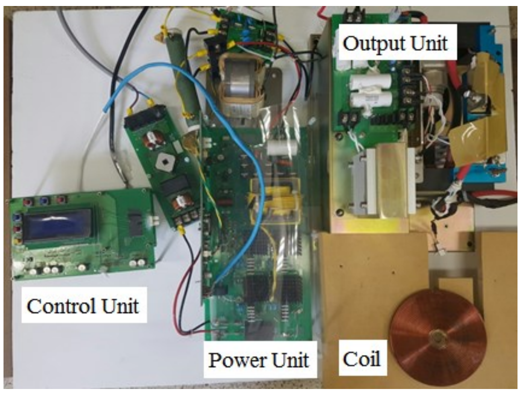

Figure 2. Overall configuration of Magnetic Tactile Stimulator

TESTING THE TACTILE SENSATION USING MagTacS

Using the developed system, tactile sensation recognition test was conducted according to the type of object (lumber, corrugated cardboard, paper box, acryl panel, and book) that was placed in between the coil stimulator and hand (Fig. 3). The test subject and coil were blocked with a black curtain to block visual information. Delivery of tactile sensation was checked by electrical sensation in the normal direction of the coil simulator separated by distance of 10 cm. The waveform of the time-varying magnetic field measured by the searching coil at hand position is shown in Fig. 3 (g).

CONCLUSIONS

A magnetic field based tactile sensation presenting technique was developed in this study. Through comparison with existing tactile stimulator systems, it was confirmed that tactile sensation could be presented in air and delivery of tactile sensation was possible even with an object in between the actuator and body. Research on various tactile sensation stimulations such as vibration and pressure sensation is additionally required in the future by controlling parameters such as strength, frequency, and stimulation time of magnetic field.

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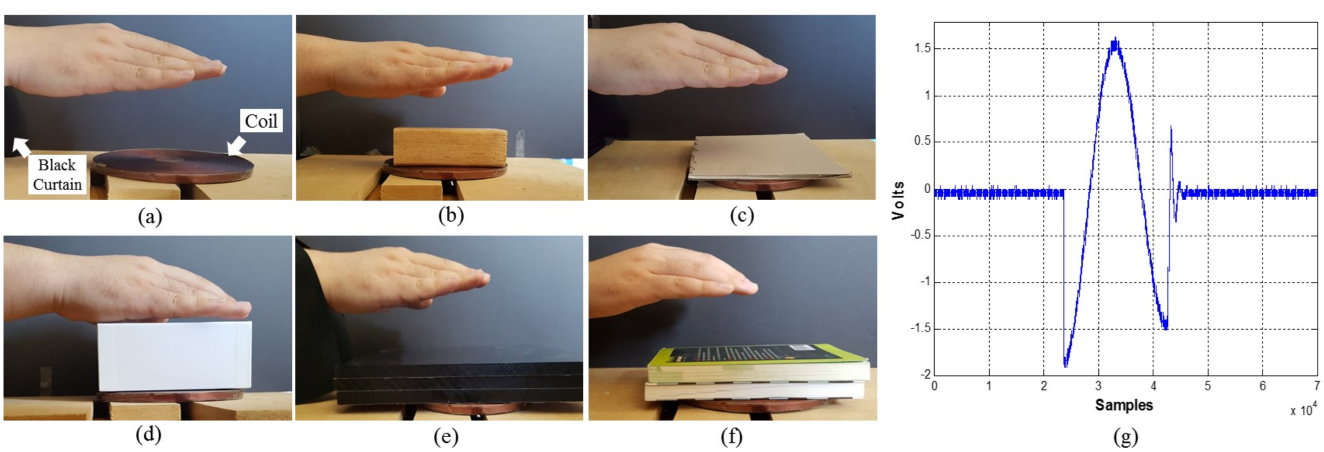

Figure 3. Tactile sensation delivery test according to type of object (a: air, b: wood, c: corrugated cardboard, d: paper box, e: acryl panel, f: book) and time-varying magnetic field measured at hand position (g)