Haptic Feedback Provided by 3D Printed Shoe Insoles*

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I. Introduction

In this study, we conducted a basic research to design haptic feelings that users are looking for in digital technology. Concretely, we studied designing haptic feedback for shoe insoles manufactured with a 3D printer.

Recently, attempts have been made to develop medical insoles using various methods [1]. Among them, research on the use of 3D printers has been remarkable. The rise of 3D printers has made it possible to digitally design and build physical entities that can present not only audiovisual but also tactile stimuli. A 3D printer can continuously vary the design parameters of the object to be modeled. By leveraging this technical advantage, we can learn the design parameters that can dominantly manipulate the feel of natural objects around us through the study of digitally recreating them. In other words, a 3D printer can be regarded as a device that can produce not only the shape of an object but also the feel of the object in a variety of ways. In recent years, it has become possible to easily produce real three-dimensional objects with complex mechanical properties by forming objects with internal geometric structures called "architected materials" [2]–[4]. By creating 3D-printed objects with architected material as a lattice structure, one can change the haptic feedback of an object in a variety of ways.

In the following section, we describe an actual case study of the production of an insole using a 3D printer.

II. Development

Each architected material (microlattice structure) was prepared with an adjusted design parameter. OpenSCAD [5] can generate 3D structures via scripting, and the structures can be designed parametrically. In this study, columns were placed on the unit cell based on the body-centered cubic structure and the pattern shown in Fig. 1a. In this study, the pillar thickness of the columns of the lattice structure was varied in three levels (L40, L60, L76) [4]. A total of 27 insoles were designed on the computer, each with a different combination of models (three pillar thickness $\times$ three different parts, $3 \times 3 \times 3 = 27$ combinations; (Fig. 1b, c, d) placed at the toe, arch, and heel. Twenty-seven different insoles were designed on CAD and manufactured by a 3D printer as an integrated unit (Fig. 1e, f). UV-cured urethane elastomer EPU41 (Carbon Inc., Redwood city, CA, USA) was used for UV modeling using an L1 photo-curing 3D printer (Carbon Inc., Redwood city, CA, USA).

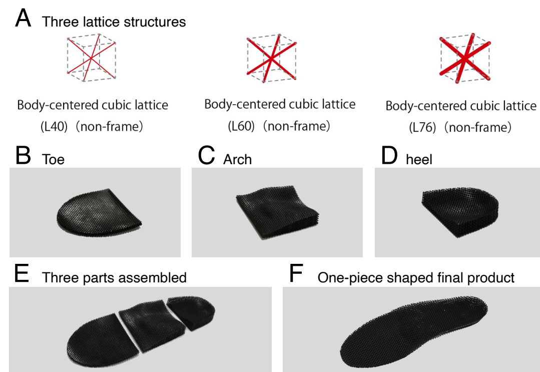

Fig. 1. Design parameters of insole sample with internal structure. (a) Each model has a different pillar thickness; (b) toe; (c) arch; (d) heel; (e) Each part of the insole is assembled; (f) One-piece shaped final product.

We are currently conducting a study on the differences in haptic feedback to the soles of the feet given by the 27 types of 3D-printed insoles that we have reported here. In particular, the authors consider it necessary to study the effects of different insole hardness on human haptic impressions through a combination of mechanical property measurements and subjective evaluation experiments.

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