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Building a haptics design platform for product tactile design *

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I. Introduction

Product surface textures are elements that significantly influence not only visual beauty and functionality but also users' tactile experiences. In diverse product fields such as automotive interiors, cosmetic cases, tableware, and packaging, it has been reported that the tactile feel of surface textures contributes to product evaluation and purchasing behavior [1][2][3]. As performance- and function-oriented products mature, the satisfaction and happiness derived from texture, i.e., sensory quality, has become an important added value that creates competitive advantage [4].

Traditionally, tactile design has been conducted through a process of "design → prototyping → user evaluation," with prototyping and user experiments being time-consuming and costly. In response, methods have been proposed that predict tactile sensations using 3D shape data such as height maps [6]. However, these methods target the average evaluation of all test subjects, failing to reflect the fact that tactile sensations depend on individual preferences and experiences [7], and they also have the limitation of not including material properties such as elasticity and friction coefficients.

On the other hand, in the marketing field, it is well established to segment consumers by attributes such as age, gender, and preferences, and optimize product strategies for each target group. For example, in the case of smartphone cases, it has been shown that differences in tactile preferences based on customer attributes influence purchasing intent [8].

Furthermore, previous studies such as "Perceptually Relevant Browsing Environments for Large Texture Databases" [9] and studies showing the influence of fingertip size on tactile spatial resolution [10], there are previous studies pointing out the importance of browsing and physical properties of texture databases. However, there are no reports of an integrated platform that combines user attribute segment information and physical property information in tactile estimation and generation models, and further enables quality confirmation including color and lighting by attaching height maps to 3D models.

This study aims to fill this gap by proposing a "haptics design platform" that enables the generation of height maps with desired tactile sensations and the visual verification of height maps on 3D models, based on a tactile estimation model that incorporates user attribute segments and material properties. Ultimately, the goal is to bring tactile variation to product development in the same way as color variation. Furthermore, this research seeks to enhance consumer interest in tactile sensations, promote the adoption of tactile design in product development and sales, and contribute to the practical application of related technologies such as tactile reproduction devices.

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II. Haptics Design Platform Overview

The "Haptics Design Platform" (Fig. 1) is a cloud-based system that allows access to many functions via a web browser. It enables digital simulation of tactile and visual sensations during product planning and design for brand owners, significantly improving the efficiency of tactile design. Additionally, by integrating digital simulation data with material processors, it facilitates smooth prototyping through actual molding and laser processing. These features improve the overall product design workflow and provide a foundation for developing tactile variations.

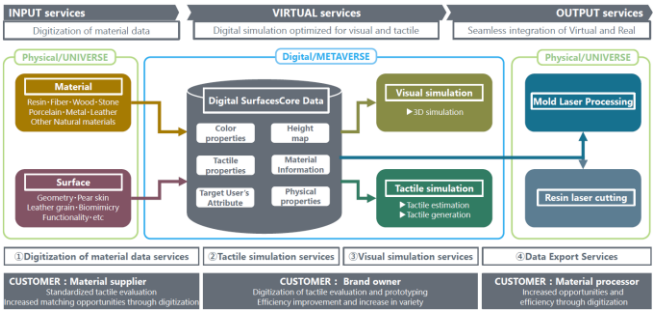

Figure.1 haptics design platform

1. Digitization of materials

Digitize various materials from material manufacturers into standardized items with physical property information and visual photos. In particular, for resin materials that can be surface-processed using molds and lasers, follow the research by Imaoka et al. [6] to evaluate the tactile sensation after surface processing using height maps (Fig. 2) and construct a model for estimating tactile sensation. (Fig. 3)

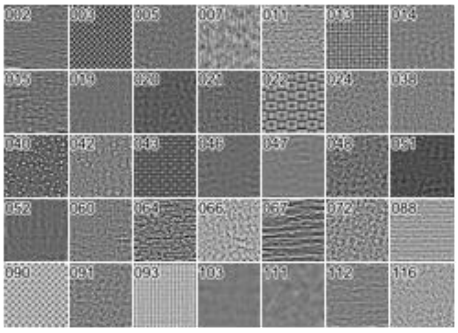

Figure.2 35 heightmaps selected from Pertex

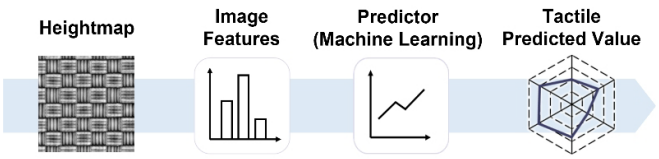

Figure.3 Tactile estimation method

In addition, when evaluating tactile sensations, we refer to the study by Nakanishi et al. [11] and collect data on subject attributes (Table 1) to enable segmentation of subjects and improve the accuracy of tactile sensation estimation by specifying targets during product design.

Table1. Attribute information questionnaire.

Category	Item	Question
Statistical Attributes	Gender	Please tell us your gender (Man/Woman).
Psychological Attributes	Risk Preference	When you usually go out, at what percentage of precipitation probability do you decide to bring an umbrella?

Table2. Definition of each segment.

Category	Segment Variable	Segment
Statistical Attributes	Gender	Man Woman
Psychological Attributes	Risk Preference	Risk Lover : Precipitation Probability > 50% Risk Neutral : Precipitation Probability = 50% Risk Avoidance : Precipitation Probability < 50%
	Personality	[Big Five] - High : Above Average [Big Five] - Low : Below Average

2. Visual and tactile simulation

In this study, we have implemented the prototype UI shown in (Fig. 4), and users (assumed to be product designers belonging to product owners) can intuitively operate attribute selection, tactile indicator settings, and texture adjustments on the screen.

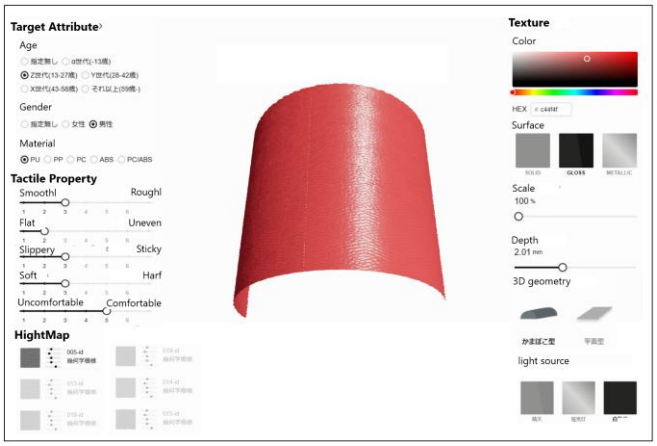

Figure.4 haptics design UI

III. CONCLUSION

The prototype of the "Haptics Design Platform" was presented to product owner companies, surface designers, and material manufacturers who are the intended users, and received very positive feedback. In particular, the method based on target user attribute information has shown improved accuracy in tactile prediction, which is well-suited for setting target personas in product development, thereby increasing expectations for practical application.

Going forward, we plan to incorporate a tactile prediction method based on material property information to further align the platform with product development workflows. Additionally, since user segmentation based on attributes requires a large amount of test subject data, we aim to collect extensive tactile evaluation data to accelerate the early service launch of the Haptics Design Platform.

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