令和３年度　未来研究ラボシステム　研究成果報告書

研究種目：共同研究　　研究期間：令和２年１０月～令和４年９月

研究課題名：フード3Dプリンターと人工知能を使用して食事体験を向上させる計算フードテクスチャ

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研究成果

This joint-collaboration project is a part of Japan Science and Technology (JST) project that aims to improve the quality of life (QOL) through the emerging technology such as food 3D printing and Artificial Intelligence (AI). We proposed a novel food technology that physically augmented target food by generating food texture on the different types of food using a food 3D printer. To allows the system to estimate the food textures to be printed, we utilized the knowledge on mouthfeel perception and human biological through jaw movement, and put it together using supervised learning method. Hence, we create food that users want to eat but do not have the opportunity to eat due to the allergies or other physical health conditions. For example, we produce the cookie that embed with beef-like food textures so that it could reproduce the beef experience. This annual report summarized a recent work in progress of this project, included (1) the dataset acquire process through user study, and (2) annotating taste indicators and converting word vectors.

1. Dataset Collection through User Experiment

In order to understand the relationship between food 3D printing parameters and food textures with mouthfeel (e.g., dry, hard, supple, smooth, sweet, bitter and sour), we have conducted the user experiment and create the end-to-end model that learns these relationship. To do so, the experiment is conducted by 3D printing cookie (as the focused food in this context) with different internal structure as 50% infills included; honeycomb, hilbert and rectilinear (Figure 1). We collected the jaw movement through EMG sensor and the mouthfeels through post-questionnaire. The experimental results from 72 participants are shows in Figure 2. The higher score shows the magnitude estimation more likely to the mouthfeel and vice versa. For example, the rectilinear

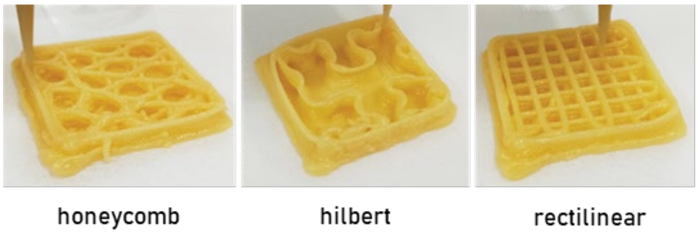

Figure 2 3D printed cookie with different internal structure.

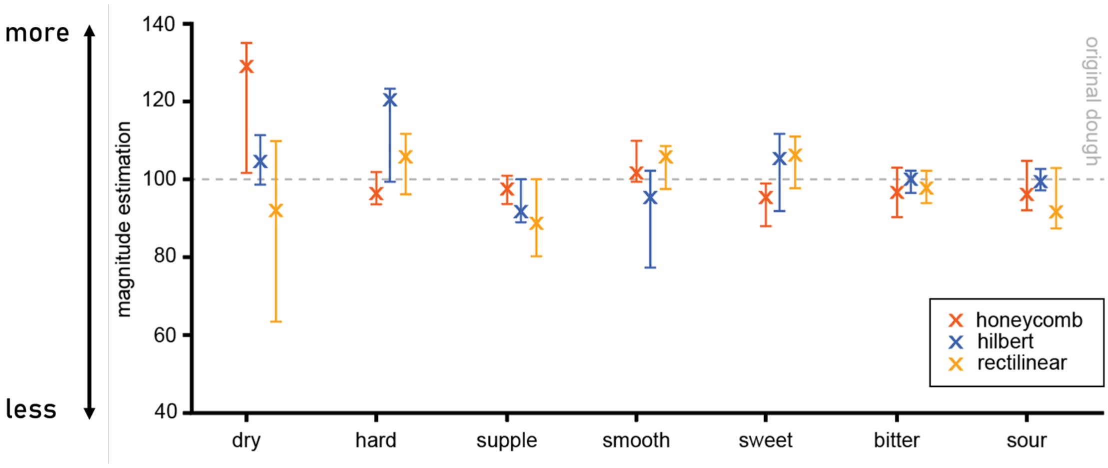

Figure 1 Magnitude estimation results on the relationship between food 3D printing parameters and mouthfeel.

cookie seems less dry compared to the honeycomb cookie when judge through the commercial available cookie as the reference. In addition, the sample (e.g., rectilinear) jaw chewing measurements results shows in Figure 3. The participants seems to consume the cookie with the similar patterns especially the amplitudes recorded in the jaw pattern.

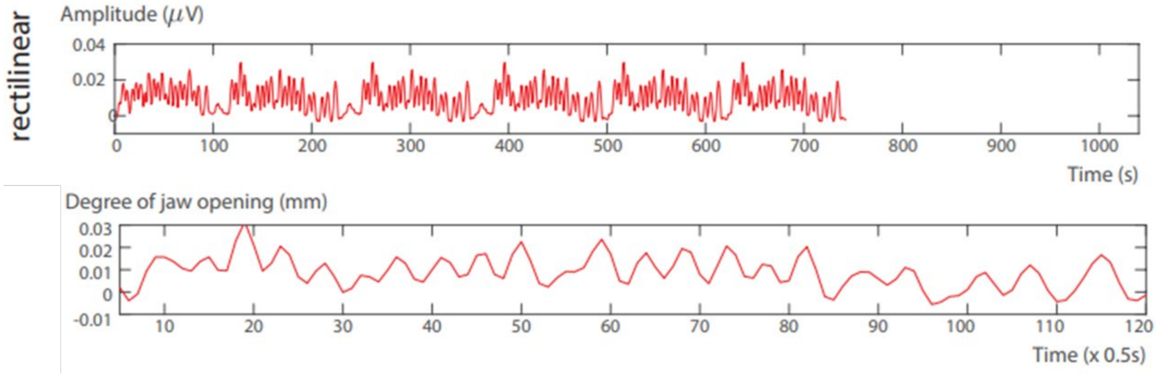

Figure 3 Sample recorded of jaw movement of participant when consuming the cookie with rectilinear internal structure.

2. Annotating Mouthfeel Indicators and Converting Word Vectors

We then create the training model that input the jaw movement and mouthfeel and predict the printing parameters and generate 3D printing internal structure based on the input food texture. As shown in Figure 4, the training model take the printing pattern to extract the mouthfeel, infill parameter, and infill density then wrap-up the g-code for 3D printing machine. We conduct the

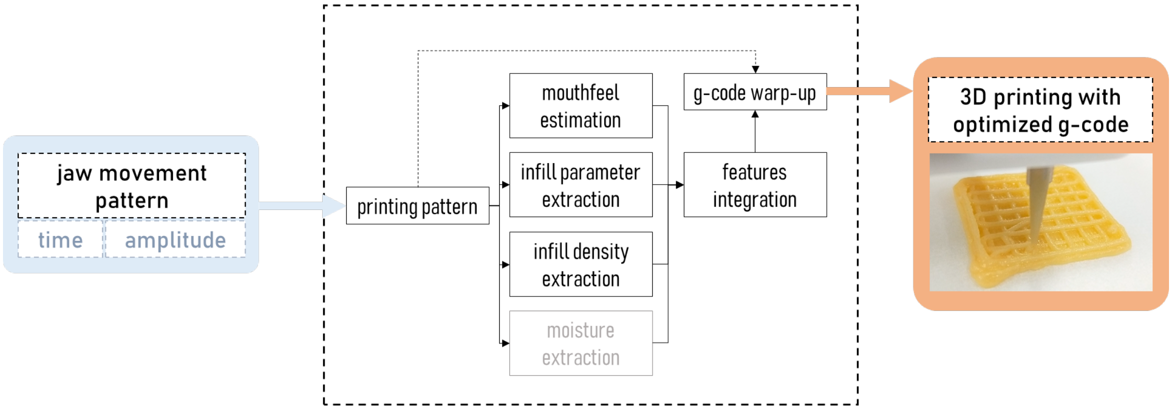

Figure 5 training model that take the jaw movement and mouthfeel as an input to generate 3D printing parameters.

short experiment to verify our training model through the back propagation (e.g., generated the 3D printing model from the network and conduct the user experiment to verify). Figure 4 shows the experimental results from 62 cases. The experimental results shows that the training model has closed to 90% prediction rate, which is high enough to predict the 3D printed output.

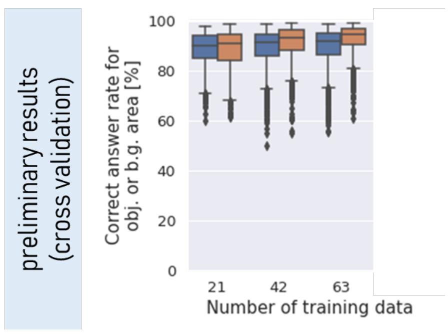

Figure 4 Validation results from the training model.

For the remained steps, we plan to build up the target perception model that allows end-to-end from the target food (e.g., commercial cookie) to the 3D printed output in the future work of this research. Also, to allow the end-to-end fabrication that allows the human-in-loop interaction, we will build up the food design platform that would allow the user to design the food they want from the input food parameters (e.g., mouthfeel, and type of cookie).

キーワード：Food 3D Printing, Eating Experience, Mouthfeel

研究経費（R3 年度）の内訳

備品費	消耗品費	旅費	謝金	その他	合計
17,394 円	4,577 円	0 円	1,894 円	27,271 円	53,029 円

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- 宮武大和・基礎工学研究科・博士前期課程 2 年

発表論文等（令和 4 年 3 月 31 日現在）

〔雑誌論文〕

- Pat Pataranutaporn, Valdemar Danry, Joanne Leong, Parinya Punpongsanon, Dan Novy, Pattie Maes, and Misha Sra. AI-generated Characters for Supporting Personalized Learning and Well-being. Nature Machine Intelligence (2021) Perspective. December 2021.
- Motoki Miyoshi, Parinya Punpongsanon, Daisuke Iwai, and Kosuke Sato. SoftPrint: Investigating Haptic Softness Perception of 3D Printed Soft Object in FDM 3D Printers. Journal of Imaging Science and Technology (Proceedings of Printing for Fabrication 2021), Vol. 65, No. 4, pp. 40406:1-40406:8(8). July 2021.

〔著書〕

なし

〔学会発表〕

- 宮武大和、プンポンサノン・パリンヤ、岩井大輔、佐藤宏介. 3D プリント食品内部への情報埋め込み. 第 84 回情報処理学会全国大会, 情報処理学会, 2022 年 3 月.

〔その他〕

なし

外部資金獲得状況・申請状況

JST ACT-X (AI 活用で挑む学問の革新と創成), ［採用］2020 年 12 月～2023 年 3 月

参考となるＨＰ等

https://www.sens.sys.es.osaka-u.ac.jp/