TTTV4: Cutlery-Type Taste Display Toward Personal Taste Media

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Figure 1: (Left) Our proposed hardware and software. (Center) The hardware is equipped with five tanks, five pumps, and one M5StickC Plus 2. (Right) The system can produce a variety of tastes by mixing five basic taste solutions in each bite.

Abstract

This paper introduces a cutlery-type taste display, TTTV4, that aims to realize the concept of "personal taste media." This device enables users to enjoy their desired taste with each bite, thereby personalizing taste content. This system enables users to easily use taste displays during meals, contributes to expanding the target users of taste displays from food creators to consumers. Accordingly, we discuss hardware performance in the context of speed and accuracy requirements arising from this shift. To explore interfaces suitable for a wide range of users, we developed two prototypes based on direct manipulation and interface agents.

CCS Concepts

• **Human-centered computing** → *Human computer interaction (HCI).*

Keywords

Human-food interaction, Taste reproduction, Flavor mixing, Cutlery device

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1 Introduction

Food serves not only as a means of nutritional intake but also as "taste content" that allows people to enjoy preferred flavors as entertainment. Currently, the food and beverage industry primarily operates under a mass media model that provides uniform taste experiences to many people. In contrast, the audiovisual domain has undergone a major shift toward "personal media," where users can freely search for desired content and AI can generate experiences tailored to each person, like SHOWRUNNER[1]. The purpose of this research is to apply this concept of personal media to the taste media, enabling each user to enjoy the flavors they desire.

To achieve this, various studies on taste displays or edible user interfaces [3] have been conducted. For example, the Norimaki Synthesizer enables control of taste through electrophoresis [4], and the TTTV series [5–9] and Virtual Flavor [1] enable control of taste by mixing taste solutions. These technologies have extended the eating experience by presenting arbitrary tastes, tasting allergens, tasting poisonous foods, and taste interaction with LLMs. However, these studies have focused on the performance of presenting tastes, and have not focused on the usability when users actually use taste displays in their eating experiences.

The concept of more personal use has also been explored. MIDAS SPOON [2] and Chronospoon [10] present specific seasoning liquids from spoons, and Füpop [12] changes taste by bursting capsules in the mouth. However, these studies present pre-prepared tastes and have not mixed multiple basic tastes to generate arbitrary tastes.

Based on this background, this research proposes a cutlery-type taste display, TTTV4 (Figure 1 Left). TTTV4 incorporates taste solutions corresponding to five basic tastes and enables dynamic taste presentation by mixing them for each bite (Figure 1 Right). This allows users to create their own taste with each bite while eating, providing a personal taste experience. Moreover, we realized "low-risk taste presentation" that allows changing the taste of each bite without changing the taste of the entire dish.

The contribution of TTTV4 extends beyond miniaturization; it also expands the target users of taste displays from food creators to consumers. This is because while previous taste displays have focused on the functions of the taste mixing, TTTV4 focuses on enabling a wide range of users to utilize taste displays. This expansion brings new engineering and design challenges. Specifically,

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[1] https://www.showrunner.xyz/

the speed-accuracy trade-off necessary for completing taste presentations within the timeframe between scooping food and bringing it to mouths is a significant concern. Additionally, designing an intuitive UI that allows diverse users, from experts to beginners, to easily operate the device becomes important. This paper discusses these challenges concretely and deepens considerations toward realizing personal taste media through the prototyping-analysis.

2 Design and Evaluation

2.1 Hardware Interface

Realizing personal media requires a device seamlessly integrated into individual eating behaviors. Therefore, we prototyped TTTV4, which transforms everyday cutlery into a taste display.

2.1.1 Output Unit. TTTV4 incorporates five tanks (5 ml capacity each), five piezoelectric micropumps (SDMP306D), and a microcomputer for control (M5StickC Plus 2), see Figure 1 Center. Each tank is filled with solutions corresponding to the five basic tastes (sweet: sweetener, salty: sodium chloride, umami: monosodium glutamate, sour: lactic acid, bitter: potassium carbonate). The M5StickC Plus 2 independently controls each pump through relays, adjusting the output amount of each solution based on operation time. The released solutions mix on the spoon, generating a customized taste for each bite. The pumps can output approximately 0.12 ml of solution per second.

2.1.2 Output Accuracy. To verify taste output accuracy of TTTV4, we conducted a sensory evaluation experiment changing milk taste to "clam chowder" and "strawberry milk" (n = 5). In addition, approximately 50 people experienced a similar demonstration at the workshop. Participants provided positive feedback such as "it's interesting how the same milk changes taste" and "if you tell me the dish name, I can recognize that taste." This confirmed that the device has reasonable taste reproduction accuracy. Simultaneously, it suggested that reproducing complex food flavors may require combination with other sensory modalities such as smell.

2.1.3 Output Speed. The delay until pump operation was 0.8-1.1 seconds, and the pump operation time itself was 0.7-7.0 seconds, resulting in a total time of 1.5-8.1 seconds from user input to taste output. Although this is shorter than previous devices [3, 5, 7, 9], it still poses a significant challenge for the "taste presentation during meals" use case.

2.1.4 Speed-Accuracy Trade-off. The output speed and accuracy of TTTV4 are governed by a trade-off dependent on taste solution concentration. High-concentration solutions enable rapid taste changes but make fine adjustments difficult. Conversely, low-concentration solutions enable precise expression but require more time to reach target tastes. Dynamically managing this trade-off based on user context (e.g., eating quickly vs. savoring slowly) remains an important challenge for future research. Another important future research direction is developing methods to determine concentration based on users' taste discrimination thresholds.

2.2 Software Interface

To enable diverse user groups to utilize TTTV4, appropriate software interfaces are essential. We prototyped two systems based on two established user interaction paradigms: direct manipulation and interface agents.

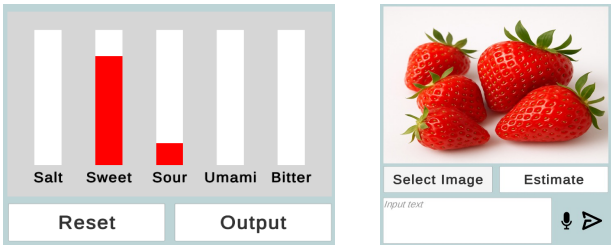

Figure 2: (Left) Direct manipulation based UI. Users can manipulate taste with sliders. (Right) Interface agents based UI. The agent (LLM) estimates taste from text or image input.

2.2.1 Direct Manipulation Based UI. For expert users or those who want to explore taste through direct control, we implemented a GUI with sliders controlling the output of each of the five basic tastes (Figure 2 Left). This method provides users with strong control and direct responsibility for results [11].

2.2.2 Interface Agents Based UI. For users without specialized knowledge or those who want to enjoy tastes more casually, we implemented an interface utilizing a LLM, specifically GPT-4o (Figure 2 Right). When users provide ambiguous instructions such as "more fruity" or show images of desired dishes, the agent (LLM) interprets the input and estimates the corresponding composition of the five basic tastes. This process removes the cognitive load of devising taste combinations from users. In tests, plausible taste estimations were possible even for ambiguous inputs, such as the system proposing to add saltiness and umami in response to "strengthen crab flavor." It seems reasonable given that crab naturally contains these taste components. However, we also observed a lack of consistency in the outputs for identical inputs. We found that this lack of consistency can improve by incorporating few-shot learning with our dataset that represents foods in terms of the five basic tastes.

3 Discussion

TTTV4 embodies the concept of "personal taste media" by enabling bite-by-bite taste output. By enabling cutlery-type taste display, it allows many users to control taste with their own personal devices, and tailored their taste experiences to personal preferences are promoted. Through this, we attempted to expand the target users of taste displays from food creators to consumers.

One contribution of this research is introducing the new value of "low-risk taste presentation." Changing the taste of an entire dish is an irreversible act that cannot be easily undone once failed. However, with bite-by-bite taste presentation, undesirable tastes can simply be changed or reverted in the next bite. This psychological safety net encourages users to embark on bolder and more creative taste exploration without fear of failure.

From a software perspective, we gained the insight that just as taste preferences vary among individuals, preferences for interfaces controlling them also depend on the individual. Some users might

want to delegate most tasks to agents while performing final adjustments themselves. Others might find even the simple input methods currently implemented, such as voice or image input, cumbersome.

In conclusion, this research implemented a prototype for realizing "personal taste media" and examined hardware and software through usage experiences. This research's key contribution lies not merely in performance evaluation and applications as a taste display, but in delving into user-centered interface design including low-risk taste presentation and individualized UI. Thereby bringing new perspectives to UI design necessary for personal taste media.

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