Intelligent Multi-sensory Food Experience with Visual and Smell simulation devices

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The field of virtual food experience has evolved a lot in the recent times with visual, taste, and smell simulation devices. However, most of the work aims only at multi-sensory experience, not much at making the multi-sensory experience adaptive and intelligent. We propose a user experience which combines the power of artificial intelligence and multi-sensory experiences together to create intelligent multi-sensory experience. The proposed experience uses scent generation devices with food visuals to create the experience. Such experience can be used by consumers in food product selection for making purchase decision. This can also be used by food scientists and food testers to rank food samples while creating and validating new recipes. Our initial study demonstrates promising results.

CCS CONCEPTS • Human-Computer Interaction • Artificial Intelligence

Additional Keywords and Phrases: Virtual Reality, Flavor Profiling, Food Innovation, Smell Simulation, Immersive Experience

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1 INTRODUCTION

Food and Beverages (F&B) firms are witnessing increased demand of healthier, personalized, and sustainable food options from consumers [1]. However, there are a lot of challenges that need to be addressed when it comes to meeting consumer needs and understanding consumer response on their products. First, with the increased demand in customized food products, understanding consumer flavor preferences has become very important. Second, they need to create sustainable, nutritional food recipes which are also pleasant. To arrive at new food recipes, flavorists and food-scientists use such insights [2]. Third, firms need to conduct faster user acceptance testing and get more concrete feedback from consumers so that they can improve their products in a better way.

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Understanding consumer's response on various products is challenging as it is dependent on physical food samples [4,15] and consumer ratings which are often subjective. Moreover, the physical samples need to retain their taste till the point they are consumed. A virtual simulation experience can help alleviate this.

In this paper, we propose an intelligent multi-sensory experience, that can be used by consumers to virtually taste food recipes and rank them. The proposed experience, as shown in Figure1, works as follows: 1) Flavor profiling and recommendation: helps in understanding user's flavor preferences (step 1 and 2). In this experience, users are presented with a set of questions about their liking for a curated list of food products. This information is used to arrive at consumer flavor preferences which is further used to recommend food products matching to the customer flavor preferences. 2) Multi-sensory experience presents the recommended food products in a virtual reality environment along with olfactory simulation (step 3). 3) Recipe variant creation experience helps users in creating variations in the recipes by changing the ingredients quantity to suit to their liking (step 4). The new recipe can be saved by the users which can be further used by food and beverage (F&B) firms to understand consumer response on new recipes and the variants suggested by consumers.

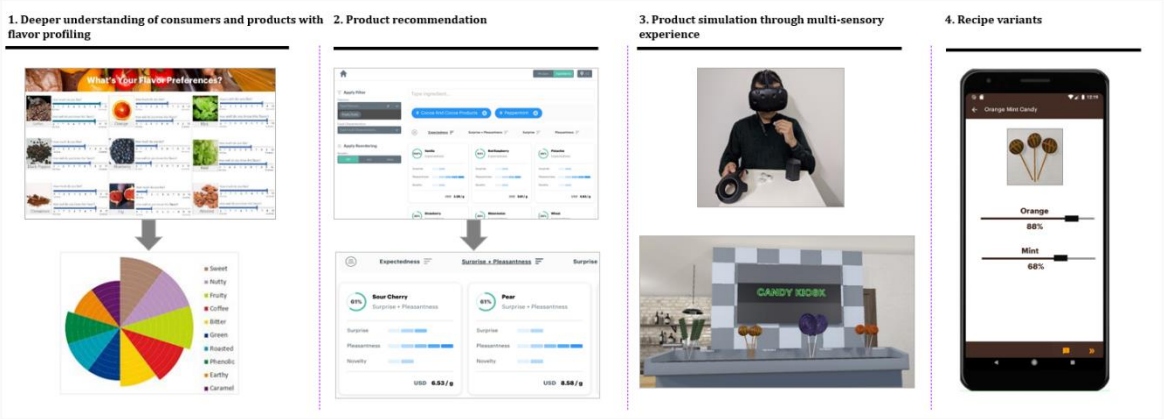

Figure 1: Intelligent Multi-Sensory Food Experience

The main focus of the paper is to evaluate feasibility of multi-sensory experience for food simulation. We conducted a set of preliminary experiments, primarily to assess the feasibility of the multi-sensory experience. Our primary aim was to study the influence of various sensory inputs on food perception and their relative ranking on pleasantness in virtual environment. We evaluated how often the human's actual food preference matches with the preference when the food products are experienced in virtual environment without any textual description. Our initial results were promising as the preferences matched 78% of time. The main contributions of this paper are: 1) An intelligent multi-sensory food experience that recommends food products to users based on their flavor preferences; the recommended product can be virtually simulated, and variations can be explored by the user to suggest changes in the recipes and 2) A preliminary user study to assess the multi-sensory experience.

The rest of this paper is structured as follows: Section 2 discusses the related work. The details of the proposed method on intelligent multi-sensory food experience are described in section 3. We present the experimental setup and user studies in section 4. In section 5, we discuss results and limitations. Finally, section 6 concludes the paper with future work.

2 RELATED WORK

We present here the related work along two main topics: first on intelligent flavor profiling and second on virtual simulation devices for food products.

Flavor profiling: Flavor is the central aspect when it comes to understanding consumer choices and recommending them food products [3,17]. We find a lot of efforts around flavor profiling [6, 14, 15, 16]. Most of the existing flavor profiling and food recommendation systems are based on either a high-level ingredients list or the data about consumer liking from review websites. Our recommendation engine looks at the recipes' composition at the flavor molecule level to create flavor profiles for recommended food products.

There are several evidences how multiple senses play critical role in food perception [6,7, 13, 19]. Researchers have proposed multi-modal and cross modal experiences [5, 8, 9, 11, 12]. Most of the systems focus either on virtual simulation or on recommendation. We propose a system that combines artificial intelligence-based recommendation system with multi-sensory experience to create a unique experience.

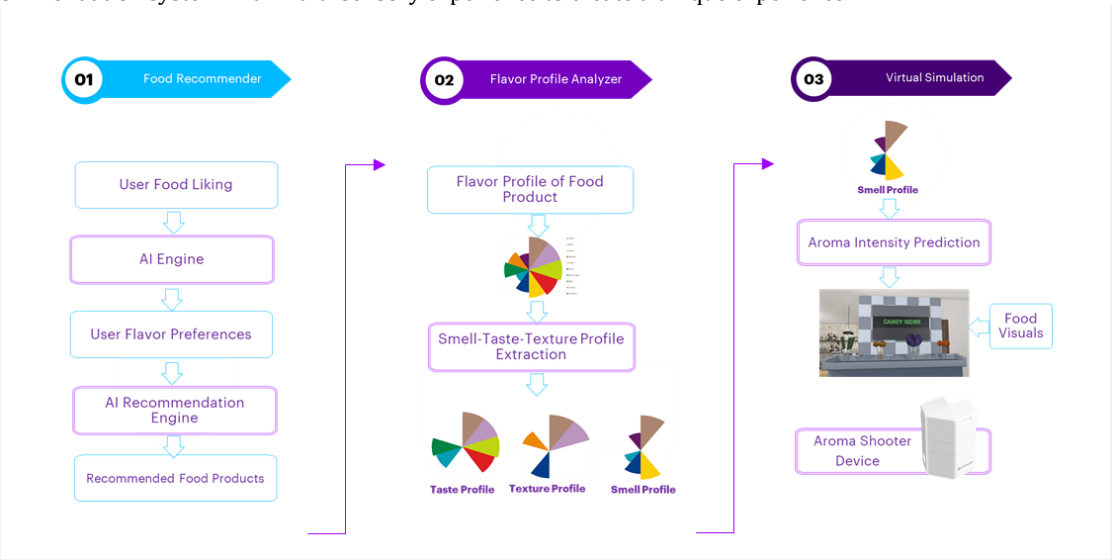

Figure 2: Intelligent Multi-Sensory Food Experience Workflow

3 PROPOSED SOLUTION

Multi-sensory food experience with IMOSK (Intelligent Multi-sensory Kiosk):

IMOSK (Intelligent Multi-sensory Kiosk) is an AI-assisted VR application that can be used to experience food products in a multisensory environment. The proposed system consists of three components as shown in Figure 2:

Food recommender: Food recommender takes users likings as input, uses an information retrieval approach to assess the contribution of different flavor molecules found in the food product, and arrives at user and food product flavor profiles (step 1). The information about flavor molecules is obtained from publicly available databases such as flavorDB [10]. A food product is recommended to a user if the food product flavor profile matches with user's flavor profile. We utilize TF-IDF feature vector and cosine similarity score to match the flavor profile of food products with user's flavor preferences.

Flavor profile analyzer: The perception of food is all about flavors, and flavor is a multisensory construct that includes scent, smell, and taste. This module analyzes the flavor profile and identifies which parts constitutes taste, texture, or smell (step 2).

Virtual Simulation: This module creates a virtual simulation with a VR environment (HTC Vive) and scent emitting device (step 3). We used Aroma Shooter, a system for scent generation. One device consists of 6 aroma cartridges. Single or multiple devices can be configured for generation of aroma blends.

4 EXPERIMENT SETUP AND USER STUDIES

We conducted the evaluation with 12 subjects (eight female and four male) to assess the system. The subjects were in the age group of 30-45. Subjects were first asked about their food preferences from a curated list of food items. We drew the relative ranking of the food products from the user responses and used that as a ground truth.

We conducted our study on three types of virtual experiences, i.e., 1. Food experience with only olfactory simulation 2. Food experience with olafactory and 3D visuals, 3. Food experience with olfactory and 3D visuals augmented with physical food consumption. Subjects were asked to browse the food products using VR application and visualize its 3D view. Product names were not disclosed. Upon the selection of a product, the scent generation module synthesizes the fragrance corresponding to the product. As continuous scent simulation induces olfactory fatigue, an interim break was given to participants to prevent this. The aroma shooter device was diagonally put towards the user at a distance of 60 cm from subject's nose.

Four produts were chosen for the virtual simulation: 1) Blueberry Mint Candy, 2) Orange Mint Candy, 3) Blueberry Candy and 4) Orange Candy. These products were selected as orange and mint are the most common candies flavors. As few subjects had no experience of blueberry flavors earlier, this selection has also helped us in understanding how subjects feel about experiencing a new flavor. Moreover, to study user experience for blend of aromas, we chose mint as third flavor that naturally goes well with either of these two. The subjects went through the three experiences as discussed earlier to experience these products and ranked the products based on their perceived pleasantness. The subjects were asked to rate their flavor experience using IMOSK quantitatively (on a scale of 0-10, 0 being not liked at all and 10 for liked a lot). We requested the subjects to give a relative rating for all the four products.

5 RESULTS

About 78% users ranked the food products in the same order as derived from the ground truth. We started with the hypothesis, that the ranking from virtual simulation is not related to the ground truth. However, using rank correlation matrix, our hypothesis was rejected as the results showed strong correlation between ground truth and the ranking obtained from the three virtual experiences. 83% users expressed that they liked the experience and the multi-sensory experience helped them in understanding the products better. One of the subjects gave feedback as follows "Experiment-3 was the most informative, and I felt that initially orange flavor was not recognizable just with smell. It became more prominent after consuming sample and experiencing the same."

6 CONCLUSION AND FUTURE WORK

We proposed a system for flavor profiling along with multi-sensory simulation devices. The proposed system has multiple applications; for instance, it can be used by food scientists to experience new recipes. Restaurants and food retailers can use this system for personalized aroma being emitted based on customer flavor profile; this can trigger more sales. Our initial results show great promises. However, there are some threats to validity. Firstly, the experiments are conducted on a limited number of subjects due to the unavailability of subjects. In addition, the assessment done by individuals on survey questions can be subjective. Secondly, the flavor is experienced better if aroma passes through retronasal passage. Although, we instructed the participants to keep their mouth open while chewing the sugar candy in the third virtual experience, there may be variations in the aroma and sweetness of sugar blending in their mouth. Lastly, we used very limited flavors for our experiments. In the future work, we plan to extend IMOSK with virtual taste simulation and texture based haptic simulation, which will further enhance its capabilities. We also plan to conduct it on a greater number of flavors.

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