Supporting Novice Cooks through Sensor-Enhanced Computing Technologies

Sen Hirano
University of California, Irvine
Department of Informatics
sen.hirano@uci.edu

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Abstract
Novice cooks routinely encounter problems with the execution and timing of recipe steps due to information not embedded in the recipe. In this paper, I describe research exploring how to help people, particularly novices, improve their cooking. I am currently exploring the viability of using various ubicomp technologies to detect cooking processes. Long term, I expect to develop a system that presents information and help while cooking using data from kitchen tools, environmental sensors, and user feedback as well as information from a broader community of users.

Author Keywords
Electronic nose, gas sensors, activity sensing, learning.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
The sense of smell is the primary method many animals use to infer information about their environment. Although human noses are less developed, it is still a sense we rely on heavily. Novice cooks are particularly interesting, because unlike professional chefs, they are

unsure of what skills to use and how to apply them even when trying to follow a recipe. Problems with execution and timing of recipe steps often result from lacking information such as, what 'browned' or 'shimmering oil' looks like. This information is tacit knowledge to more experienced cooks and generally not embedded in recipes, and can be unobtainable even by those with such knowledge if the food is enclosed, such as when making waffles.

Previous research has shown that gas sensors can be used to discriminate accurately between odors when used in testing chambers; however, potential real-world applications would require these sensors to be able to perform an analysis *in vivo*. After preliminary testing, I have found gas sensors to have potential for detecting the doneness of various foods. After refining, these sensors could "see" into a waffle iron and determine when the waffle is fully cooked. Eventually, I expect to create a system that can use data from these and other sensors and present it to users in a way that they can understand what is happening and be able to use that information and learn techniques that can be used even without the assistance of the system.

Cooking help and education

Previous research indicates that ubicomp technologies can be used to teach people to learn a language while cooking [4] or to stay on task without becoming distracted [7]; however, no one has yet explicitly examined the role interactive computing systems can have for instructing and supporting novice cooks with cooking in particular, a focus of my research.

Most interactive systems that support cooking are aimed at stepping users through recipes. Relaying that steps have occurred but not provide insight into the cooking processes. One system, Panavi, assists users in staying within a particular temperature range and reminds users to practice good pan movement through the use of sounds and projected information onto the burner where the pan resides [8]. Other systems such PersonalChef help users understand the cooking process by providing videos of recipes being prepared from both third person and first person perspectives rather than intervening with cooking [5]; however, these cases neglect the state of the food, which can vary due to differences in ingredients and equipment. Thus, there is an open area of inquiry for measuring food state while cooking. An optimal situation would provide data from within the food; however, gas sensors provide a more practical proxy.

Gas sensors

Gas sensors have been used to detect differences in foods [1]; however, these applications for tracking food are limited because they perform strict identification, which is unrealistic in a dynamic kitchen environment due to the scent isolation they typically require as well as the increased difficulty of identifying a substance when not narrowed to its type (e.g., identifying a particular type of coffee from another) [3]. Very few projects have used non-laboratory equipment to perform the sensing, but primarily these few projects have tracked the stages of roasting [2]. Although these projects show the ability of gas sensors to help infer information about the cooking process, the application of these methods in the HCI community is lacking. Using smell as a source of information to determine doneness will change how systems interact with users.

Research Design

I use both qualitative and quantitative methods in my work. Across four studies, I will design and develop hardware to infer cooking state, understand how the hardware should be interacted with by users and what kind of issues it should try to address, create a system based on this technology and understanding, and finally evaluate it to reveal barriers and nuances that such systems should address.

Study 1: Detecting Cooking State with Gas Sensors

To inform the creation of a sensor platform that can detect food state changes that occur to food during the cooking process, I will build an array of gas sensors selected for cooking in mind. The following methods will be performed on each of these food types: dry cooking (*i.e.,* lack of water), wet cooking (*i.e.,* with water), and additive cooking (*e.g.,* one pot cooking). For each food type, many samples of several foods will be cooked that exemplify that food type and sensor data will be collected throughout the cooking process. Then extensively test and develop methods to track cooking using machine learning on the data from the experiments. The goal of these experiments is to get multiple data points that correspond to different levels of doneness for each food. From these data, I am testing features that I hypothesize will be able to resist the effects of differing temperature and other environmental factors. After the classifiers are trained, the system should be able to determine how close to the "ideal" state the food currently is.

Study 2: Issues of Novice Users

In addition to developing the technology, I need to understand how people might use and wish to use such a system. In particular, I am will try to understand the practices of novices to explore how sensors can be used in helping overcome issues novices face when trying to cook. Thus, I will perform an interview study with instructors and novice cooks and observe novices while cook food. The analysis for this study on novices will focus on finding problems participants have while cooking, understanding current approaches and biases toward cooking, feelings of confidence, and where participants want the most help while cooking.

Study 3: Exploring the Design Space for Novice Cooks

From the analysis of study 2, I will explore how to translate these requirements to features that can work with gas and other sensors in a way that would make a compelling system. These designs will be evaluated by holding focus groups to get walk through sketches and high-level prototypes. Then, based on feedback from pool of users to refine to a single prototype to continue with and develop it using iterative feedback from a couple novice cooks and teachers of novice cooks.

Study 4: Prototype Evaluation

To evaluate the system, I will use a randomized block design, to divide participants into two groups to control for their proficiency of performing the cooking techniques to be described. Within these two groups, participants will be randomly assigned to be control, tutor, and intervention by the research staff. Only for the intervention group, will there any feedback from the system; every condition will have the sensors will collect data. The control group will conduct the cooking sessions without any feedback from researchers or the system. The tutor group will have a researcher trained to help participants be aware of impending state changes in the food, much as the system would. The intervention group will use the system with a set of

training data that would be the same for each participant to ensure consistency across participants.

Current Status

Study 1 is one-third completed and study 2 is just starting. Initial findings indicate the possibility for basic machine learning to predict cooking state with approximately 80% accuracy. Patterns in sensor data suggest the necessity of a different approach to account for temporality and fuzzy matching of larger timescale patterns. Study 2 has shown that very novice cooks find themselves mostly lost while cooking and they lack both the equipment and knowledge to know where to start most recipes.

Objective for attending the DS

At the moment I have yet to concretize my research topic, which I am currently struggling to identify the thread that situates my work. At the Doctoral School, I hope to try to hone my research trajectory by engaging with of various backgrounds to better find my niche.

Biographical Sketch

I am entering my third-year as a PhD student in the department of Informatics at the School of Information and Computer Science at the University of California, Irvine. I am advised by Dr. Gillian Hayes and I work with the Social and Technological Action Research (STAR) Group located in the Laboratory for Ubiquitous Computing and Interaction (LUCI). I entered my program in 2009 and expect to graduate June 2016.

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