# The Ambient Kitchen: A Pervasive Sensing Environment for Situated Services

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## ABSTRACT
In this paper we describe the demonstration of the Ambient Kitchen, a pervasive sensing environment designed for improving cooking skills, promoting healthier eating, and helping cognitively impaired people to live more independent in their own homes. The kitchen is instrumented with an embedded sensing infrastructure including RFID, Newcastle University Culture lab's proprietary wireless accelerometers (WAX), microphone, camera, pressure sensors and tablet computers. Several applications including real-time activity recognition, recipe displays, and real-time food recognition are deployed in our kitchen.

### Author Keyword
Embedded sensors, kitchen utensils, accelerometers.

### ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## INTRODUCTION
This paper introduces the demonstration of a hardware-software infrastructure and applications in the Ambient Kitchen (see Figure 1). The Ambient Kitchen represents a significant improvement from the previous version [1] replacing the web service-base software infrastructure of the previous version with a publish and subscribe messaging service and enriching the environment with more embedded sensing devices such as sauce pans, frying pans, chopping board etc.

The design and development of the Ambient Kitchen follows Weiser's vision of ubiquitous computing [2]: the sensing technologies and computing devices are hidden from people because they are woven into the fabric of their surroundings. In the Ambient Kitchen, sensors are embedded in the environment and objects such as food containers, utensils and appliances, allowing users to perform cooking activities in a natural way without intrusion from the technologies.

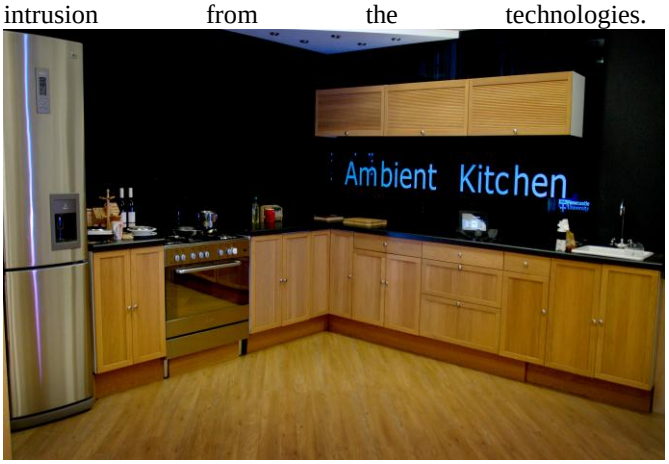


**Figure 1. The Ambient Kitchen**

## HARDWARE INFRASTRUCTURE
Most hardware deployed in the Ambient kitchen is wireless. Particularly, tiny, fingertip sized WAXs. These WAX can easily be embedded into kitchen utensils and appliances. Figures 2 and 3 illustrate kitchen utensils and appliances that are instrumented with WAXs.

**Figure 2. An off-the-shell peeler re-built to house a WAX (seen behind the peeler with its white casing)**


*DIS 2012*, June 11-15, 2012, Newcastle, UK.

**Figure 3. WAX-instrumented utensils and appliances**

The utensils include a chef's knife, a slicing knife, a paring knife, a bread knife, a large spoon, a large slotted spoon, a spatula and a whisk. The appliances include 3 frying pans, 2 sauce pans, a large bowl, a sieve, weighing scales, and a chopping board. A WAX is embedded in the handle of each utensil or frying pan while two WAXs are embedded in each sauce pan, one in the handle and the other in pan lid. Additionally, the chopping board is instrumented with optical fibers feeding to an embedded camera; a microphone is in contact with the surface. Therefore, a total of 22 WAXs are integrated into the objects in the Ambient Kitchen for monitoring user's activities. In addition, several containers for food such as sugar, oil and salt have RFID tags attached, and RFID readers are installed under the work surface of the kitchen. There are 4 large LCD screens hidden behind a glass façade on the wall for situated display. Finally, pressure sensors are integrated into the floor of the kitchen for tracking a user's location.

## SOFTWARE INFRASTRUCTURE

In contrast to the previous version – in which communications between system components and applications was based on a Web Service mechanism - communication among sub-systems in the Ambient Kitchen is based on the messaging queue paradigm of publish-and-subscribe. This pub/sub system is topic-based with messages from the publisher sent to topics and subscribers receiving all messages published to their topics. As the sensing infrastructure in Ambient Kitchen is composed of multiple types of sensor, each sensor type has its own receiver program and topic.

### Real-time Activity Recognition

Real-time activity recognition [3] is a fundamental framework deployed in the Ambient Kitchen and it plays an important role in situated services (i.e. prompting [4]). The recognition of human activities and visualization from multiple acceleration data streams in real-time are displayed on the 2nd screen in the kitchen.

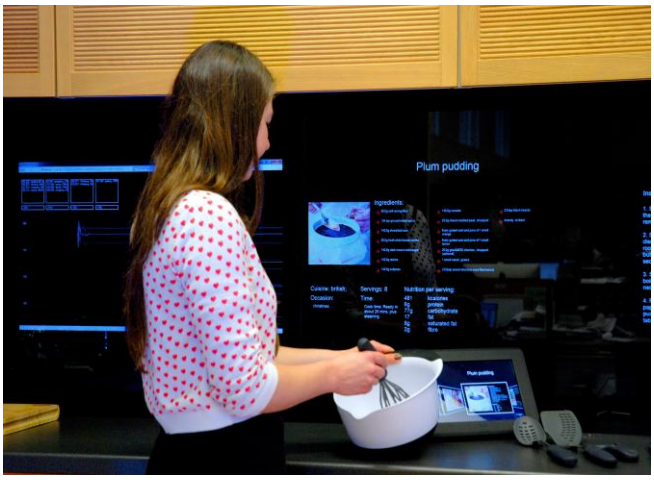


**Figure 4. Real-time activity recognition (left) and recipe displays (right)**

### Recipe displays

The recipe display system is primarily designed to assist people with cognitive impairments. A recipe selection sub-system runs on a tablet PC that wirelessly connects to the rest of the system. It is very easy to use: the user simply swipes the screen of the tablet PC to select a recipe. The selected recipe's ingredients and nutritional information are shown on the 3rd screen, and the instructions are shown on the 4th screen (see Figure 4): these can prompt a user with cognitive impairment should they become disoriented while cooking. Available ingredients are marked with a green color, and unavailable ones with red. This is simple but effective not only for selecting a recipe, but also for tracking available foods in the kitchen.

## SUMMARY

In summary, with upgrading both hardware and software infrastructures, the Ambient Kitchen is more pervasive and enriched with sensing objects. Several applications such as recipe tracking, language learning, food recognition etc. are being developed for the Ambient Kitchen.

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