An Accessible Smart Kitchen Cupboard

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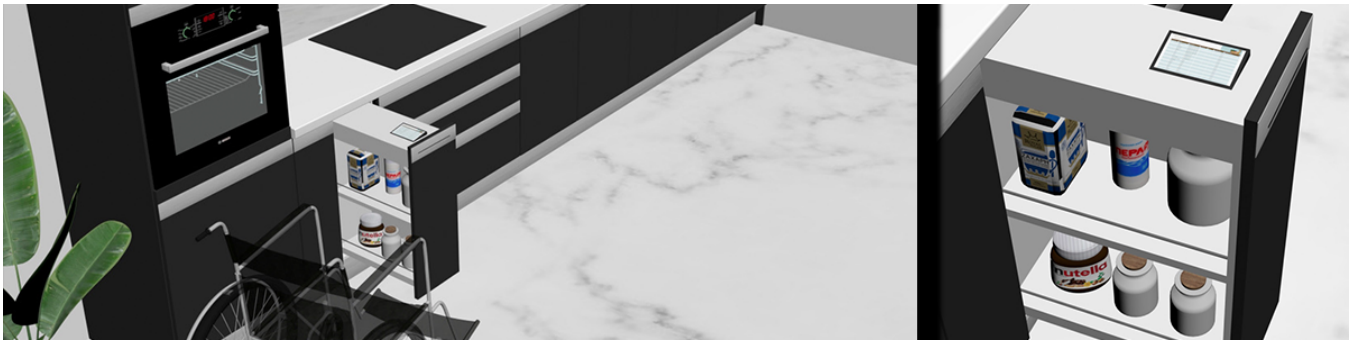

Figure 1: 3D representation of the accessible smart kitchen cupboard placed in a typical kitchen.

ABSTRACT

Nowadays more than a billion people worldwide experience some form of disability pointing out that accessibility is a major issue that should be taken seriously into consideration. Attempting to make people's daily habits in the kitchen area easier and more comfortable, we designed an innovative smart accessible cupboard that can identify various information about the products that are placed inside it, such as their type, quantity, location and expiration date. The Smart Kitchen Cupboard is a component of the Intelligent Kitchen aiming to support users in that space by indicating where to find a desired item, assisting in a context-sensitive manner during the cooking process and helping the overall inventory organization. Our immediate plans include planning a full-scale user evaluation in order to get useful feedback about the current design decisions so as to further improve the prototype and integrate more features.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Accessibility**; *Interaction devices*; *Ubiquitous and mobile computing systems and tools.*

KEYWORDS

Smart cupboard, Intelligent cabinet, Ambient Intelligence; Intelligent Kitchen, Accessibility

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1 INTRODUCTION

The kitchen is an important domestic place and could be characterized as the heart of a house, since it is not only where the meals are prepared and consumed, but also gatherings of families and friends are taking place. People are accustomed to cooking delicious meals, communicating around a kitchen table and generally doing simple everyday things. Spending a lot of time in a kitchen makes it very tempting to find smart ways to make the casual daily habits easier and more comfortable. [2]. However, despite the fact that every home should be a comfortable and safe place for its residents, the majority of people with disabilities [7] do not feel that their kitchen, and specially their cupboards, fulfil their everyday needs [8], as individuals with various kind of impairments (visual, motion, cognitive etc.) have serious difficulties when attempting to accomplish even "simple" tasks in the kitchen [9]. For example, wheelchair users prefer low height kitchen cupboards over wall-mounted ones [14], while for blind individuals there is

a high correlation between their impaired vision and dangerous situations in the kitchen area [10]. So, accessible and properly designed kitchen furniture would make people with disabilities to feel safer, reduce their reliance on family members and make their life better and more independent. Aiming to enhance people's experience within a kitchen and improve their quality of life, we followed the "Design for All" [16] approach towards creating an innovative accessible Smart Kitchen Cupboard that especially assists users with disabilities while performing their daily tasks in that area (Fig. 1). The smart cupboard is a part of the very promising and ever-growing field of Ambient Intelligence, in which smart environments proactively provide context-sensitive services of high quality to people. Our cupboard supports multimodal input/output (e.g. voice commands, touch, light, audio) and seamlessly interoperates with the Intelligent Kitchen of FORTH-ICS [1] aiming to support users while cooking and organizing their inventory.

2 RELATED WORK

The idea of developing a kitchen cupboard targeting people with disabilities is not new. Landero, Magarino et al. initially developed [5] and then improved [6] a tracking memory loss system in home environment using smart kitchen cupboards. Their initial idea was to detect symptoms of memory loss, such as in cases of patients suffering from dementia and Alzheimer disease, therefore their research would indicate when a person has forgotten where some ingredients are placed by looking in successive kitchen cupboards quickly. Their smart cupboards had door sensors that they perceived their status (open/close) and their signals were processed and transmitted via WiFi into the user's laptop. Moreover, smart drawers have been used not only in a kitchen environment but also for medical purposes. The work described in [1] aims to create smart drawers to reminding someone elderly to take prescription on time and raise an alert if there is a deviation. All the medicine bottles that are stored at the drawers have an RFID tag which is read by an RFID reader. The system has the ability to recognize which medicine bottle has been used, updating a database and interacting easily with the user through a laptop screen. Additionally, a very interesting usage idea of kitchen furniture is for user authentication procedures. The authors in [11], introduced a behavioral bio-metric system that receives data from the daily interaction between the user and the smart objects/furniture without the need of phone-based mechanisms. One of their augmented object was a smart cupboard that was integrated with contact switches for detecting opening and closing events, with microphone to measure sound press levels and an IMU (Inertial Measurement Unit) that collected acceleration, gyroscopic movement and orientation data.

The accessibility issues of cupboards in the kitchen domestic area has been analyzed and studied by various related researches. Waithera, Mwirigi et al. [17] emphasize the need for storing related items in a cupboard in order people with disabilities or limited dexterity to be able to find easily what they are looking for. They also mention that adding internal lighting inside a kitchen cupboard is a very helpful feature for a more comfortable food product searching in the pantry. Also cupboards' accessibility is strongly related with their height and where they are placed as the high wall-mounted ones cause access problems [14] [3].

[1] AmI-Chef: FORTH-ICS intelligent Kitchen, https://ami.ics.forth.gr/en/project/ami-chef

3 CONCEPT

As already outlined, people with disabilities face numerous difficulties within a kitchen. In particular, blind users should be relieved from the increased mental and physical effort that is needed to ensure that they know where everything is placed at all times, while they should be assisted in determining the available quantities and expiration dates of the products. Regarding motor-impaired individuals, they should not be required to continuously move around the kitchen to get the items they need, or reach them from inaccessible deep shelves (i.e. being beyond an arm's reach) with hard-to-manipulate doors. As far as people with cognitive disabilities are concerned, they should be provided with mechanisms that assist them in easily recognising the desired items (e.g., while following a recipe). Finally, the elderly should be aided in case they face any of above issues, in isolation or even in conjunction.

The Smart Kitchen Cupboard (Fig. 2) resides within the Intelligent Kitchen, and was designed and developed to accommodate the needs of blind individuals, wheelchair users, people with mild cognitive impairments, the elderly, and people without disabilities as well. It is a wooden 45cm x 60cm x 85cm (W x D x H) cupboard, appropriate for food storage, which can be placed under the kitchen countertop, consisting of a moving (right) and a fixed (left) part. The former is a motorized sliding column with two shelves that extends mechanically along its horizontal axis. The latter secures two metallic railways on top of which a small camera is attached; the camera moves across a vertical plane to view and recognize the contained food items.

Through Machine Learning the cupboard collects information for every product inside it. To minimize disturbances, scanning runs during "off" hours; i.e. the system performs a "quick" scan while the user is occupied cooking and a "deep" scan late at night while the user is sleeping. Through this process, the cupboard can determine for each of the contained items: a) its kind, quantity and expected expiration time (based on its kind), b) approximate location on a shelf, c) the time that was initially inserted, d) the time of its first and last use. All these information are subsequently shared with the Intelligent Kitchen, thus turning the smart cupboard into a intelligent assistant who can support users while cooking (e.g. remind them where a specific item is), inform them when its time to replenish their supplies (e.g. consume items that are about to expire, restock ingredients).

To accommodate the interaction preferences of the target audience, multimodal I/O is supported. To begin with, the user can easily control the moving part of the cupboard through a touch-sensitive metallic plate placed in the upper part of its front face (e.g. touch to partially open, double touch to fully open, touch and hold to lock). As soon as the embedded touch screen -located on the upper shelf and appropriately tilted- unveils, the user can view details regarding the contained products (e.g. expiration date, quantity, location, statistical information about their use) and optionally select those to be retrieved. Next, multiple coloured LED strips appropriately light up to indicate the status and location of the requested products (e.g. yellow color indicating imminent

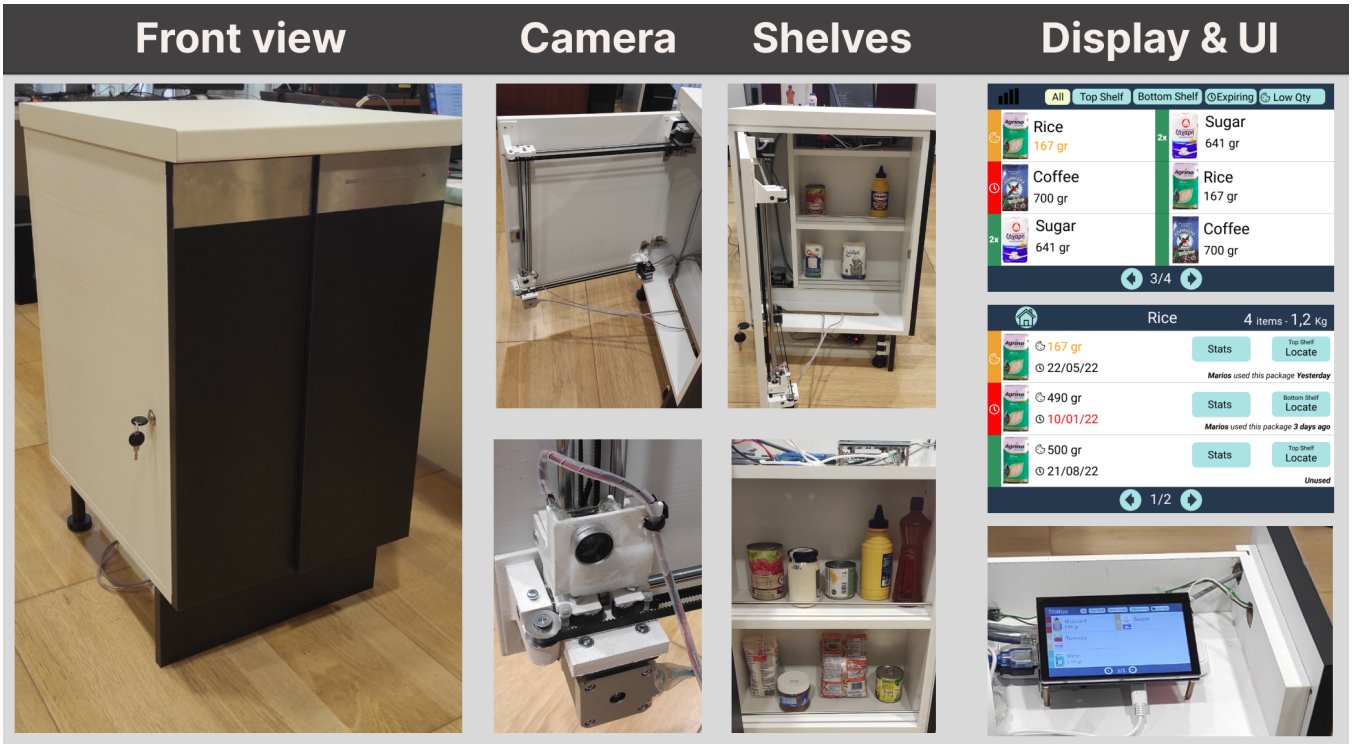

Figure 2: An overview of the features of the Smart cupboard

expiration, illuminate a specific item to guide a user with cognitive impairments). Additionally, voice interaction is also employed for controlling the cupboard (e.g. open/close the door, locate an item), since it is considered a recommended solution in cases when the user's hands are unavailable (e.g. they can be dirty during cooking) [**?**]. Finally, an auditory display and vibrotactile feedback is used to communicate subtle messages to the users (e.g. play a chime when the cupboard door is opening to avoid accidents, vibrate when the user's hand approaches the correct product).

As an indicative interaction paradigm example consider a blind individual cooking the "Risotto with crispy Mushrooms" recipe suggested by the Intelligent Kitchen. When required to sear the canned mushrooms, the cupboard that contains them plays a subtle beeping noise guiding the user to the correct direction. As soon as the user touches the metallic plate on its door, an audio notification informs them that the cupboard is about to open. Then, when the cupboard is fully extended, the user can move their hand over the shelves and as soon as they approach the required item they can feel the vibration from the integrated sensor. Finally, when they collect them and go away the cupboard automatically closes.

4 CONCLUSION - FUTURE WORK

Accessibility should be a key parameter in the design of a smart product as there are a lot of people with disabilities that face enormous interaction difficulties [4], especially within the nouveau domestic world where Ambient Intelligence shapes the new interaction paradigm. Unfortunately though, despite the fact that the kitchen is a key space in that environment where people spend a lot of time every day, studies [3] have shown that most kitchens do not meet the needs of people with disabilities. To this end, we created an innovative accessible Smart Kitchen Cupboard, which in contrast to the majority of the relevant state-of-the-art projects that mostly focus on determining opening/closing events [5], [15], it integrates various features towards enhancing user experience and improving the quality of life. In particular, different interaction modalities enable its operation independently of the user abilities, while its integrated intelligence permits the cupboard to assist users with their day-to-day activities within the kitchen (e.g. locate items, make enquiries about quantities or expiration dates). Our immediate next steps include an in-vitro full-scale user-based evaluation with a wide range of user groups. In particular, given that users with mobility or visual impairments mostly need accessible food storage areas, we will greatly value their opinion regarding our prototype. Moreover, we will include users of different ages and genders (e.g. children, elderly) and connect it with more services (e.g. facilities of the Intelligent Living Room [12]) in order to assess a variety of usage scenarios and interaction modalities.

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