BROWN, J.N.A. 2017. Building an intuitive multimodal interface for a smart home: hunting the Snark. Cham: Springer [online]. Available from: https://doi.org/10.1007/978-3-319-56532-3

Building an intuitive multimodal interface for a smart home: hunting for the Snark.

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2017

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"…A Lesson in Natural History": Introduction to the Smart Home

Abstract: Human evolution is intertwined with technology evolution, from wooden tools to computers. In the 1990s Weiser announces ubiquitous computing, and called for a re-imagining of computerized systems, making them "calm". This chapter addresses the historical developments of smart environments in general and smart homes in particular, referring to first attempts considered as smart, e.g. from Leonardo and emphasizing the wrong technology-oriented approach in the field—as shown by the Honeywell kitchen computer. An attempt to change to a more non-technical and HCI-driven approach is shown with the example of the Casa Vecchia project, concluding the chapter.

Keywords: Evolution; Smart home; Wise home; Domotics; HCI; History of home automation

The evolution and adaptation of humans is intractably intertwined with the evolution and adaptation of our technology [1]. This was true when our ancestors added wooden handles to stone adzes, and it is true today. Around twenty years ago Mark Weiser warned that Ubiquitous Computing (UC) would require the development of a tremendous change to the way in which we interact with computers and the machines that house them [2]. His prediction of ubiquity has come true and we are surrounded by computerized systems that shape most of our day-to-day interactions with technology [3]. Despite the ubiquity of computers and computerization we have done very little to adapt the proliferating technology to our new way of life [4]. Weiser's proposed solution, "Calm Technology" (CT) describes tools made to suit the natural ways in which humans perceive, process, and respond to the world [5]. He called for a re-imagining of how we interact with computerized systems, so that the entire process could become more suitable to human abilities and limitations [6].

Answering that call, we have demonstrated intuitive interaction with 32 unfamiliarized volunteers with a subset of the heterogeneous computerized

devices found in the standard home of the 21st Century. Shown how to remotely perform 2 normal day-to-day tasks, our participants went on to intuit how to perform 7 others with a smart phone app that allowed two very different types of multimodal interaction; one centering on natural speech and the other centered on familiar gestures.

Smart Environments

From cockpits and nuclear power plants to the average 21st century home theatre or media center; from virtual reality-augmented surgical theatres to immersive-gameplay arcades; smart environments are no longer restricted to science fiction. In fact, it can be postulated that, given the ubiquitous use of smartphones, their expanding toolset, and the almost universal nature of connectedness, we now carry our smart environments with us. Ubiquitous computing has turned not only our homes and workplaces, but even the most prosaic environment (a train, a car, or a city park) into a node in a network of embedded systems. The average person may not even be aware of the degree to which they are connected. Since the dawn of the internet and the beginnings of incidental connectivity, our proclivity for connectivity and our demand for service have surpassed all predictions. One area in which this proclivity has been a driving force is the domestication of the technology behind smart environments. We will now review the history and state of the art of this subset of smart environments, the Smart Home, before returning to the more general field to conclude our discussion.

The Smart Home

Research into smart homes has been going on for decades and detailed reviews of the literature have been conducted by Cook and Das [7–9], by Chan et al. [10], and more recently by De Silva, Morikawa and Petra [11]. The focus of these studies is often on Active and Assisted Living (AAL) for the elderly [12]

or for people with special needs [13, 14], but the entry threshold for AAL is dropping with the advent of innovative design and technology integration [15]. This is changing the nature of smart environments, especially as technological advances allow display and control to change from single-user to multi-user [16].

Leonardo da Vinci gave us what may be the first documented transcription of technological innovations into normal living space in his folios numbered 16r and 37v, as seen in the collection of codices of the *Institut de France* [17]. It wasn't until the early 20th Century that the modern concept of a home technology entered the public consciousness, largely in the form of comedy in which incredibly-complex, automated, Rube Goldberg-style machines were proposed as a means to "simplify" day-to-day tasks, such as the feeding machine in Charlie Chaplin's "Modern Times" [18]. The advent of practical computer technology in the middle of that century, and the creation of the first mass-produced microchips led to the beginnings of home automation. Simple devices such as remote controls for televisions and garage door openers were quickly accepted internationally [19]. More complex devices generated publicity but not sales. One example is the "Honeywell Kitchen Computer" (H316 pedestal model) offered in the Neiman Marcus consumer catalogue in the United States in 1969 [20]. This machine was advertised as being able to help housewives plan their menus and budgets, but it was roughly three times as expensive as a house and required that the user take a two-week course in order to learn to use the toggle-switch input panel and to read the flashing binary light output.

Both price and demands on the user would have to be lowered before computerized assistive devices could become realistically viable in the home. It is interesting to note that, according to Atkinson, Gordon Bell [Vice President of Engineering at Digital Equipment Corporation (DEC)] wrote a memo describing possible improvements to the "Honeywell Kitchen Computer" that was the inspiration for DEC to enter the field of domotic computing. In fact, in the memo, Bell wrote that, with an improved interface, a home computer could be directed not at the kitchen but for use with entertainment, games and studying [21]. By the end of the century, Smart Home systems were being developed and tested in academic and corporate laboratories around the world [22].

One of the major drivers in the quest to build Smart Home technology is the profit motive of certain groups of developers who show little concern for how

the technology will be used or whether it is compatible with other technology. In 2002, Zayas-Cabán proposed a methodology for conducting home assessments in order to implement specialized technological systems that suit the house and the inhabitants [23]. As discussed a decade earlier in the Report of the European Foundation for the Improvement of Living and Working Conditions, the manufacturers of technological devices were putting the cart before the horse: rather than assess the environment and develop technology in response to needs, they were waiting until after technology was developed and deployed before worrying about how suitable it might be [24]. This has led to a vast treasure trove of commercial systems and components and to a dearth of commercial attempts to work with other developers. The void is being filled now, at least on a theoretical level, and many academic and commercial research teams are turning their attention to finding not just models, but actual working systems for the unification of commercially and technologically diverse distributed Smart Home interfaces.

Many of the Smart Home systems developed to date have two unfortunate elements in common with the kitchen computer discussed above: they remain expensive (despite some improvement), and they make high demands on the user. Both of these elements were addressed in the Casa Vecchia project [25].

Casa Vecchia: Making an "Old House" Smart

Leitner and Fercher developed Casa Vecchia, a Smart Home project that was outstanding when it was started, not only for addressing issues of cost and cognitive load; and not only for setting out to evaluate the viability of deploying Smart Home systems in their community; but mainly because it deals with the oft-ignored guideline suggested by Venkatesh:

> Don't assume that what the technology can do in the household is the same as what the household wants to do with the technology [26].

After a decade of conducting anthropological-style field studies and large-scale longitudinal and cross-sectional surveys in order to determine the technological and social elements affecting technological diffusion in the home, Venkatesh developed an underlying theoretical structure that included a conceptual model

of the *cyber-household* [26]. His theory of household-technology interaction is generated from a modified structural-functionalist approach that has sound footings in ethnography but is largely ignored by the technological community.

Leitner and Fercher, like Venkatesh, approach the Smart Home from the points of view of both utilitarian material culture (focusing on tools and tool use) and a socio-psychological approach in which the social dynamics of the household must be paramount. By combining these perspectives, Venkatesh was able to model the use of technology in relation to household structure, and so propose a dynamic and adapting system that would change according to the needs or wants of the occupants of the home. This dynamic, human-focused application of technology is exactly what Leitner and Fercher set out to apply and study, in the hopes of "… finding as many missing pieces of the jigsaw of UX in the context of AAL as possible".

They have done this by combining HCI approaches to the human side of the equation with innovative applications of off-the-shelf technology while standing on the shoulders of those who have gone before them. To use their words:

> The focus of the project is to deploy a customized system into more or less arbitrary homes based on the achievements gained by researchers all over the world [25].

The homes in question are the real houses of real people in the province of Carinthia, Austria. The number fluctuated, but at any given time, there were about 20 active homes involved. The senior citizens living in these homes agreed to the introduction of domotic technology, but with the promise from the researchers that this would be done in a slow and smooth manner. They, their families and their primary caretakers were all involved in an ongoing process of feedback and response as the researchers and the participants co-developed the customized systems that best suit the household. The results of longitudinal surveys will soon be available. In the meantime, though the whole range of results has been yet to be reported, this truly human-focused means of developing a smart environment was instrumental in fostering the theoretical and practical work reported in this brief.

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