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Implicit Interaction: A Prerequisite for Practical AmI

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Abstract. Intelligent User Interfaces represent one of the three distinguishing characteristics of AmI environments. Such interfaces are envisaged as mediating between the services available in an arbitrary physical environment and its inhabitants. To be effective, such interfaces must operate in both proactive and passive contexts, implicitly and explicitly anticipating and responding to user requests. In either case, an awareness of the prevailing situation is essential – a process that demands a judicious combination of data and decision fusion, as well as collaborative and centralized decision making. Given the constraints of AmI environments realizing a distributed lightweight computational infrastructure augmented with a need to address user needs in a timely manner poses significant challenges. In this paper, various issues essential to enabling seamless, intuitive and instinctive interaction in AmI environments are explored.

Keywords: Implicit Interaction, Ambient intelligence, embedded agents

1. Introduction

Usability is fundamental to the success or otherwise of all kinds of consumer electronics, and software services are no exception. In his original manifesto for ubiquitous computing, Mark Weiser unequivocally stated that the whole point of ubiquitous computing was applications [1]. Furthermore, seamless and intuitive interaction was seen as a key feature of such systems, though how such features were realized in practice remained and remains to be seen.

AmI [2] was conceived as a means of managing interaction in ubiquitous computing as it was realized that should embedded devices all seek users' attention simultaneously, it would mean that such environments were effectively unusable and that users could and would take actions to avoid such environments. AmI envisages Intelligent User Interfaces (IUIs) [3] as mediating between users and the environment, and in this way addressing the usability issue. Though the purpose of IUIs is widely acknowledged, how such interfaces should be designed and implemented in practice remains an outstanding problem. In cases where the user is interacting directly with an embedded artifact, the situation is straightforward, and the interface may not really need to exhibit sophisticated behavior. However, the situation is more complex when environments seek to act in a proactive or anticipatory fashion, and interaction may be expressed in diverse and subtle ways.

2. Interaction Modalities

If Intelligent User Interfaces (IUIs) that truly enables intuitive instinctive interaction are to be developed, an innate understanding of how people communicate is essential. It is useful to reflect on this briefly. Humans communicate using a variety of means verbal being a prominent communication modality. Yet nonverbal cues have over four times the effect of verbal cues [4]. For interfaces to act intelligently and instinctively, non-verbal cues need to be incorporated into their design.

In most encounters with computing, interaction is explicit – an action is undertaken with the expectation of a certain response. In computational parlance, it is event driven. The reset button is pressed and the workstation reboots. This is the default interaction modality that everyone is familiar with, even in non-computing scenarios. When designing interfaces, a set of widgets is available that operates on this principle. No other issue is considered. The application is indifferent to emotions and other contextual parameters. Should the context be available, a number of options open up but the appropriate course of action may not be obvious in all circumstances. If it is determined that the user is stressed for example, is the designer justified in restricting what they can do? Should certain functionality be temporarily suspended while certain emotions are dominant? If applications are to act instinctively, the answer is probably yes; thus embedded applications will have to support multimodal I/O.

Interaction may also be implicit, and it is here that non-verbal cues may be found. All people communicate implicitly. The tone of peoples' voices, the arched eyebrow and other facial expressions reinforce what they say verbally. Intriguingly it can also contradict it. Though people can seek to deceive with words, gestures can indicate when they do so. Thus if we seek interactions that are based on truth, an outstanding challenge is to harness and interpret implicit interaction cues. This is computationally complex, requiring that such cues be captured, interpreted and reconciled in parallel with explicit interaction events.

One subtle point with implicit interaction is that it can, in certain circumstances, represent the direct opposite of explicit interaction. In short, what is NOT done, as opposed to what is done, may indicate a choice or preference. For example, in ignoring an available option, users may be saying something important about their preferences. What this means is of course domain and context dependent.

In all but the simplest cases, implicit interaction is multimodal. It may require the parallel capture of distinct modalities, for example, audio and gesture. Or it may require that one modality be captured but be interpreted from a number of perspectives. For example in the case of the audio modality, semantic meaning and emotional characteristics be may extracted in effort to develop a deeper meaning of the interaction.

2.1 Interaction – A Computing Perspective

Various models of interaction have been proposed in computational contexts, for example, those of Norman [5] and Beale [6]. Ultimately, all frameworks coalesce around the notions of input and output, though the humans and computer interpretation of each is not symmetrical. Obreovic and Starcevic [7] define input modalities as being either stream-based or event based. In the later case, discrete events are produced in direct response to user actions, for example, clicking a mouse. In the former case, a time-stamped array of values is produced.

In the case of output modalities, these are classified as either static or dynamic according to the data presented to the users. Static responses would usually be presented in modal dialog boxes. Dynamic output may present as an animation - something that must be interpreted only after a time interval has elapsed.

2.2 Interaction – the AmI Challenge

As can be seen, enabling interaction where the full semantic meaning and the context in which it has occurred are transparent and completely understood remains a formidable challenge even in conventional computing systems. For AmI environments, the complexity is increased by an order of magnitude. Yet if AmI environments that can manage interaction intelligently and instinctively are to be realized in practice, such communication must be achieved. Inherent in this is the need to effectively manage implicit interaction. How this can be achieved within the constraints of embedded artifacts and heterogeneous sensor arrays remains to be seen. Numerous examples of implicit interaction are emerging. The Google android phone enables action based interaction by simply shaking the phone. Accelerometers permits the detection of movement signatures and the systems can respond based upon the context.

For the purposes of this discussion, embedded intelligent agents are considered as the atomic components on which AmI environments can be realized and intelligent user interfaces delivered. Such agents are inherently distributed and incorporate a range of characteristics that make them suitable for such a task. However, as shall be demonstrated, for such agents to capture, interpret and respond to user initiated interactions within an appropriate time frame demands that the availability of robust strategies for both data and decision fusion.

3. Embedded Agents

Embedded agents [8] offer an effective model for designing and implementing AmI applications and services. Such agents have been deployed in a variety of situations including user interfaces implementation on mobile devices [9], realizing an intelligent dormitory for students [10] and realizing a mobile information system for tourists [11]. Within this paper we will explore the use of such agents in managing a rich portfolio of implicit interactions, where the interaction may be as instinctive as walking past an artifact or interacting with an artifact in some way like lifting it or moving it. In such scenarios we will observe the dismantling of the traditional boundaries be-

tween the physical and digital world. The manner within which we invoke assistance and receive assistance from computing systems will become almost subliminal. Such a major interaction paradigm shift demands a level of intelligence, adaptivity and proactivity that has hithertofore not existed.

4. Conclusion

Interaction modalities are quickly evolving. It may manifest itself in a range of instinctive ways, like walking past an artifact or interacting with it in some way through lifting or moving it. In such scenarios, the dismantling of the traditional boundaries between the physical and digital world will occur. This paper will explore novel instinctive interactions within ubiquitous sensed environments and the computational challenges that this brings.

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