Using Electronic Storyboards to Support Interdisciplinary Design of Pervasive Computing Systems

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***Abstract*—In an interdisciplinary setting, the rapid creation and evaluation of prototypes is critical to achieve a favorable design outcome. For pervasive computing systems, this means creating many interactive prototypes, often when non-computing team members are unfamiliar with programming, networking, or sensing. To overcome this difficulty we propose the use of electronic storyboards as a tool to define pervasive computing systems. Our research will show how storyboards can be used to capture behavioral elements such as action, context, and time. From the storyboard we will create formal models about the behavior of the prototype that can be synthesized or simulated.**

I. Introduction

The vision of pervasive computing is a world where computing technology is embedded into the clothes, objects, and environments of our daily lives. This embedding of technology serves to create supportive and helpful interactions with computer systems that disappear into subconscious use. However, to achieve this subtle and seamless use of computing systems, the design of pervasive computing systems must expand beyond engineering to include experts in the domains where the pervasive systems will be deployed. By this we do not mean engineers, who until now are the typical creators of pervasive systems, but the fashion designers, industrial designers, and architects that are trained to work in these domains. The purpose of this proposal is to explore research issues in intellectual tools for supporting interdisciplinary design of pervasive computing systems. Specifically we propose the use of storyboards as a common, accessible medium for describing pervasive computing systems.

While many tools have been created that attempt to lower the bar to learn programming languages or are customized tools that target specific domain applications. These tools fall short for one of two reasons. First, even a simplified programming language is a barrier for team members who are not programmers as their understanding of the behavior of the prototype is solely dependent upon how well they understand the language. Second, domain specific tools cannot handle the various types of prototypes that could be expected by a design team. In contrast to these existing approaches, we seek to create a new tool that does not teach programming, but leverages existing practice to create interactive prototypes. We propose to explore the research issues involved in a novel storyboarding tool that will fit within the interdisciplinary design paradigm for pervasive computing systems. This tool will not generate final implementations, but is instead intended to generate prototypes that enable the rapid evaluation of design ideas during the system's design and development.

II. Proposal

Storyboards convey context, location, action, and temporal phenomenon [1] that cannot be expressed by current programming tools. These temporal and contextual phenomenon are key aspects of the user experience for pervasive systems. Using storyboards, design teams can describe pervasive computing systems in a medium that is accessible to all members of the team and reason about key domain semantics. Storyboards have been shown to be an effective communication tool in an interdisciplinary setting [2] and contain enough formal structure that they have been the basis for several existing programming tools.

Our proposed work seeks to explore research questions involving the development of a storyboarding tool for pervasive computing. We seek to understand how pervasive computing applications can be designed using a storyboarding paradigm, how the storyboard can then generate a prototype, and what are the needs of different team members in an interdisciplinary group. In accomplishing these tasks we will allow design teams to create prototypes more rapidly, thereby increasing the exploration of the design space and leading to better design outcomes. Furthermore, as storyboards can represent the physical and interactive elements of a prototype, we can

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present a new "shared view" between the designers and engineers in an interdisciplinary team.

While the storyboard as a whole can be understood by the entire design team, it also contains physical and behavior information that is relevant to both engineering and industrial design. This information could be separated such that each discipline can have a customized view of the prototype, in additional to the global view presented by the storyboard. These separate views can be linked such that changes in one influence the other. In this way, large design changes can be automatically reflected in the global, and domain specific views.

We propose to automatically extract behavioral information about the prototype by analyzing the visual and textual annotations, and the framing used in a storyboard. Each storyboard is viewed as a collection of frames, wherein each frame there are visual markings, coupled with textual annotations about the activity, context or behavior of the prototype. By understanding these elements we hope to infer the intentions of the design team and develop a behavioral model of the prototype. This model could then be implemented, or simulated by the design team to realize the prototype. Visual elements will be interpreted using sketch recognition and similarity comparison between frames, while the textual annotations for each frame can be parsed with natural language processing techniques. The overall layout of the storyboard provides information on the ordering of events in the storyboard, as well as their importance determined by the size of the frame [3].

A. *Research Questions*

Given our proposed research, there are several questions that need to be addressed. First, how are time, context, and action depicted within a storyboard? Additionally, how can this information be extracted automatically, or in some assistive manner? We seek to understand how these key domain semantics are represented in a storyboard and through what analysis methods can they be extracted. Once the information content of the storyboard is understood, how can this information be ordered to form a behavioral model of the prototype? A storyboard can contain abrupt changes in time or context such that time can "flash-forward" or "flash-back". Similarly, context can be represented as a hierarchy of experiences, with some global contexts existing throughout the storyboard, and others more transient. The proposed tool will reason about causality between events to create a model of computation that defines the behavior of the prototype. Understanding changes in time and context are required to determine the relationship between events within the storyboard.

Once a model of the system has bee defined, how are the events and actions in the model simulated or implemented in hardware? Likely the information extracted from the storyboard will be a high-level description such as "push button", "turn on", or "rotate". These descriptions can be recognized as events or actions of the system, but to evaluate the prototype, they must be implemented or simulated. Our research will explore practical methods to define these events or enable teams to simulate their interactions.

B. *Contributions*

The goal of this proposal is to raise the level of abstraction when designing pervasive computing systems. We propose to move away from general programming tools towards design semantics that reason about general, interaction level concepts. In answering the research questions proposed we will contribute new knowledge to the understanding of interdisciplinary design practices and will create a new, more rapid method for prototyping pervasive applications. In particular the proposed research will have three major contributions. First, it will guide the creation of a prototyping tool that will cover multiple application domains while remaining accessible across disciplines. Second, our research will reveal what elements of a pervasive computing application are important to various team members, and how that information should be conveyed to them. Finally, as storyboards can contain abrupt changes in time and context, we will develop methods to reason about causal and temporal events in the storyboard and the intended behavior.

III. Conclusion

In this proposal we have argued for a new paradigm to design pervasive computing systems. We suggest using storyboards to capture high-level behavior about the intended system, and to parse the storyboard to form a behavioral model that can be implemented or simulated. Using this technique avoids common issues when working in an interdisciplinary setting, and provides a descriptive medium that is accessible to all members of a design team. We have posed research questions that illuminate issues regarding time, action, and context within a storyboard that will enable the creation of a novel design tool for pervasive computing.

References

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