Using Communicative Acts in High-Level Specifications of User Interfaces for Their Automated Synthesis

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ABSTRACT

User interfaces are very important for the success of many computer-based applications these days. However, their development takes time, requires experts for user-interface design as well as experienced programmers and is very expensive. This problem becomes even more severe through the ubiquitous use of a variety of devices such as PCs, mobile phones, PDAs etc., since each of these devices has its own specifics that require a special user interface.

Therefore, we developed a tool-supported approach to automatically synthesize multi-device user interfaces from high-level specifications in the form of models. In contrast to previous approaches focusing on abstracting the user interface per se, we make use of *communicative acts* derived from speech act theory for the specification of desired user intentions in interactions. In this way, we approach a solution to the given problem, since user interfaces can be efficiently provided without experience in implementing them.

Categories and Subject Descriptors

D.2.1 [**Software Engineering**]: Requirements/Specifications

General Terms

Design

Keywords

Communicative Act, UI Specification, Intention

1. INTRODUCTION

Programming is hard, error-prone and expensive. This is the case for programming user interfaces (UI) in particular. In addition, UI design requires special expertise. However, user interfaces have become more and more important, they are even needed now for multiple devices. Therefore, it is highly desirable to have means for high-level specifications that can be provided by domain experts and do not necessarily require experts for UI design, and automated synthesis of UI code, which should be very cost-efficient as compared to manual programming.

We propose a new way to specify user interfaces on an interaction basis (instead of, e.g., a screen or widget basis) by means of *communicative acts*. They are derived from speech act theory and express rich semantics describing desired effects on the environment. Even more importantly, communicative acts are able to carry intentions. Especially the latter aspect makes it "natural" for humans to express interactions in this form.

Based on such specifications, our approach allows automated synthesis of multi-device user interfaces. Since communicative acts describe their desired effect on the environment device-independently, it is possible to use the best set of widgets available on each platform to achieve this effect. We have fully implemented this approach in a generator tool, which is already in use for real-world applications supporting diverse devices, e.g., PCs, mobile phones, PDAs, etc.

2. COMMUNICATIVE ACTS

By investigating human communication, philosophers observed that language is not only used to describe something or to give some statement but also to do something with intention — to act.

Early and seminal work on speech acts was done by Searle [4]. He claims that "the speaking a language is performing speech acts, act such as making statements, giving commands, asking questions, making promises and so on" and that such speech acts are basic units of language communication. E.g., the speech acts "*Sam smokes habitually.*" and "*Does Sam smoke habitually?*" have the same *propositional content* (Sam smoking habitually) but different *illocutionary forces*: making an assertion and asking a question.

Analogously to human-human communication, human-computer interaction can also be viewed as enacting communicative acts. For this reason and because of the previous uses in other areas, we make use of communicative acts in abstract specifications of user interfaces and their automated synthesis.

3. UI SPECIFICATION AND AUTOMATED SYNTHESIS

We follow the approach of specifying user interfaces through abstract UI models. More precisely, communicative acts are part of our UI models. In addition, these models contain domain knowledge in the form of UI domain objects, which represent the entities of the domain to be displayed in the concrete user interfaces. Finally, they contain information about navigation paths in the form of finite state machines.

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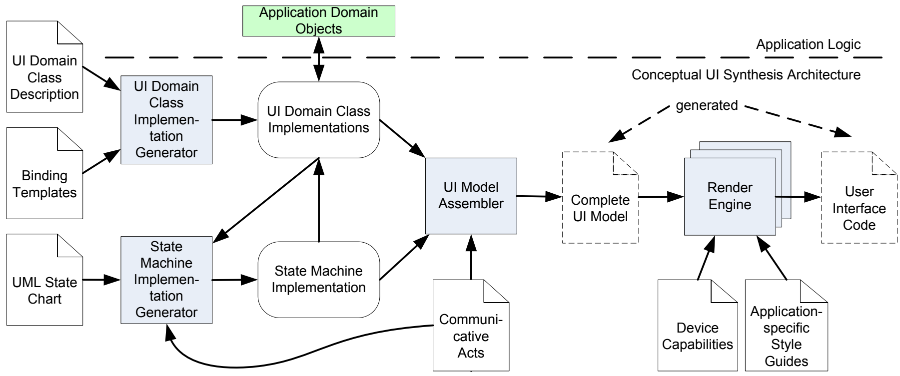

Figure 1: Conceptual Synthesis Architecture.

Specifying such a model directly in OWL[1] or XML syntax can be a daunting task comparable to programming user interface code. Therefore, we have also built an IDE (Integrated Development Environment) for supporting this modeling task through a graphical interface. This IDE compiles the OWL representation of communicative acts and UI domain objects. State machines can be either built using graphical UML tools, which generate an XMI representation, or directly within this tool.

From such a model, our generator tool automatically synthesizes concrete user interfaces for diverse devices. The synthesis process sketched in Figure 1 is divided into the following four steps that generate a UI implementation corresponding to the Model-View-Controller Pattern (MVC):

1. Synthesis of the UI domain classes' implementations together with their technology binding to the functionality offered by the application domain objects,

2. Generation of the finite state machine implementation,

3. Assembly of the UI domain information and the communicative acts according to each state, and

4. Rendering of the concrete user interface based on the complete UI model. This rendering process is guided by device profiles, user preferences, application-specific style guides, and some heuristics. The heuristics mainly guide the widget selection and are based on the communicative acts, UI domain objects, their numbers and types, and their properties.

4. RELATED WORK

Most of the related approaches use declarative models for the description of user interfaces (usually *Presentation models*, *Application models* and *Dialogue models*), which are employed for the user-interface synthesis. The work described in [5] shows that the integration of such multiple models is non-trivial and provides a solution for their automated integration. While this work describes interactions by dialogue models, it does not model intentions involved in the interactions as in our work.

For important work on user interface languages see, e.g., the User Interface Markup Language (UIML) [1] and XForms [2]. It is on a much lower level of abstraction than ours, however, which has its focus on specifications of intent for automated UI synthesis.

An advanced way for generating multi-device user interfaces based on task models is presented in [3]. The basic approach is to start from tasks to be supported by the application and to separately generate user interfaces for different devices according to specific device characteristics. While this approach seems to be of great help for user interface developers, it is still widget-oriented in contrast to our approach and most of the transformations between the different levels of models have to be done manually.

[1] Web Ontology Language, see http://www.w3.org/2004/OWL/.

5. CONCLUSION

The key innovation of our work is the use of communicative acts for the specification of intentions to be conveyed through the user interface. The strengths of our approach are:

- The need for one high-level specification rather than coding several user interfaces for diverse devices;

- The feasibility to provide such user interfaces with some technical knowledge, but without experience in UI programming;

- Faster development for shorter time-to-market, due to the automation involved.

In summary, we demonstrate tools based on a new approach to using communicative acts in high-level specifications of user interfaces. They allow specifying on a high level and fully automatic synthesis of multi-device interfaces.

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