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Introduction

During the early user interface (UI) design phase, different design solutions should be explored and iteratively refined by the design team. Sketching on paper is acknowledged as a quick way to document ideas and design details before they are forgotten. However, paper sketches are hard to be kept and modified, particularly in a rapidly evolving scenario, which often results in having to redraw the mockups several times (Landay & Myers, 1995). Incorporating the sketch's natural, unconstrained and informal virtues, for which it is praised in many areas (Kieffer, Coyette, & Vanderdonckt, 2010) into a computational solution could make early prototyping easier and faster. As stated by Gross, "certainly there are many practical benefits to addressing and resolving the challenges of sketch-based interaction and modeling: the design, graphics, and media industries depend heavily on drawing, and being able to engage with artists and designers in their (still) preferred medium of choice is a tremendous advantage" (Gross, 2009).

Even with the advantages of sketches, the mouse-based interaction is very popular and well established amongst users. Due to the large number of years spent using this technology, mouse-based computer interfaces for drawing graphics are considered so efficient and "natural" that, nowadays, changing from mouse to pen would shift industry practices (Kurtenbach, 2010). Besides that, most applications that come with pen-based computers such as Tablet PCs are still designed focusing in the mouse-based interaction, usually ignoring the power of pen strokes and sketching (Davis, Saponas, Shilman, & Landay, 2007).

However, as technology advances and bigger screens and portable devices become more popular, the mouse supremacy may be at stake: it may still be the predominant pointing device for conventional desktop Graphical User Interfaces (GUI), but as new devices arise, the comprehension of new input methods is becoming more important, amongst them, the pen input (Po, Fisher, & Booth, 2005). Developing a pen-based application implies in a paradigm break, going beyond a simple redesign and actually rethinking the application to take

advantage of the pen input's intrinsic capacity for rapid, direct, modeless 2D expression (Gross, 2009).

This dissertation presents UISKEI (User Interface Sketching and Evaluation Instrument), a tool being developed bearing in mind the use of a Tablet PC, so as to explore how the pen can be used in a "paperless" user interface prototyping application. Maintaining the natural characteristic of drawing shapes on paper, it adds the computational power of moving shapes, resizing them and interpreting them as interface elements. More than an interface prototype drawing tool, UISKEI also features the definition of the prototype's behavior, going beyond navigation between user interface containers (e.g. windows, web pages, screen shots) to allow changes to be made to the state of user interface elements and widgets (enabling/disabling widgets, for example).

This dissertation also presents a study and comparison of similar tools (Chapter 2) and the main concepts underlying UISKEI (Chapter 3). The user interface drawing stage is detailed in Chapter 4, explaining how the conversion of sketches to widgets is made by combining a sketch recognizer, which uses the Douglas-Peucker simplification algorithm and the Levenshtein distance as a similarity measure, and the interpretation of recognized sketches based on an evolution tree. Chapter 5 discusses the different solutions explored to address the issue of drawing an interface behavior, suggesting an innovative mind-map-like visualization approach that enables the user to express the event, conditions and actions of each interaction case, while still keeping the pen interaction paradigm in mind. Chapter 6 explains how the end users can interact with the simulation of the sketched user interface and thus help to evaluate its behavior. Chapter 7 describes a test to determine the values to be used in the recognizer. Chapter 8 presents an evaluation study of creating a prototyping — from the interface building and its behavior definition to the prototype evaluation — using UISKEI and two other techniques (paper prototyping and Balsamiq®). The last chapter (Chapter 9) suggests future work and presents the final conclusions of this dissertation.