Electronic Sketching on a Multi-platform Context: A Pilot Study with developers

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Summary

During the past 45 years there has been a recurrence of interest on supporting sketching at electronic devices and interactive surfaces, and despite being sketching recognition fairly well addressed on the literature, the adoption of electronic sketching as a design tool is still a challenge. The current popularization of touch screen devices allows designers to sketch using their device of preference, while the current multi-platform capabilities made possible by HTML5 allows sketching systems to run on many devices at the same time. Those two factors combined might pose new opportunities for researchers to explore how designers use sketching on flexible setups by combining heterogeneous sketching devices for design sessions.

This may arise new possibilities in the field of prototyping user interfaces since by using such multi-platform systems, designers would now be able of designing interfaces for multiple devices by producing and testing them on the device itself. This paper reports a pilot experiment conducted with 6 developers, grouped into pairs on design sessions using GAMBIT – a multi-platform sketching system that provides a lightweight approach for prototyping user interfaces for many devices at once. We performed a discourse analysis of the professionals based on recorded videos of interviews conducted during and after design sessions with the system and aggregated the data in order to investigate the main requirements for multi-platform sketching systems.

Keywords: Sketching, Multi-platform, User interface design, Discourse evaluation

JEL Classification:

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Electronic sketching on a multi-platform context: A pilot study with developers

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A B S T R A C T

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1. Introduction

Sketching is an important – perhaps necessary – tool for design, since it function not as a mere fixation of finished solutions but as an external part of the mental process itself (Sachse et al., 2004). For over 45 years since the first sketch-based computer systems were proposed (Ivan, 1963; Ellis et al., 1969) there has been recurring interest in supporting sketching with computation (i.e. sketching at electronic devices and interactive surfaces).

Despite being sketching recognition fairly well addressed on the literature, the adoption of electronic sketching as a design tool is still a challenge (Johnson et al., 2008).

The current popularization of touch screen devices and the multi-platform capabilities made possible by HTML5 might pose new opportunities for developers to build distributed interactive systems with minimum effort on adapting the system for each platform. Systems to support design activities such as sketching are also included on this set of new opportunities, also giving room for researchers to investigate how designers use sketching to prototype interfaces on the current multi-platform scenario.

We then define multi-platform sketching as the activity of drawing with an electronic stylus at different devices while having the same system running on those different devices (Sangiorgi et al., 2012).

When designing, people draw things in different ways, which allows them to also perceive the problem in new ways. People engage in a sort of conversation with their sketches in a tight cycle of drawing, understanding, and interpreting (Schon and Wiggins, 1992). However, nowadays there are many devices available for designers to sketch upon (MacLean et al., 2011), with different characteristics such as screen sizes, weight and processing capabilities; this is a fact to be addressed into contemporary sketching research.

Therefore, the fundamental question we seek to answer with this paper is regarding the sketching activity for prototyping. Since designers need to consider many factors while designing interfaces for many device types, what are the most important requirements for a sketching system for prototyping interfaces?

In this paper we report a pilot experiment conducted with 6 developers from IT companies in Belgium, grouped into pairs on design sessions using a multi-platform distributed sketching
system called **GAMBIT** (Gatherings and Meetings with Beammers and Interactive Tablets) (Sangiorgi et al., 2012). The system is flexible enough to accommodate various configurations and its interface can be distributed among many different devices (Desktops, Tablets, Smartphones, etc.).

We performed a discourse analysis of the professionals based on recorded videos of interviews conducted during and after design sessions with the system and aggregated the data in order to investigate the main requirements for multi-platform sketching systems.

This paper is organized as follows: the next session shows the motivation for sketching user interfaces in a multi-platform context. **Section 3** presents the state of the art on the areas of Sketching and Distributed Systems. **Section 4** presents the GAMBIT system and its initial requirements. **Section 5** describes the experiment with some indications of improvements for the system and **Section 6** concludes.

### 2. Sketching in user interface design

Sketching is considered to be a powerful tool for doing design. As the findings of Goel (1992) point out, the presence of ambiguity in early stages of design broads the spectrum of solutions that are considered and tends to deliver a design of higher quality.

Some works had already investigated the sketching activity as a fundamental human activity, as van der Lugt (2002) who conducted an experiment to analyze the functions of sketching in design, in which participants produced individual sketches and then presented them for the group for discussion. Three primary sketching functions were identified:

- **F1** Sketching stimulates a re-interpretive cycle in the individual designer’s idea generation process: Schön (1983) describes design as a cyclic process of sketching, interpreting and taking the sketches further.
- **F2** Sketching stimulates the designers to re-interpret each other’s ideas: when sketching to discuss (as opposed to sketch for self-interpretation), the designer invites others to interpret her drawings as well. The function of inviting re-interpretation is especially relevant for the idea generation process, as re-interpretation leads to novel directions for generating ideas (van der Lugt, 2002).
- **F3** Sketching stimulates the use of earlier ideas by enhancing their accessibility: Since it is externalized, sketching also facilitate archiving and retrieval of design information.

UI design by sketching is recognized for several proved virtues such as, but not limited to: maintaining an informal representation to foster creativity (Coyette et al., 2007; Newman et al., 2003; Mangano et al., 2008), complementarity between paper and pencil and software (Bailey and Konstan, 2003; van der Lugt, 2002), capability to take one design idea at a time and work it out in details or consider alternative designs at a time (i.e. lateral transformation Mangano et al., 2008), ability to reveal as much usability problems as if it was a real UI (Johansson and Arvola, 2007).

In order to support sketching into UI design, we needed to analyze the process in which UI design is included. Currently, the development life cycle of interactive applications consists of a sophisticated process that does not always proceed linearly in a predefined way. The tools available for UI development are usually not focused on UI **design**, in which designers usually explore different alternatives but in UI **modeling** as a final product, where designers must attend to formal standards and notations.

There are many tools available for both modeling and design, however practitioners are currently forced to choose formal and flexible tools. Whichever they choose, they lose the advantages of the other, with attendant loss of productivity and sometimes of traceability and quality.

As the study reported in Cherubini et al. (2007) mentions, designers desire an intelligent whiteboard because it would not require hard mental operations while sketching during meetings and design sessions.

However, electronic sketching is still behind the classical sketching in paper, since the tool in use becomes too evident (Weiser, 1991). Perhaps until the gap between displays and paper are minimized, (for instance with paper-like displays Shah and Brown, 2005), this distance will continue high, hindering the designer’s conversation.

A great care must be taken to support the designer’s reflection when making design software that employs sketch recognition, for instance. If the system interprets drawings too aggressively or at the wrong time, it may prevent the designer from seeing alternative meanings.

Therefore, we can observe that fostering creativity is the main concern of current sketching tools for design. This is specially important since design is essentially a problem of wicked nature, i.e. the process of solving it is identical with the process of understanding it (Rittel, 1973). In wicked problems, the designer does not have a clear understanding of what to produce and has only a vague goal in mind in the beginning.

However, electronic sketching has some important advantages over classical ‘pen and paper’ approach. While sketches are useful to facilitate discussions on the conceptual level, computer prototypes are useful for discussing operational and interaction issues (Johansson and Arvola, 2007). Thus, raw sketches and interactive prototypes are complementary.

One important issue with currently sketch-based systems for prototyping of user interfaces is that they are single-platform, since they are usually made to be used on Desktop computers (Newman et al., 2003; Mangano et al., 2008), even though the prototypes are targeted at multiple devices (Lin et al., 2002). The motivation question here is: At what extent can we successfully design multi-platform systems by prototyping and testing using single-platform systems?

A designer could sketch and test interfaces for many platforms using just a single platform such as a large sketching device (e.g. Wacom, TabletPC). However, assuming that the main benefit of sketching as a prototyping technique is to allow us to ‘see-as’ and ‘see that’ (Schon and Wiggins, 1992), we observe that in current prototyping practices that benefit is hindered since only the size of the target device is being considered, while there are other significant factors such as weight, screen resolution, brightness and interaction modes (e.g. multi-touch, WIMP).

When designing multi-platform user interfaces, designers either have to design a UI separately for each device, which is time consuming, or use a program to automatically generate or adapt interfaces, which often result in interfaces that are awkward (Lin, 2005). Whichever method used, designers would lose the benefit of iterative design, considered critical for creating good user interfaces.

We argue that a more complete prototyping system would allow sketching and simulation on the target device, enriching both designers’ and users’ experience with an interactive prototype, allowing them finally to have a richer conversation with the working design at hand.

### 3. State of the art

This section describes the current state of the art considering the two main areas in which the GAMBIT system is included: Sketching and Distributed systems. We also position the system...
according to other tools already developed for supporting UI design.

3.1. Sketching systems

Systems that have sketching as their main interaction mode can be classified by the “Sketching intention” (i.e. the goal for the sketching as an activity). Therefore, the intentions can be classified into one of three categories, as grouped by Mangano et al. (2008): Thinking, Talking or Prescriptive. We added another category: Prototyping, since prototypes are used to communicate to a stakeholder (talking) and also produce an interactive artifact, a final product of a design session (prescriptive). Thus, tools might support one or more sketching intentions:

- Thinking sketches Exploratory models that help the designer think and work out the solution in their mind. When designers externalize a mental model, part of the cognitive process needed to hold it in memory is relieved (Tversky, 2002). A tool that supports this kind of sketching does not “get in the way” between the designer and the model at hand;
- Talking sketches Models that facilitate rapid, impromptu exchanges between collaborating designers. While sketching, designers often create ambiguous diagrams that need to be clarified in conversations (Cherubini et al., 2007);
- Prototyping sketches They are used to communicate to a stakeholder and also produce an interactive artifact, an intermediate product of a design session.
- Prescriptive sketches Models that communicate the final solution developed by the designer, or generate a specification for UI.

As the study reported in Cherubini et al. (2007) mentions, designers desire an intelligent whiteboard because it would not require hard mental operations while sketching during meetings and design sessions.

However, electronic sketching is still behind the classical sketching in paper, since the tool in use becomes too evident (Weiser, 1991). Perhaps until the gap between displays and paper is minimized, (for instance with paper-like displays Shah and Weiser, 1991) perhaps until the gap between displays and paper is narrowed, and design sessions.

There are other tools such as TEAM STORM (Hailpern et al., 2007) and I-LAND (Streitz et al., 1999) that are more intrusive, since they alter the work environment considerably, by demanding designers to work with interactive whiteboards. WALLSHARE (Villanueva et al., 2010) provides a shared zone that is displayed by a projector over a wall, and users can collaborate through the shared zone using PDA’s with the system installed on them.

We position GAMBIT together with tools for Talking, Thinking and Prototyping, since it is mainly a tool for aiding brainstorm sessions, helping designers to test ideas and prototype interactive systems, also including users and stakeholders in the process (Fig. 1).

3.2. Distributed systems

As categorized by Gallud et al. (2011), a Distributed User Interface (DUI) is a user interface whose components are distributed across one or more of the dimensions input, output, platform, space, and time, and can be described as follows:

- Input (I) Managing input on a single computational device, or distributed across several different devices (so-called input redirection).
- Output (O) Graphical output tied to a single device (display), or distributed across several devices (so-called display or content redirection).
- Platform (P) The interface executes on a single computing platform, or distributed across different platforms (i.e., architectures, operating systems, networks, etc).
- Space (S) The interface is restricted to the same physical (and geographic) space, or can be distributed geographically (i.e., co-located or remote interactive spaces).
- Time (T) Interface elements execute simultaneously (synchronously), or distributed in time (asynchronously).

The tools can be categorized as DUI’s according to the previous description, as depicted in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Tool</th>
<th>Input</th>
<th>Output</th>
<th>Platform</th>
<th>Space</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calico</td>
<td>One</td>
<td>One</td>
<td>One</td>
<td>Single</td>
<td>Sync</td>
</tr>
<tr>
<td>DENIM</td>
<td>One</td>
<td>Many</td>
<td>One</td>
<td>Single</td>
<td>Sync</td>
</tr>
<tr>
<td>DAMASK</td>
<td>One</td>
<td>Many</td>
<td>One</td>
<td>Single</td>
<td>Sync</td>
</tr>
<tr>
<td>I-LAND</td>
<td>Many</td>
<td>Many</td>
<td>One</td>
<td>Multi</td>
<td>Async</td>
</tr>
<tr>
<td>TEAM STORM</td>
<td>Many</td>
<td>Many</td>
<td>One</td>
<td>Multi</td>
<td>Async</td>
</tr>
<tr>
<td>WallShare</td>
<td>Many</td>
<td>Many</td>
<td>One</td>
<td>Multi</td>
<td>Async</td>
</tr>
<tr>
<td>Dazzle</td>
<td>Many</td>
<td>Many</td>
<td>One</td>
<td>Multi</td>
<td>Async</td>
</tr>
<tr>
<td>CrossWeaver</td>
<td>One</td>
<td>Many</td>
<td>One</td>
<td>Single</td>
<td>Async</td>
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<tr>
<td>Inkkit</td>
<td>One</td>
<td>One</td>
<td>One</td>
<td>Single</td>
<td>Sync</td>
</tr>
<tr>
<td>SketchXML</td>
<td>One</td>
<td>One</td>
<td>One</td>
<td>Single</td>
<td>Sync</td>
</tr>
<tr>
<td>GAMBIT</td>
<td>Many</td>
<td>Many</td>
<td>Many</td>
<td>Multi</td>
<td>Async</td>
</tr>
</tbody>
</table>
CAULCO (Mangano et al., 2008), InkKit (Plimmer and Freeman, 2007) and SketchXML (Coyette et al., 2007) are categorized as single input, single output, single platform systems despite being created for sketching in general, cannot be effectively used for designing multi-platform systems.

DAMASK (Lin et al., 2002), DENIM (Newman et al., 2003), i-LAND (Streitz et al., 1999), Team Storm (Hailpern et al., 2007), CrossWeaver (Sinha and Landay, 2003), WallShare (Villanueva et al., 2010) and Dazzle (Oehlberg et al., 2012), despite having the possibility of distributing the output across many devices, are single-platform, which means that all the devices need to run the same environment.

We position Gambit as a distributed system that not only can have input and output from many devices, but also from many platforms, ranging from desktops and interactive televisions to smartphones and e-readers. In this sense, devices that are better suited for sketching input can be used for pen interaction while large displays can be used for visualization. Also, a session can have parts of the shared “wall” interface distributed in space among many projections, composing a virtual meeting room, for instance.

4. Gambit system

The tool support for the investigation is the Gambit system, a multi-platform system with a distributed interface designed to be physically deployed around a table, with tablets and a projector. It is multi-platform since it can run as a ‘wrapped’ application or through the device’s browser in full screen. All the platforms operate through the same interface so there is no difference between mobile and desktop devices.

The system can have many physical configurations and its interface can be distributed among different devices. Each device connected to a session is identified on the screen, so large devices can be used as dedicated areas for sharing sketches, while small devices can be used for testing.

4.1. Requirements

We have observed design sessions conducted in two companies related to user interface development. The people involved on those sessions were designers, project managers, programmers and frequently stakeholders. In overall, in these companies the design sessions are usually done around a central topic, about which people discuss in order to produce some artifact, usually a storyboard on a wall for discussion.

The usual sketching cycle at the observed UI design sessions.

Gambit’s initial requirements and its current state is described as follows:

R1 Support drawing sharing, visualization and consequently discussion: The wall device acts as a sharing repository of sketches, aiding the discussion around a design. It is possible to send sketches to the wall, organize them, put them side-by-side for comparison, etc.

R2 Support session storage and retrieval: Sessions storage are supported, and can be loaded, saved and continued. History support is also planned.

R3 Support private/public production of sketches: Each input device is able to produce live sketches or to produce a sketch separately for later publication on the wall. Subgroup collaboration of two or more participants to produce a sketch is planned, but yet to be supported.

R4 Provide a broad view of the drawings: The wall was designed to serve exactly as a physical wall with ‘projected sheets of paper’, which are the images and sketches.

R5 Provide a fine view of a drawing: The input device can serve as a fine view of any sketch, and they can be redrawn and sent once again to any other device.

R6 Support the UI Design with different levels of fidelity: For the moment, only low fidelity is supported.

4.2. Tool

The system is currently developed as depicted in Fig. 3: the many input devices can be tablets, mobile phones, large graphical tablets, etc.

Many devices can be used to sketch and submit drawings to a virtual wall where all the drawings are organized spatially. The roles of the devices are interchangeable – a user might request the wall’s control at any time, organizing and grouping the sketches, or even creating the possibility of drawing “out of sight” (i.e. out of the public projection) and then putting the drawing for public discussion, like in the sessions observed at the IT companies.

Fig. 3 also shows user A visualizing a big part of the screen on its own laptop, while user B is focused on sketching a document on the upper part of the wall and user C is navigating through a prototyped interaction path.

Since Gambit is a web-based system operating through a browser, the wall might be a full-screen browser window opened on a desktop computer, a projection or a large interactive display (Fig. 4).

The system was developed as a cloud-based HTML5 application and uses HTML5 (canvas) element and Javascript routines to
capture the mouse/pen/ touched events. In this sense, it was possible to centralize the code for different platforms, therefore the system can run on any device with a compliant browser.

5. Pilot experiment

We conducted a pilot experiment with 6 UI developers from IT companies, grouped into pairs on design sessions GAMBIT. We recorded videos of interviews conducted during and after design sessions with the system and aggregated the data in order to investigate the main requirements for multi-platform sketching systems.

Our exploratory question for the experiment was “what are the positive and negative points of designing and discussing functionalities of a system using electronic sketching on multiple devices?”

We have used a set of three devices: Smartphone, Tablet and a large Tabletop. The smartphone used was a Motorola Droid 2 with Android, the Tablet used was a Samsung Galaxy tab 10.1 with Android and the Tabletop was a projection system on top of an horizontal smartboard measuring about 30 inches diagonally, as the wall we have used a second display of 19 inches of an iMac with an Intel processor.

We decided to group subjects into pairs in order to enforce the communication about aspects of the system (referring back the references, we therefore stimulated the use of Talking sketches). The goal was to aggregate the participants’ discourses for analysis.

We asked subjects to design a simple “I Spy Bingo” game for kids to play in the backseat of a car during travels. The children would use tablets to tag different objects they see along the way. The parents, prior to the travel, would choose which objects the kids would have in their tablets to tag. Therefore subjects were asked to draw the two interfaces.

Fig. 5 depicts the experiment design and progression over time. Participants had the chance to design on one device at a time, having a large screen in front of them, displaying GAMBIT’s wall. We have designed 3 tasks of 10 min each.

In the first 10 min, the pair of developers started the design using the first device. Then they were asked to fill the questionnaire (IBM CSUQ) about overall aspects of the system. After the questionnaire, we gave subjects another device and asked them to continue the design in another slot of 10 min, and again with the third device for 10 min, accounting for 35 min in total. After the design session, we conducted an interview for assessing new requirements for the GAMBIT system.

All three groups tested all three devices, answering the questionnaire after the usage of the first device. Therefore, each group first experienced the system through the perspective of either a small, medium or big device, in order to normalize the responses for the IBM CSUQ questionnaire. In this way, subjects were not influenced by previous experience with the system on other devices.

6. Results and lessons learned

By observing the questionnaire results, it is possible to see that subjects were not very satisfied with the system (questions 1, 2 and 19), and did not think they could complete the work very quickly or efficiently (questions 3, 4, 5 and 8) even though they felt comfortable with it (6) and reported it was easy to use (7). Overall, subjects did not rated any question with more than 5, except for the question 7.

We have also analyzed the discourse of the subjects by using word clouds. A word cloud is a special visualization of text in
which the more frequently used words are effectively highlighted by occupying more prominence in the representation.

The work of Mcnaught and Lam (2010) describes an experience on using word clouds to inform qualitative research. This kind of visualization allows researchers to grasp the common themes in the text, and sometimes even to find out main differences between sets of responses (Fig. 6).

Even though a more profound analysis need to be done in order to grasp the context of words at different utterances, it is possible to compare the overall differences in subjects’ discourses while using the three types of devices, like in Fig. 7.

The word faire (do/make) is the most common occurrence, since during the whole design session subjects discussed about how the user (the parent, in this case) would do to make the list of objects to be tagged by the children.

Subjects used the tablet to simulate the interface to be used by the children. That is why the words là and ici (there and here) have a high occurrence rate. Subjects also complained about the

Fig. 6. Results for the IBM CSUQ questionnaire.

Fig. 7. Word clouds for each device type.
smartphone’s screen size for drawing and manipulating the system, this is why the wordécran (screen) have a high occurrence rate in the cloud for the smartphone.

About the post-experiment interviews, we have asked several questions about the system current state and how it could be improved. Overall, all the three groups indicated that:

1. The system need predefined forms (lines, squares, circles, etc) which would ease the process of producing "reasonably good looking" interactive screens with minimum effort. That would ultimately improve their experience with the smartphone, since they do not feel much comfortable;
2. It was difficult for the subjects to sketch using the smartphone due to its' screen size;
3. It was very helpful to have a big screen in front of them to discuss and refer to previously drawn ideas;
4. The system’s speed was slower the smaller was the screen size, being ranked from fastest to slowest as Tabletop, Tablet, Smartphone, in their opinion.

7. Lessons learned

Despite being the research conducted in this paper related to the sketching activity, we observed that if we are aiming at including stakeholders and developers in the design process we then need to provide the means for them to participate not only with their own devices, but also with their own ways of composing interfaces.

During the interviews for gathering requirements designers often mentioned that during brainstorming and design sessions users, programmers and stakeholders are not very comfortable on drawing in front of the others. The solution adopted by some of the designers when conducting such sessions is to give them a separate spot on the meeting. They referred to that as anaparté (aside) activity and it is something GAMBIT could foster with its' usage.

It was clear on the experiment that, from the system side, GAMBIT needs to have pre-defined forms in order to help people express their ideas, and not only provide sketching as the sole interaction mode.

The reason why developers are more comfortable with pre-defined forms is perhaps because they are used to work with UI widgets in order to specify the system’s functions. This observation is aligned to other studies (e.g. Johansson and Arvala, 2007) which report that developers are much more focused on system’s function (how the system will perform) over other variables such as operation (how users will use the system) or concept (what is the system’s purpose). That is a strong reason why the design iterations should include, as much as possible, people from all the parts involved a the system’s design.

Also, the preferred devices were ranked from fastest to slowest as Tabletop, Tablet, Smartphone, in the opinion of the developers, therefore further work is necessary in order to observe if this the rank is based on only one variable (size or speed) or not.

8. Conclusion and future work

The study reported on this paper is part of a larger study about how people sketch and test user interfaces for many platforms. As Schon and Wiggins (1992) pointed out, people engage in a sort of conversation with their sketches in a tight cycle of drawing, understanding, and interpreting.

The main benefit of sketching as a tool for prototyping is to allow us to ‘see as’ and ‘see that’ (Schon and Wiggins, 1992). In current practices (i.e. where only one type of media is used) that benefit is hindered since only a few variables of what is being prototyped are considered, such as the screen size of the target device. There are other significant factors such as weight, screen resolution, brightness and interaction modes (e.g. multi-touch, WIMP) that are part of the user’s experience with a system.

We presented the current state of GAMBIT system for electronic sketching on a multi-platform context. The tool is a fundamental part of a research on sketching, whose goal is to advance the state of the art in electronic sketching, and foster its usage in current design practices taking into account the diverse multi-platform context.

The system poses as a contemporary example of distributed and collaborative tool for aiding design sessions, since it was designed based on current design practices by observing brainstorming sessions. As for its implementation, since it is a web application (as opposed to a client–server application like the related works) there is no need to deal with issues of communication in a lower level (e.g. IP addresses and ports, UDP or TCP packages, etc.). That reduces the complexity at the deployment of the system to a simple task of opening an application or a website and logging in.

With the pilot study presented in this paper we began to assess the current state of the system in order to evolve it based on requirements of different parties on a design session: designers, developers, stakeholders and users. This pilot study will serve as a comparison between discourses of those different parties in future experiments.

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