

A technique to improve sketches of rich interactions

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ABSTRACT

Sketching is considered a core activity in design and is a well-established practice in many areas of design. Interaction design is a new field of design that poses challenges for sketching, due to particular characteristics of the field such as being dynamic and “immaterial”. In this study we focus on screen-based interactions, and particularly on rich interactions. To overcome these challenges one approach that has not been much explored is trying to improve sketches of interaction done on paper. With this in mind we propose ActionSketch, a technique that tries to accomplish this and is composed of four parts: frames, colors, symbols and rules. To validate the technique we conducted four workshops with 24 professionals, followed by a period of continued use of approximately three weeks. Our findings confirmed the need for better representations of interactions on sketches, offered insights into the benefits of using the proposed technique and indicated some opportunities for improvement. One major point for discussion is how the technique extends the current practice of sketching, and how it benefits from doing so.

Author Keywords

Interaction design, rich interactions, sketching, paper based, technique.

ACM Classification Keywords

H.5.2 User Interfaces: Evaluation/methodology; Prototyping.

INTRODUCTION

Sketching is considered a core activity in design [14,19,26] and even as the essential activity that would define design [11]. Since the seminal work of Schön [39], who describes the act of sketching as having a “conversation with the drawing”, it has been increasingly clear the importance of sketching and its dialogic nature during early stages of the design process [11,18,20,27,46].

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In a process where the designer almost simultaneously creates and reinterprets the representation, sketching is “not merely an act of representation of a preformulated image ... it is, more often than not, a search for such image” [19]. While the designer tries to define what a particular shape should be, sketching helps with “a back and forth swaying movement which helps translate particulars of form into generic qualities, and generic rules into specific appearances” [19].

Sketching is a well-established practice in many areas of design, such as product design and architecture [6,26,33], but is still in its infancy in interaction design (IxD) [11], a field that can be defined as “the design of the subjective and qualitative aspects of everything that is both digital and interactive” [30]. In this context, the area poses particular challenges for sketching because it deals with objects that are dynamic [2,10,11,17,37] and which have “immaterial” qualities [8,10,32], and so traditional sketching practices are sometimes insufficient [11,16].

In this article we propose ActionSketch, a technique to improve the practice of sketching interactions. Since interaction design (IxD) has evolved to encompass an enormous range of products [37], we focus our research on screen-based systems [30] and particularly on rich interactions [35,47].

Sketching in design

The term “sketch” can be interpreted in several ways, so for this article we will use the word in terms of “proposition drawings” [26], those drawings that the designer does to propose a possible outcome to a problem, which can be described as:

“The process here [of proposition drawings] seems to be one in which the designer externalizes some features of the design situation in order to examine them in a more focused way. [...] Designers describe this also as temporarily freezing something in order to explore the implications of it.” [26].

Some studies argue that this kind of drawing can be understood as an extension of the designers cognitive system [18]. During early stages in the creative process, designers often make sketches as part of a strategy that has been called “analysis through synthesis” [27]. The designer studies the problem through successive attempts to solve it, and the “problem-solution pair” emerges in a joint evolution [27]. Dorst and Cross exemplify the process as follows:

“The designers start by exploring the [problem space], and find, discover, or recognize a partial structure. That partial structure is then used to provide them with a partial structuring of the [solution space]. They consider the implications of the partial structure within the [solution space], use it to generate some initial ideas for the form of a design concept, and so extend and develop the partial structuring. [...] . They transfer the developed partial solution structure back into the [problem space], and again consider implications and extend the structuring of the [problem space]. Their goal is to create a matching problem–solution pair.” [15]

Using this approach, which was described as a “reflective practice” [38], designers use the sketch as a way of experimenting with some features of a design solution while other features remain fixed. In this sense, sketches are a way of making, recording and testing hypotheses and the sketch “becomes a sort of graphical ‘what if’ tool” [26]. In this sense, sketching can be considered the “easiest and most immediate external device that we can use to amplify mental imagery and to extend it” [20].

As proposed, creating a sketch is an intricate process that occurs both in the designers mind as well as on the representation that is being generated. For this reason the tool used becomes an important factor to consider, and it should be unobtrusive and familiar to the designer [46]. In this sense, freehand drawings on paper is a common alternative for making sketches in many areas of design and even in IxD [12,20].

While it presents some drawbacks for IxD, as we will explore later, it provides important affordances when compared with the computer, such as: not imposing an extra layer between the designer and the representation, being more portable and being better suited for face-to-face collaboration, among others [12]. Therefore, even knowing about its limitations, the tool proposed in this article is based on the belief that drawings on paper can be an interesting tool for early stages in the design process.

Sketching interactions

Interaction design (IxD) is a new field of design that emerged in the 1990s with many characteristics of industrial design, graphic design and computer science [37]. Within this field, in this article we focus on screen-based systems [30] and particularly on situations where there is a screen, mouse and keyboard, like on WIMP-based systems.

It has already been noticed that IxD poses new challenges for sketching, due to particular characteristics of the field [11,16], such as being dynamic [2,10,11,17,37] and “immaterial” [8,10,32].

An area of IxD that is particularly difficult for applying sketching techniques is the one concerned with rich interactions [7,35,47]. This kind of interaction is closer to

direct manipulation than the turn-taking paradigm present in command-line interfaces. While performing an action, the system might start “talking back” to the user by providing him with clues and responses, even before the action is complete. Each micro-action of the user, such as “grabbing” an icon with the mouse, can generate micro-responses of the system, such as generating a shadow to be dragged and highlighting possible valid targets for that icon to be dragged to. The paradigm shifts from separate screens to several possible states of the same screen.

Sketches of rich interactions present more challenges because of this simultaneous nature of the interaction, which involves a greater level of detail. When there is a clear turn-taking in the interaction it is easier to depict how the interaction takes place: system presents screen 1, user gives an explicit input, system presents screen 2, and so forth. In the case of rich interactions the dialogue between user and system is much more subtle and constructed by many micro-interactions that combined build up the user actions [7,35,47].

To overcome this complexity, one possible approach is to bring freehand drawings into the computer and then complement these static images with the dynamic and invisible aspects in the interaction with some sort of procedural tool, such as programming or just by “linking” static images to simulate an interaction. This line of work has many interesting alternatives, combined in three main directions: scanning freehand drawings [13,48]; using a tablet for pen-based input [1,13,22,25,28,29,31,34,40]; and using an augmented reality setup, such as a sensitive table and a projector [1]. While these approaches present interesting insights, we believe that producing sketches for interaction design as freehand drawings on paper can also yield interesting results. Moreover, our review of the literature indicates that the field remains largely unexplored.

We found some literature that explores the practice of paper prototyping [36,41], but there’s an important difference between the approach of these authors and the one that we propose in this article. When producing paper prototypes the designer is usually more interested in refining and validating one or just a few alternatives. In contrast, when producing sketches the focus is on the rapid generation of large quantities of ideas [11].

In terms of incorporating time and behavior on paper sketches we found two solutions that try to overcome these barriers: the use of annotations, side notes that explain the interaction in textual form [37] and by embodied action (talking and gesturing), which happens when two designers talk about an interface [44]. These are valid and important tools, but they both present limitations.

Annotations are textual descriptions and therefore aren’t as agile as visual representations. Particularly for rich interactions, which have many subtle details, textual

descriptions end up being too long and time consuming to be produced [47]. Embodied action, on the other hand, is extremely efficient and allows describing an interaction fast and in many details. The disadvantage of this approach is that, once the conversation is over, what is recorded and visible to all the designers is only the drawing, which lacks all the details and variations mentioned during the conversation [44].

Concluding, while there are several alternatives for making sketches of interaction design, we believe that the field of freehand sketches of interactions presents many opportunities for improvement.

We understand that investigating paper as a support for sketches of digital products might sound like a contradiction. The medium of the sketches, paper, doesn't support some of the essential characteristics of the digital medium, such as being dynamic and "immaterial", and so the approach would not be adequate.

However, this first impression is questioned by the fact that the practice of paper sketches is widely adopted and has been fostered as good practice, both by practitioners as well as by scholars [7,12,21,30,37,42,47].

A way to look at this issue is to analyze the use of paper sketches in other fields of design. For example, sketches in product design use orthographic projections to represent three-dimensional objects on the flat surface of paper [6,33]. Also, motion graphics uses storyboards to create sketches that depict the notion of time [23]. In both cases drawing techniques allows designers to create representations that goes beyond the essential nature of paper.

Considering this, we believe that it is possible to do the same with sketches in interaction design, that is to say, to develop a technique that enables designers to represent the interaction on paper.

THE PROPOSED TECHNIQUE

We now present ActionSketch, the technique that tries to achieve this. It is composed of four parts: frames, colors, symbols and rules.

Frames are used to represent the interaction happening over time. They are arranged like a storyboard, just as it's used in film and motion graphics [23]. This is already a common practice in interaction design [11,21] and we found it the most suitable for our technique.

Colors are applied to organize the sketch. To better represent the interaction, in other words, the dialogue between the user and the system, we represent each frame with three stages: initial state, user actions and system actions.

In order to indicate these stages in the same frame we use colors to separate them in layers [45] following this association:

- Black: initial state.
- Green: user actions.
- Orange: system actions.

Symbols are defined to improve consistency in specific situations and to represent elementary user actions and responses from the system. Each of the three stages, initial state, user actions and system actions, has a specific set of symbols.

For the initial state we proceed according to the current practice, to draw a wireframe by hand [6]. We only add four symbols presented in Figure 1.

Description	Symbol
button (right and bottom borders are thicker)	
area	
invisible area (dashed rectangle)	
element which reloads automatically (curved arrow)	

Figure 1: Four symbols for the initial state.

To represent the user actions we propose 12 symbols that cover basic actions that the user can do with a pointing device and a keyboard, presented in Figure 2.

Description	Symbol	Description	Symbol
mouse click		mouse over	
mouse double click		mouse out	
mouse down		key click	
mouse up		key down	
mouse move		key up	
scroll		type some text	

Figure 2: 12 symbols for the user actions.

For system actions we propose a set of eight actions that the system can produce on the screen, presented in Figure 3.

Description	Symbol	Description	Symbol
show		highlight	
hide		remove highlight	
enlarge		move	
reduce		reload (not automatic)	

Figure 3: Eight symbols for the initial state.

Rules of use are the fourth and last part of the technique. These three rules are meant to help applying the technique, and can be described as:

1. **Draw only what changes between frames.** To make sketches faster draw the whole screen on the first frame, but on the following frames only what changes needs to be represented.
2. **On each storyboard stay focused on just one idea.** This helps to focus on one specific task that the user is doing. For example, each of the tasks “add item” and “remove item” should be drawn on a separate storyboard.

3. **The goal is to express an idea, employ the technique when useful and modify it as needed.** The main purpose of the technique is to help make sketches, not to be a straitjacket. According to the situation it might be better to draw in one way or another, or even to adapt the technique. Customization is expected.

To demonstrate the technique we provide two practical examples. On these examples we have several icons on the screen and we add them to a side panel (labeled “cart”). In the first case the user simply drags the icon on top of the closed panel. We show this example on Figure 4.

- Frame one: the user puts the mouse over the icon and the system highlights the item.
- Frame two: the user grabs the icon, drags it to the tab of the panel and releases it. The system carries a shadow of the icon with the cursor and when the user releases it the shadow disappears and the tab moves a bit to indicate that the item was added.

In the second case the panel is open and already has five items. When the user drags the sixth item some of them need to shift place and a scroll bar appears. We show this example on Figure 5.

- Frame one: the user drags the icon to the desired position. The system moves some of the icons down to free some space and displays a scroll bar.
- Frame two: the user releases the icon and the system snaps it to a grid.

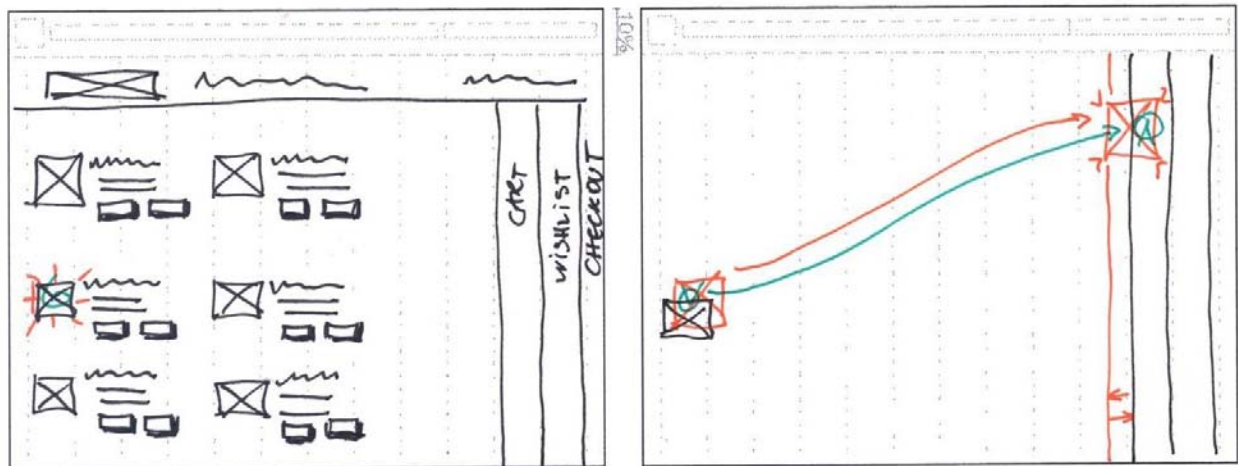


Figure 4: Add the item through drag and drop mechanism.

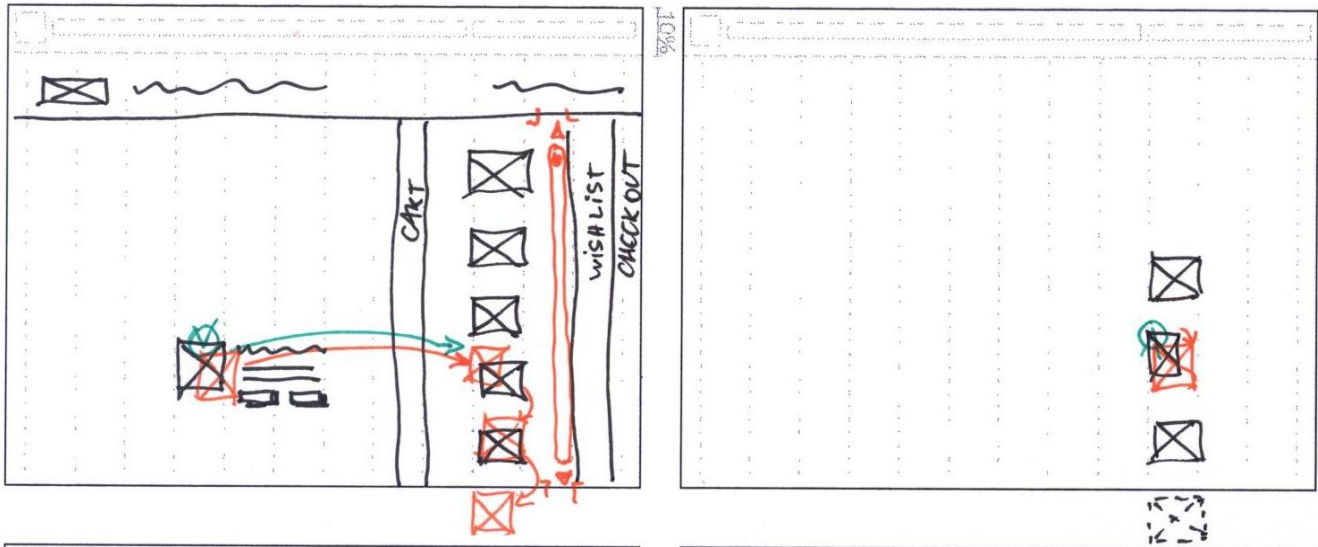


Figure 5: Add the sixth item to the side panel.

The technique is currently on its ninth version. It was initially based on a literature review, followed by a series of iterations through exercises. We presented earlier versions of the technique previously, but at that point it was just a proposition, before any formal feedback from interaction designers [3].

Since those studies we performed in-depth interviews with eight interaction designers and revised many aspects of the technique. After that we validated the technique in workshops, which we describe in detail in the next session.

DESIGN STUDIES

For our design studies we proposed an introductory workshop to present and practice the technique and collect initial feedback. After that there was a continued use period, when the participants tried to apply the technique in their daily work and finally an individual interview to collect feedback and materials generated.

Figure 6 presents an overview of the whole process. We carried out four workshops in four different companies, with 24 participants in total. Three of the companies were

interactive design agencies and one was an in-house team of a newspaper (workshop 2).

Table 1 presents an overview of the participants. In the second column, just as a reference, we have the total number of employees of the company. On the third column we have the total number of participants, who were all coworkers. The fourth column shows the number of participants whose tasks were focused mostly in IxD. The other participants were part of the interaction design team but had complementary roles, such as visual designers, managers and usability analysts.

Workshop	Employees	Participants	Focus on IxD
1	150	5	3
2	500	9	4
3	14	6	4
4	60	4	3

Table 1: overview of participants in each workshop.

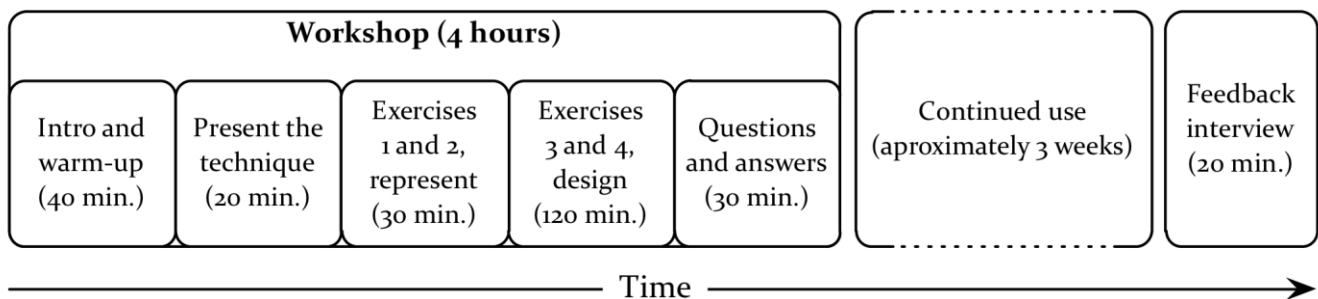


Figure 6: Overview of the workshop, continued use and feedback interview used in the study.

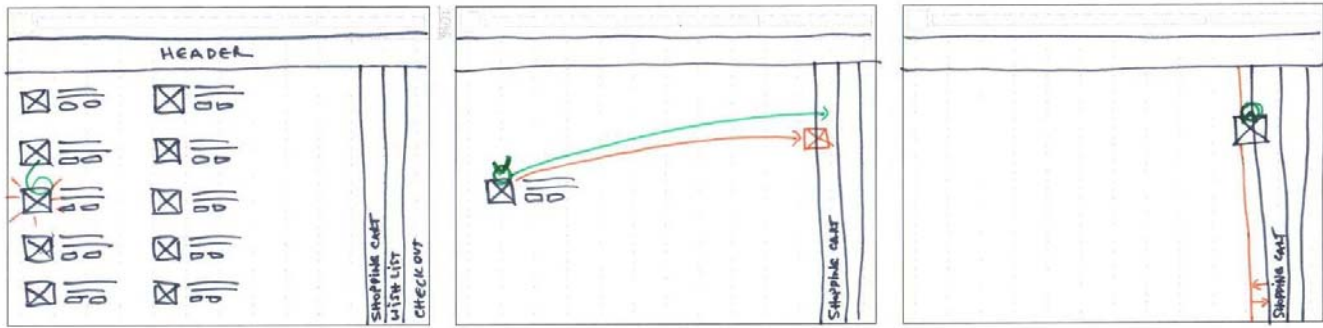


Figure 7: Example of exercise 2 done by participant.

As shown in Figure 6, the workshops lasted around four hours each and followed the same structure. An initial questionnaire collected some information about the participants profile and previous practice with sketching activities. Then a high-level overview of sketching was presented and a warm-up exercise proposed (40 minutes). Then the technique was presented (20 minutes) and four exercises that used the technique were proposed.

The focus of the first two exercises was just on using the technique for representation, therefore the participants were asked simply to sketch an interaction that was presented to them (30 minutes). On the next two exercises the focus shifted for designing a solution, thus they were asked to sketch proposed interactions for a series of situations using the technique (120 minutes). Figure 7 shows an example of exercise two, which is similar to the example presented in Figure 4.

The workshops were concluded with a session for questions and answers. The participants also filled a 14 question written survey asking about their initial impressions of the technique, its usefulness in their work and comparing it with their previous practice (30 minutes).

Each participant received a kit for the workshop containing a cheat-sheet of the technique, some template sheets and black, green and orange pens. These materials were left with the participants after the workshops for the continued use, which lasted three weeks average. During this period the participants received daily emails both as a prompt to remind them to try to use the technique when possible as well as to collect feedback.

At the end of the continued use we conducted a short individual interview with the participants (20 minutes). In this interview participants reported how they used the technique, its advantages and disadvantages, in addition to other observations. We also collected the drawings made, both during the workshop as well as during the continued use.

Findings

Our findings from these studies confirmed the need for better representations of interactions on sketches, offered insights into the benefits of using the proposed technique and indicated some opportunities for improvement.

Previous practice: many sketches but little interactions

In terms of their practice before the use of the proposed technique, we found in our study that the participants made heavy use of sketches for early explorations, which is in line with the literature [7,12,21,30,37,42,47]. Almost all users from the IxD group (12 out of 14) create sketches regularly. However, most of the times the interaction was not represented in these sketches, only the screens. We found two main reasons for this to happen.

When discussing an alternative with colleagues, designers usually describe the interaction through an embodied practice. They make sketches of the screens, but the interaction is explained and discussed only through speech and gestures and is not represented on the drawings. This situation coincides with the findings of [44].

In another scenario the designer leaves the interaction for a later stage. Again, the sketches contain the screen layouts but not the interactions, which are only implied on the sketches and should be detailed on a more complete document to be done afterwards, usually a clickable prototype or a wireframe done on the computer. This can happen either because the designer thinks that the interaction is too simple, and there's no need to be represented, or because it seems too complicated, and it would be too difficult or impossible to represent on paper. Either way, the interactions are left out of the sketches.

A particular case in this second scenario is the use of textual descriptions of the interactions on side-notes. This is mentioned in the literature [9,21] and was expected in our study. However, only two participants in our study stated that they sometimes used side-notes on sketches. Most of them said that they didn't use side-notes on sketches, only when they would create a more complete document in a later stage.

We see two major problems of not representing the interaction on sketches. In the first place, it means that the interaction was left out of the activity of sketching, creating a handicap for interaction designers. The sketch is a way to help the designer “expand” his cognitive ability by externalizing the designed entity in some way. When the designer draws the layout of a screen, but not the interaction, it means that s/he is using the sketch to help think about the layout, but only to a very limited extent in the case of the interaction. Secondly, leaving the interaction for a latter stage means that there will be less room for exploration, which hinders the generation of alternatives.

ActionSketch improved representation of interaction in sketches

A key benefit of the technique was enabling the representation of the interaction on sketches. As one participant said: “[The technique] allows me to represent things that until then I found very difficult”. And even though the sketches were done on paper, a static medium, they communicated adequately the interactions. As another participant stated: “Although it is static [the drawing], the interactions come to life”. This representation had effects both in terms of the cognitive process of the designers as well as in the communication between designers.

One effect on the cognitive process was that the technique seems to improve the feedback loop between the sketch and the designer’s mental process. As one participant stated: “[in my former practice] I would do it in a similar way, but I would have to draw many more screens and describe the interactions in text. [...] The technique reduces the number of drawings, and therefore the time and effort to register and communicate ideas”. This means that with the technique he drew much faster. As Goldschmidt [19] explains, sketching is a dialogical process between the designers mind and the representation. By using the technique, which improves the representation, we also

improve the process as a whole, or, as another participant said, s/he felt that “was able to think faster”.

Another positive aspect was an improvement of the recovery of information. Previously, when interactions were not represented on sketches, the designers had to rely on their memories to remember how a particular interaction was proposed. By using the technique they had a sketch which was much more complete and accurate. As another participant describes, the technique “[allowed me to] document the process of interaction, my thoughts. It is just like taking a picture of the process of elaborating a solution”.

In terms of communication between designers, we believe that the most important result was that it became easier to read and explain the interactions. Since the technique proposes a common way to represent the interactions it allowed coworkers to “read” each others drawings more easily, without the need to explain them. For example, Figure 8 shows two alternatives presented by participants for the task of “adding a item”.

The left frame shows how it would be done with a drag and drop mechanism from a top panel, while the other frame depicts an alternative where the user needs to open a side panel first. In these situations there was no need to describe the interactions, because they were already represented in the drawings. In another article we explore these effects in more detail [5].

Opportunities for improvement

The previous findings indicate that the technique is needed and that it in fact helps in the process of sketching interactions. They support our initial hypothesis and indicate that our direction seems promising. However, we also found some aspects of the technique that can be improved. We now focus on these aspects.

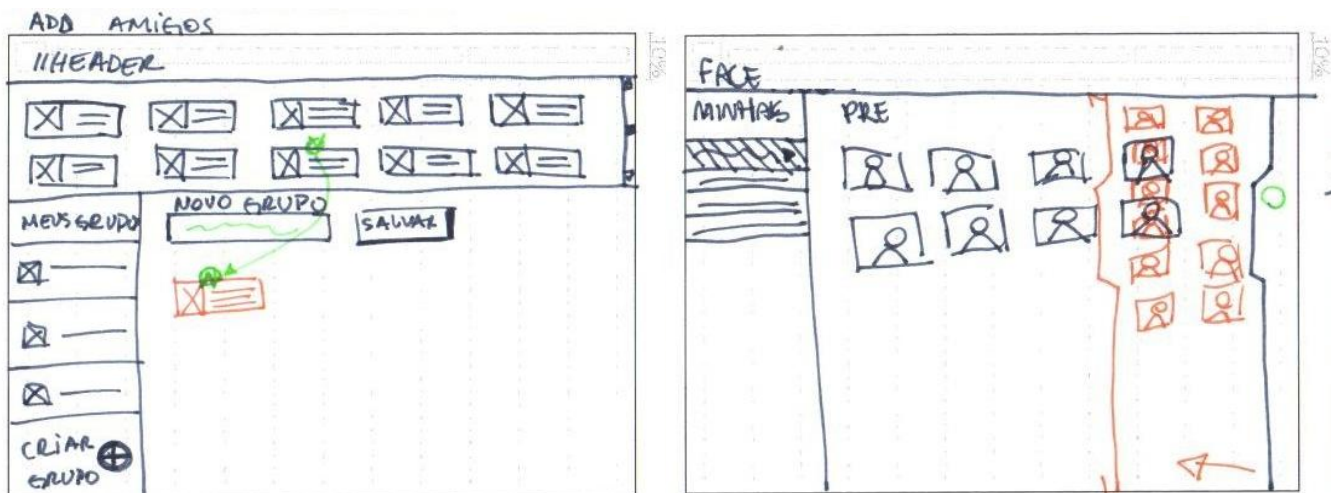


Figure 8: Two alternatives for the action “adding an item” proposed by two participants.

Four participants pointed an important aspect: they prefer to use flowcharts instead of a storyboard to represent the interaction. In our technique, the proposed structure is the storyboard, focused on one particular task. To show the different variations, for example recovering a password on a login task, the designer could create separate storyboards. Still, these four participants found this alternative awkward and would prefer to use a flowchart instead.

Nevertheless we see that the technique can be combined with storyboards as well as flowcharts, and this can be an interesting alternative, with one caveat. Usually flowcharts don't show the layout of the screens, and they are represented by a simple rectangle, to make the flowchart smaller [21]. With our technique we would recommend the use of a particular variation of a flowchart, sometimes called a "wireflow", where the screen layouts are present [21].

We also received some suggestions for improvements from the participants. Three participants found the symbols for mouse over and click to be too similar, which could cause misinterpretation, so we should review them. One participant also suggested that the symbols could be present in the template sheets we provided, making them easier to learn and remember. It's an interesting point and we believe that it's an improvement for the templates used in the technique. Finally several participants would like to have a template with four frames instead of six, which is also an interesting alternative.

Another aspect that needs some attention is how the technique is presented initially, and how to give access to special cases and more advanced aspects. Our point of departure was that it should be as simple as possible in a first contact and so in the workshops we presented only what we considered strictly essential. For example, we had a symbol for alternate click and a numbering scheme, which allowed representing explicitly the order of actions in one frame. These two aspects of the technique were not shown on the workshops because we felt that they aren't needed so often.

However, during the workshops two participants asked about the alternate click and in three of the workshops the numbering scheme was a frequent demand. This indicates that the technique needs documentation in a modular format, preferably online. Initially only the essential aspects are shown, but as the designer uses the technique, s/he can look for more advanced aspects as needed. This seems to be in line with other studies, which indicate that designers appreciate and consider more useful tools that are simple to comprehend and that can be learned as they are used [42].

DISCUSSION

Looking at our findings, three aspects should be discussed: how the technique extends the current practice, how it benefits from doing so, and some directions for future work. We present these aspects below.

Extending current design practice

We believe that one crucial attribute of the technique is that it is not disruptive in relation to current practice, but instead, tries to complement it. Almost all designers already make sketches and the technique extends this activity to include the interactions. As one participant said, the technique "*fit into my way of thinking and structuring the interactions and their consequences*".

Stolterman and others [42] refer to this type of practice as "designerly tools" and defines them as "methods, tools, techniques, and approaches that support design activity in way that is appreciated by practicing interaction designers". Another study [43] warns that this kind of concern is critical when developing a technique like the one presented in this paper.

Standing on the shoulder of giants

One unexpected aspect we found when analyzing the data was that some of the positive feedback we got was not related to the use of the technique, but to the practice of sketching alone. In fact, the sketching is supposed to have a positive impact both in the cognitive process of the designer as well as in the communication between professionals [26]. So we found that the technique was "standing on the shoulder of giants": since it stimulates the practice of sketching, positive impacts were found even without applying the technique, just by making more sketches.

For example, some participants reported that they thought that a major benefit of the technique was that the communication between team members increased, as people began to draw more and that lead to more discussions. Another example of a positive impact was the speed and flexibility of drawing on paper, compared to the computer.

We consider this a positive aspect of the technique, but it also means that a special attention to this aspect was necessary during the analysis of the results. This was achieved by comparing the results after the workshops with the information collected about the previous practices of each of the participants, and during the final interviews, when necessary. Fortunately it was possible to state that ActionSketch brought positive results beyond those arising solely from sketching.

Future work

One evident direction for future works is to use the insights from our study to improve the technique in new directions. First, we should generate a new version of the technique, which includes wireflows as an alternative to storyboards, reviews some of the symbols used and improves the templates provided. This should be version 1.0 of the technique.

Another improvement is the creation of a website to document the technique in a modular format. In this structure there should be a basic level, which presents the

essential information to allow a designer start using the tool. Additional information, such as special cases and extensions of the technique would be available as additional modules and explored as needed. For this purpose, research into the documentation from other techniques should provide interesting insights. One interesting example is the Foundations page of the Arduino project, accessible at <http://arduino.cc/en/Tutorial/Foundations>.

Besides the new version of the technique and the online documentation we also see some opportunities to incorporate the technique on drawings made on the computer, since sketch recognition presents some interesting directions for a more natural interaction with computers [24].

One way to do this would be to use the symbols of the technique as gestures to allow the designer to associate a screen element with a particular user input or system response. For example, by drawing a symbol of a click over a button would automatically prepare that button for a click event. We imagine that this would be useful for creating working prototypes of the interface using a more natural interaction.

Another direction is to expand the technique to encompass other kinds of interfaces beyond the WIMP paradigm, such as multi-touch interfaces used in tablets and smartphones. We have already some preliminary work in that direction[4].

CONCLUSION

We have presented ActionSketch, a technique to improve sketches in interaction design. It's based on current practices of interaction designers, so it takes advantage of being a non-disruptive practice and, at the same time, extends this practice to make it easier to represent the interaction on sketches.

ActionSketch is based on the use of colors to represent three stages of the interaction: initial state, user actions and system actions. Each of these stages also has symbols to represent common situations. The results from our study show that improving the representation had a positive effect both for the cognitive process of the designers as well as for the communication between designers.

We verified our technique with 24 professional designers, and found that it has a positive effect on sketching interactions, with very positive feedback from the participants. However, the study also indicated some improvements and directions for future work.

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