IEEE Proceedings of 4^{th} International Conference on Intelligent Human Computer Interaction, Kharagpur, India, December 27-29, 2012

Can a Paper-Based Sketching Interface Improve the Gamer Experience in Strategy Computer Games?

Matthieu Macret
School of Interactive Arts and Technology
Simon Fraser University
Surrey, B.C., Canada V3T 0A3
Email: mmacret@sfu.ca

Alissa N. Antle
School of Interactive Arts and Technology
Simon Fraser University
Surrey, B.C., Canada V3T 0A3
Email: aantle@sfu.ca

Philippe Pasquier
School of Interactive Arts and Technology
Simon Fraser University
Surrey, B.C., Canada V3T 0A3
Email: pasquier@sfu.ca

***Abstract*—The field of sketching interface design in regards to video game is relatively young and has not been investigated in great depth. Freepad is a custom paper-based MIDI musical interface. We describe an extension to Freepad that supports user customization for real time strategy games. Using only a webcam, a pen and a sheet of paper, players can design their own interface by drawing shapes and linking them to simple or complex actions in the game. In an user study, we use this extended Freepad to explore the potential of sketching interfaces in strategy video games. Our results indicate that using Freepad improves the efficiency of players and their enjoyment in this kind of games.**

***Index Terms*—K.8.0 [Personal Computing]: General Games; H.5.2 [User Interfaces] Evaluation / methodology**

I. Introduction

The field of sketch-based interfaces focuses on developing methods and techniques to enable users to interact with a computer through sketching. Sketching and gesturing with a pen are two modes of informal, perceptual interaction that have been shown to be especially valuable for creative design tasks [1]. Sketching interfaces have been mainly used for Computer Aided Design (CAD) for tasks such as user interface design [2] or industrial design [3]. Contrary to current user interfaces which could make the designer focus on inappropriate issues during early stage of design, sketching interfaces have the benefits to be intuitive to use, flexible and to stimulate creativity [2]. This kind of interfaces has been also successful to control other applications (digital scrapbook applications [4] or annotation applications [5]) with the same benefits but has been little used in video games.

Real-time strategy game (RTS) is a kind of strategy video game in which the player is concurrently involved into three activities [6]:

- *Conquest*: the player has to destroy the enemy bases, take its resources and expand her territory,
- *Exploration*: the player has to explore the game map to find new resources and locate enemies,
- *Economy*: the player has to exploit resources, develop her bases and trade.

The main challenge for the player is to deal with these activities simultaneously and in real time [7]. In order to achieve these three tasks, the player can perform a limited number of actions, for example building a new infrastructure or unit, moving a unit or using a competence. To perform these actions, the user can use the mouse, click on the Graphical User Interface (GUI) and use the keyboard hotkeys. Since the player has to deal with three activities concurrently, the sole use of the mouse is not efficient. These activities, most of the time, are spatially distributed in different locations throughout the game map. For instance, when attacking the enemy's base, the player also has to keep developing her base and keep exploiting the resources. To achieve that, she has to switch between different views, and therefore cannot focus on one activity. One solution provided by the game engine is to use hotkeys which make possible to execute actions such as building new units without moving the camera. However, conventional keyboard interfaces are chronically difficult to learn, and many users fail to adopt keyboard-based input strategies in practice [8].

In real-time strategy games, the possible interactions are numerous and the players can develop their own personal playing styles. In this context, interface customization has potential to improve player efficiency giving her more freedom in game interactions design [9] and in tailoring the interface to her strategy. In most of the actual real time strategy games, players are able to customize their own hotkeys. Some customizable keyboards have also been designed like the *SteelSeries Zboard Bundle:* $StarCraft^{®}$*II* which gives to the player the opportunity to specify macros to be used in the game. However, the customization possibilities of these additional interfaces are most of the time specific to a single game [9] and requires extra hardware.

Sketching interfaces have potential to deal with these customizability and accessibility issues while helping the player dealing with the game tasks simultaneously. Freepad [10] is a paper-based sketching system that enables anyone with a web-camera, paper and a pen, to draw their own MIDI (Musical Instrument Digital Interface) interfaces and play with it. MIDI is an industry-standard protocol that enables electronic musical instruments, computers and other electronic equipments to communicate. Freepad is free, designed to be accessible without buying new hardware and provides the user with a customizable, generic and efficient interface she can use in real-time. This system uses computer vision techniques such as background subtraction, image moments, and collision detection. These techniques allow the system to parse all closed drawn shapes, analyze the real-time video stream and assemble the interface in three stages (see Figure 1):

1) SET - Set up a web-camera pointing at a piece of paper, and set the background from which Freepad subtracts the interface.
2) DRAW - Quite simply draw out the desired interface, and tell the system to set it.
3) PLAY - Once Freepad has parsed the interface, simply set up the MIDI output, and then start playing the custom interface.

We did extend this system with the possibility to draw interfaces to play in any strategy video games. The new version of the Freepad software including this new functionality, as well as demonstration videos, are available for download on the Freepad website [11]. By performing a pilot user study using the game $StarCraft^{®}$II, we explore the potential benefits of our extended Freepad to improve player experience in terms of enjoyment and efficiency [7]. We show that it complements the use of keyboard and mouse making the user more efficient in the game.

II. Related work

Wellner with his DigitalDesk [12] is one of the first to introduce the concept of interactive paper-based interfaces. His system provides a computer-augmented environment in which paper gains electronic properties that allow it to overcome its physical limitation. It is built around three features: it projects electronic image down onto the desk and onto paper documents, it responds to interaction with pen or bare fingers and it can read paper documents placed on the desk. It enables people to use paper documents to perform useful tasks that are more awkward to do in other ways: tasks such as copying a long number into a calculator, translating a foreign word, replicating part of a sketch, or remote shared editing of paper documents. Wellner claims that this system seems to have a wide variety of potential applications, well beyond those described in his work.

Champaneria et al. [13] work on capturing pen-based input using computer vision. Their system*PadCam* is a perceptual interface for pen-based input that uses live video of handwriting and recovers the time-ordered sequence of strokes that were written. More recently, *Smart pen* technologies, such as LiveScribe or Fly Pentop, have emerged [14]. These technologies differ form the previous one in that the computer vision part of the system is directly embedded into the pen. It makes possible a large number of applications such as recording notes on the fly or searching on Internet. Synchronous interactions between pen, paper and computer can be used to build paper interfaces that control an application, for instance a digital scrapbook application [4] or an annotation application of digital documents using printouts as proxies [5]. Our work differs from these researches in that we do not focus on leveraging printed material, but on facilitating customizable off-screen controls in RTS.

Sketching of interfaces has been also widely investigated, although the work has focused on enabling designers to produce rough sketches of an interface that at later stage can be translated into an operational interface [2]. Sketching is generally considered to be the preferred preliminary capture process for designers because it provides a quick and easy way to externalize design ideas [15]. In contrast to interface sketching for design, VoodooSketch [16] introduced sketching as an end-user technique for on-the-fly creation of controls that are immediately usable for interaction. This system makes possible to form a number of interactive surfaces with physical interface palettes on which the user can dynamically deploy physical objects or draw elements such as sliders and buttons and use them in her application. Villar et al. with their VoodooIO gaming kit [9] used the physical part of this system in video games. They demonstrated how it enables making gaming spaces more appropriable for players, allowing them to customize their preferences. However, in our case, we focus on the sketching power of Freepad and not on adding physical objects to the game interface. Our system is only based on a webcam and paper and not on other additional hardware, which make it easy to setup and more accessible than other systems presented here.

III. Motivations

In this research, we want to explore the potential of sketching interfaces to improve the enjoyment and the efficiency of the player in strategy video games. We extend the Freepad sketching interface promoting usability principles such as accessibility, simplicity and customizability [7].

Accessibility is the quality of the system to be easy to get and to set up. Desurvire et al. define heuristics to evaluate the playability of games [17]. One heuristic concerning the *Game usability* states that: “Upon initially turning the game on the Player has enough information to get started to play”. In video games, more than in other applications, accessibility is a requirement because upon the game on, the player has to be able to play. It implies that as little as possible extra hardware should be needed to start playing. In Freepad, accessibility is achieved by the use of common hardware and tools: webcam, sheets of paper and pen. The end user doesn’t need not to buy new hardware to use Freepad but only to install the software.

In order to make it easy to use and enjoyable, the interface has to be as simple as possible to use. This requirement is important for the same reason than for the *accessibility* criteria: the player has to be able to play upon the game on without losing too much time to configure extra hardware. In Freepad, the configuration of the system is a three steps process (see Figure 1) and we try to design the GUI to be easy to understand implementing as less buttons and fields as possible to be functional.

Customizability is the quality of the interface to be easily adaptable to the player. Pinelle et al. in one of the heuristics they give to specifically evaluate usability in games [18]

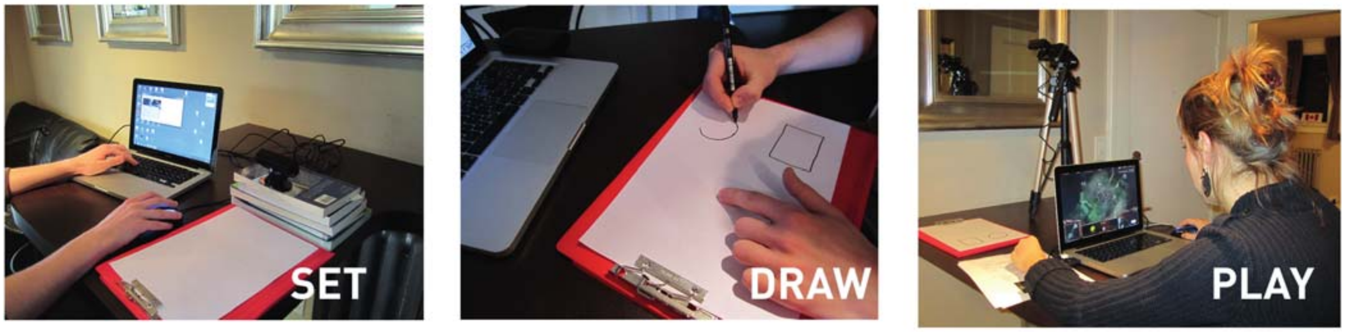

Fig. 1. FreePad's setup process

state that the game should "provide controls that are easy to manage, and that have an appropriate level of sensitivity and responsiveness". Customizability is one of the answers to this heuristic and is at the center of the Freepad's design. The end user can select the functionalities she wants to implement on her interface but also their shapes and their locations on the piece of paper. This feature could be seen as the main advantage over customizable macros-based interfaces such as the *SteelSeries Zboard Bundle:* $StarCraft$® *II* where the user is assigning macros to fixed physical buttons. Defining shapes and locations makes the user interface appropriation easier and quicker.

It also enables the user to adapt and use Freepad for various play styles and gaming skills. For example, a novice player could define only basic functionalities she uses many times during a game such as *Build 10 marines* or *Build a specific building*. An expert player could define more complex functionalities which could make her able to change her strategy during the game. For instance, a player could define a *rush* functionality for the early moments of the game such as *Build 10 marines and 5 firebats* and a more advanced *siege* functionality for later in a game such as *Build 3 tanks, move them around the enemy base and build 3 ghosts*.

Freepad doesn't offer the possibility to easily define new functionalities on-the-fly during the game and presents some limitations such as the difficulty to re-use a saved configuration or the fact that the user can't move the camera or the sheet of paper during the game. However, given the qualities described above, Freepad can be reasonably considered as an appropriate medium for exploring sketching interfaces in RTS gaming.

IV. Freepad extension for RTS gaming

The first version of the Freepad gave the possibility to the user to link each drawn shapes to a MIDI messages. Each time a shape is beaten, the linked MIDI message is generated (see previous publication for more technical details [10]). We extend Freepad giving the possibility to link streams of keystrokes to shapes.

A. Triggering keystroke messages with Freepad

Triggering keystroke messages enables genericity and gives the user the possibility to use Freepad in any strategy games. Keyboard hotkeys are available in any strategy games and they can be triggered through Freepad. In this way, it provides users with a variety of options regarding the design and use of their custom interface. For example, let's call *Ctrl+B* the hotkey to select the specific building B in the game and *U* the hotkey to build a specific unit in this building. Assigning the following stream *Ctrl+B U* to a shape, the user can easily trigger the action *Build the unit* by hitting this shape.

In Freepad, the end user can record a stream of keystrokes she wants to use in the game and links it to a form drawn on the piece of paper. It is actually the message between the *Keyboard device driver* and the *System message queue* which is captured and stored when the user records a keystroke. Capturing the messages at this level makes possible to use Freepad with any type of keyboards (for instance, AZERY, QWERTY or japanese keyboards) and gives to Freepad the potential to be used by other keyboard-based applications than $StarCraft$®II (for example other strategy games but also word processing or drawing applications). Once the configuration is done, each time the user will hit the linked form, the captured messages will be sent to the *System message queue* and the stream of keystrokes will be interpreted as if performed directly on the keyboard.

B. Freepad setup process

We focus on redesigning the GUI to make the Freepad setup as easy and fast as possible. The result is a three-step setup process. The steps are: setting the background, parsing the interface and linking the shapes to keystrokes' stream.

The first step in the process requires the user to establish the background image (see *SET* in Figure 1), which Freepad uses to discern the interface from it. The only requirement is that the user places the desired sheet of paper on a flat surface in the camera's range of vision, and clicks to take a picture of the background. Once this background image is set, the paper cannot be moved or the system will lose the ability to track any of the shapes drawn.

In the second step, the user is actually drawing and then detecting the interface (see *DRAW* in Figure 1). The system works with closed shapes such as rectangles or ellipses, and cannot detect shapes which are too small, long, or not closed.

The final step lets the user linking streams of keystrokes to each drawn shape. The user can now trigger the defined streams of keystrokes by hitting the shapes (see *PLAY* in Figure 1). To link Freepad with the game, the user has just to choose to set up streams of keystrokes corresponding to the streams of hotkeys for the actions she wants to perform.

Configurations can be saved and reused. However, the camera and the sheet of paper must be placed in the same position to reload properly the configuration. To deal with this issue, a calibration screen will be provided in the next version.

V. Study design and methodology

This research aims to study the effects of Freepad on the efficiency and the enjoyment of the player in strategy video games.

A. Study design

We define two configurations: with Keyboard and Mouse (KM) and with Keyboard, Mouse and Freepad (KMF). We did not study the configuration: with Mouse and Freepad (MF) but in our experiment all participants were using only the mouse and Freepad when they were asking to play in KMF configuration. Our hypotheses are:

- *The player will be more efficient playing the game in KMF configuration than in KM configuration*,
- *The player will find the game more enjoyable to play in KMF configuration than in KM configuration*.

11 participants from various social backgrounds (eight males and three females), ranging in age from 22 to 31 years old (mean: 24.73, SD: 2.53) participated to this user study. They were average video game players (mean: 3.09, SD: 1.30 on a 5-points Likert scale questionnaire asking how experienced in gaming they believe themselves to be). A laptop, a webcam $PSPEye^{®}$ and the game $StarCraft^{®}$II were used for each experiment. The $StarCraft^{®}$II map "Steppes of war" was specifically modified for the user study (see Figure 2). We added the following constraints to the original map:

1) The map is entirely known,
2) There can be only two players (the computer and the player),
3) There is only one path between the two bases,
4) The player has unlimited resources,
5) The computer has only a limited number of units and buildings at the beginning and cannot acquire more,
6) In this scenario, the player has a very simple goal: *Destroy the enemy base in less than five minutes*.

Because of constraint 1), there is no exploration of the map needed to find new resources or to spot the computer's base. The player only has to focus on two tasks: building units (economy) and destroy the computer base (conquest). This situation is realistic and representative of the second part of a game when the player has already explored the map and knows where are the resources and the enemy.

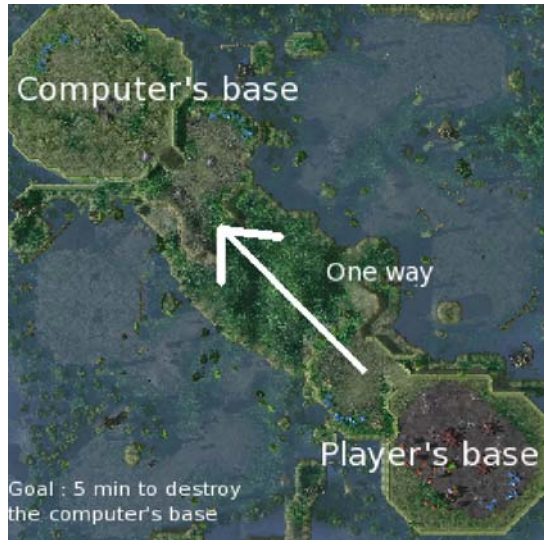

Fig. 2. Modified "Steppes of war" map

B. Procedures

The experiment follows the procedure described below. First, the participants received a presentation of the game to make sure that they understand how to play the game and use the different controllers (keyboard, mouse and Freepad). They also received a $StarCraft^{®}$II keyboard hotkeys sheet. Then, they were asked to draw their own interface and to link it to the game. Novice players could receive advices from the experimenter for selecting pertinent actions if they asked for. Figure 1 shows a example of an interface drawn by a user. In this example, the square was assigned to the action: *Build 6 zerglings and send them close to the enemy base* and to the circle to: *Build 3 hydralisks and send them close to the enemy base*? In this example, simple shapes have been used but more complex shapes could have been drawn as long as they are closed and not too small in surface. As long as the sheet of paper does not move, the user can add new shapes and modify the action assigned to existing shapes in Freepad but the game has to be paused.

Then, each participant was asked to play the map twice: one time in KM configuration and one time in KMF configuration. To limit the learning curve effect, the first condition asked to play has been randomized. At the end of the experiment, the participants were asked to answer a demographic questionnaire and some questions about gameplay that covered familiarity with video games in general and with strategy video games in particular. Using a 7-points Likert scale questionnaire, participants were also asked to evaluate their efficiency and enjoyment in the game using the Freepad. A last question asked if they were interested in customizing their own Freepad interface.

C. Efficiency: Measurement

Bernhaupt et al. [19] define *efficiency* as the extend to which a user is able to be productive with a system. In strategy

TABLE I
N_s: DESCRIPTIVE STATISTICS FOR THE INDICATOR

Group	Mean	Standard Deviation
Winners	0.36	0.17
Losers	0.22	0.09

video games, we have access to a lot of data that we can use to evaluate the efficiency of the player (time to win, victory or defeat, wealth, number of buildings destroyed, number of buildings built etc.).

To determine which parameter is significant enough to evaluate the efficiency of the player, we analysed eight replays on the same map which was modified for the user study ("Steppes of war"). These replays were chosen randomly from a $StarCraft^{®}$II replay website [20]. We calculated the number of units produced by seconds (N_s) as a predictor for efficiency. The distribution of this parameter appears to be normal. Table I shows the descriptive statistics of the two independent groups: "the players who won the game" (Winners) and "the players who lost the game" (Losers). To validate this indicator, we ran a t-test between these two groups. We found that the mean of N_s is significantly higher for *winners* than for *losers* (t-test→($t(15) = 1,91$, $p < 0,01$)). In strategy video games, the efficiency of the player is directly linked to her ability to win. Thus, we can use N_s as efficiency indicator in our user study. The differences in the indicator values between the KMF and KM configuration would be studied to determine the impacts of Freepad on the efficiency of the player in the game. To support our findings on efficiency, a 7-points Likert scale question ranging from "1: Strongly disagree" to "7: Strongly agree" was also asked in the questionnaire: "Using Freepad, I am more efficient in the game".

D. Enjoyment: Measurement

Sweetser et al. [7] introduced the gameflow: a model for evaluating player enjoyment in games derived from the Csikszentmihalyi's works [21] about the optimal experience. RTS games were used to validate their model. They define *concentration* as the ability of the player to concentrate on the game's tasks. They claim that this criteria is particularly important for making RTS games enjoyable, with player enjoyment pivoting on mastering, scheduling and coping with the numerous tasks. Thus, if the use of Freepad can improve the efficiency of the players making them more focused on the game's tasks, we could infer that it may also improve their enjoyment. To support our findings about enjoyment, the following 7-points Likert scale question ranging from "1: Strongly disagree" to "7: Strongly agree" was also asked in the questionnaire: "It is more enjoyable to play with Freepad than only with the keyboard and the mouse".

VI. Results and analysis

A. Efficiency: Results

Table II shows the descriptive statistics for the two configurations. The distribution of our efficiency indicator N_s is not normal and the two configurations are not independent because the same participant has to play once in the KM configuration and once in the KMF configuration. So, we performed a non-parametric test: Wilcoxan Matched Pairs Signed-Ranks Test to assess weather the Freepad can improve the efficiency of the player in the game. We found that the mean of our efficiency indicator N_s is significantly higher in the KMF configuration than in the KM configuration (Wilcoxan→($t(15) = 33.000$, $p < 0.01$)). The data therefore provide evidence to conclude that novice players using Freepad are more efficient in the game than players using solely the keyboard and the mouse. This result is also supported by data from the questionnaire. At the question: "Using Freepad, I am more efficient in the game", participants mostly answered "Agree" (mean: 6.7, SD: 0.67).

B. Enjoyment: Results

Concerning our second hypothesis about the enjoyment of the player, according to Sweetser's works [9], we could infer that it may contribute to make the game more enjoyable because it enables the player to better mastering, scheduling and coping with the numerous tasks. This claim is also supported by the answers to the questionnaire. At the question: "It is more enjoyable to play with Freepad than with a keyboard and mouse alone", participants strongly agreed (mean: 6.5, SD: 0.52).

C. Observations and other findings

Customizability was not evaluated in this study. However, one question was asked about it in the questionnaire: "I am interested in customizing my own interface to play in a strategy video games", participants strongly agreed (mean: 6.3, SD: 0.49). If most of the participants used common shapes such as squares, circles or triangles as provided as example, some were more creative and drew shapes similar to a Zergling for the action *Build 6 zerglings and send them close to the enemy base*. Others drew the letter Z for the same action. These two examples taken from the user study give already an idea of the customizability potential of sketching interfaces for RTS gaming.

A initial observation about the study is that all participants were using only the mouse and Freepad when they were asking to play in KMF configuration. It may come from the difficulty for players to master the use of hotkeys [8]. Contrary to the keyboard where each button has a predefined form and intent (write a letter, figure, punctuation), Freepad lets the player customize each element of the interface. Each form can be drawn in a meaningful way to represent its intent. It may make the use of Freepad easier and more straightforward than the use

TABLE II
N_s: DESCRIPTIVE STATISTICS FOR THE STUDY

Configuration	Mean	Standard Deviation
KMF	0.40	0.12
KM	0.22	0.08

of keyboard and it could explain why, in KMF configuration, the keyboard was not used.

Our observations during the study also show that adding Freepad makes possible to better distribute the different tasks the player has to perform (*Conquest* and *Economy*) between the mouse and Freepad. For example, a player in KM configuration, when attacking the enemy base, is always using the mouse to move the camera in his base to be able to produce new units. Then she uses the mouse again to set the camera back in the enemy base to manage her units attacking the enemy buildings. Repeating this action makes her lose a lot of time and prevents her to focus on her attack. In KMF configuration, performing the action of building new units can be done by simply hitting a form drawn on Freepad. The player has not to move the camera with the mouse to perform it and can focus on her attack of the enemy base. The tasks the player has to perform does not rely only on the mouse but they are distributed between the Freepad and the mouse.

Using Freepad also allows more parallelism in the actions the player can perform. In KM configuration, the stream of actions the player perform is sequential: managing her units, moving the camera to her base, building new units, moving the camera back to the enemy base, managing her units. The player cannot manage their units when the camera is in her base. In KMF configuration, the player can keep managing their units with the mouse when building new units with the Freepad.

VII. Conclusion and future work

This study analyzed the effects of the use of Freepad on the efficiency and enjoyment of average players in the strategy video game $StarCraft^{\circledR}$II. Our findings shows that using Freepad does improve the efficiency of the player. It makes possible to better distribute most of the different tasks the player has to perform (Conquest and Economy) between the keyboard, the mouse and Freepad. It also allows more parallelism in the actions the player can perform. Because of similar gameplays and game interfaces, our results can be generalized to other strategy video games than $StarCraft^{\circledR}$II.

A more complete user study, including more expert players and a larger population, will be required to reinforce the claim that using Freepad improves the enjoyment of the player in the game. We chose a within-subjects design for this study but it would be interesting to use a between-subject design to address the problem of asymmetric skill transfer in this particular task of playing RTS. Customizability in Freepad has also to be studied in the next user study. It would also be interesting to test our sketching interface without constraints on the map and in real gaming conditions, for example on battle.net. From a broader game perspective, the learning-to-play process is part of the game. Investigating the effect of becoming more efficient quickly on the overall enjoyment to play the game would be also interesting to consider.

The predictor used in our study is likely only appropriate in this very specifically constrained game type (specific map, time constraint, race constraint, etc). It would be interesting to look at other metrics to evaluate efficiency in non-constrained game types.

Future works will study the impact of Freepad on the user in other applications than strategy video games like word processing software, graphics editing programs or game consoles that do not come with a keyboard or a mouse.

References

[1] M. Gross and E. Do, "Ambiguous intentions: a paper-like interface for creative design," in *Proc. ACM symposium on User interface software and technology*, 1996, pp. 183–192.

[2] J. Landay and B. Myers, "Sketching interfaces: toward more human interface design," *IEEE Computer*, vol. 34, no. 3, pp. 56 –64, March 2001.

[3] M. Masry, D. Kang, and H. Lipson, "A freehand sketching interface for progressive construction of 3d objects," *Computers & Graphics*, vol. 29, no. 4, pp. 563–575, 2005.

[4] D. West, A. Quigley, and J. Kay, "MEMENTO: a digital-physical scrapbook for memory sharing," *Personal and Ubiquitous Computing*, vol. 11, no. 4, pp. 313–328, 2007.

[5] C. Liao, F. Guimbretière, K. Hinckley, and J. Hollan, "Papiercraft: A gesture-based command system for interactive paper," *ACM Transactions on Computer-Human Interaction*, vol. 14, no. 4, pp. 1–27, 2008.

[6] A. Rollings and E. Adams, *Andrew Rollings and Ernest Adams on game design*. New Riders, 2003.

[7] P. Sweetser and P. Wyeth, "GameFlow: a model for evaluating player enjoyment in games," *ACM Computers in Entertainment*, vol. 3, no. 3, pp. 3–3, 2005.

[8] T. Grossman, P. Dragicevic, and R. Balakrishnan, "Strategies for accelerating on-line learning of hotkeys," in *Proc. ACM SIGCHI conference on Human factors in computing systems*, 2007, pp. 1591–1600.

[9] N. Villar, K. Gilleade, D. Ramdunyellis, and H. Gellersen, "The voodooio gaming kit: A real-time adaptable gaming controller," *Computers in Entertainment*, vol. 5, no. 3, p. 7, 2007.

[10] S. Chun, A. Hawryshkewich, K. Jung, and P. Pasquier, "Freepad: A custom paper-based midi interface," in *Proc. New Interfaces for Musical Expression Conference*, 2010, pp. 31–36.

[11] "Freepad website," last accessed: November 2012. [Online]. Available: http://www.metacreation.net/freepad/

[12] P. Wellner, "Interacting with paper on the DigitalDesk," *Communications of the ACM*, vol. 36, no. 7, pp. 87–96, 1993.

[13] A. Champaneria and R. L., "Padcam: A real-time, human-centric note-taking system," in *Proc. AAAI Fall Symposium*, 2004, pp. 35–41.

[14] C. Liao, F. Guimbretière, and C. Loeckenhoff, "Pen-top feedback for paper-based interfaces," in *Proc. ACM symposium on User interface software and technology*, 2006, pp. 201–210.

[15] B. Plimmer and M. Apperley, "Computer-aided sketching to capture preliminary design," in *Proc. Australasian conference on User interfaces*, vol. 24, no. 4, 2002, pp. 9–12.

[16] F. Block, M. Haller, H. Gellersen, C. Gutwin, and M. Billinghurst, "Voodoosketch: extending interactive surfaces with adaptable interface palettes," in *Proc. International Conference on Tangible and Embedded Interaction*, 2008, pp. 55–58.

[17] H. Desurvire, M. Caplan, and J. Toth, "Using heuristics to evaluate the playability of games," in *ACM CHI extended abstracts on Human factors in computing systems*, 2004, pp. 1509–1512.

[18] D. Pinelle, N. Wong, and T. Stach, "Heuristic evaluation for games: usability principles for video game design," in *Proc. ACM SIGCHI conference on Human factors in computing systems*, 2008, pp. 1453–1462.

[19] R. Bernhaupt, M. Eckschlager, and M. Tscheligi, "Methods for evaluating games: how to measure usability and user experience in games?" in *Proc. ACM international conference on Advances in computer entertainment technology*, 2007, pp. 309–310.

[20] "Starcraft replay website," last accessed: November 2012. [Online]. Available: http://www.starcraft-replay.com/

[21] M. Csikszentmihalyi, *Flow: The psychology of optimal experience: Steps toward enhancing the quality of life*. Harper Collins Publishers, 1991.