Building a More User-Centered Digital Pen Operating System Interface Using HCI Design Principles

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ABSTRACT

In this work, the author proposes a Pen-Centric GUI to empower user interaction at the Operating System Level on tablet and hybrid-tablet devices

A user survey of eighteen respondents, who use a pen-input device machine as their main computer, was conducted to obtain user feedback for the design. The results of this survey are reported in this work.

Additionally, the author presents a description of the current interfaces employed on these devices, highlighting their design choices from the viewpoint of a user using a pen-input device.

Additionally, the author explains the interfaces of these devices and their shortcomings around pen input. Furthermore, the author, reviews, and presents to the reader, potential interface solutions found in the literature relating to this GUIs and digital pens.

Finally, the author proposes the interface design called "Pen-Centric GUI," and explains interface from a user level and from a technical implementation level.

HCI CONCEPTS

User Centered Design, Gulf of Execution

KEYWORDS

HCI Pen Input Operating System OS User Centric Design

1 Introduction

As computing devices continue to become more ubiquitous, the variety of ways to interact with them continue to grow. One of the founding fathers of HCI, Ivan Sutherland, along with his team, had the foresight, ambition and expertise to create the Sketchpad Computer Application, which used, for the first time, drawing as the interaction method [1]. Nowadays, one cannot explore a college campus without seeing someone interact with a tablet or hybrid touch machine with a pen input. This is truly a testament to how computers have become more ubiquitous; they are replacing pen, pencil, notebook, paper and scratchpad technologies.

Related to this, in this work, the author proposes a User-Centered-Design (UCD) interface called "Pen-Centric GUI" for user interaction with a stylus or digital pen on tablet and tablet-hybrid devices. This proposal is informed by 1) user feedback obtained from a survey that targets the foreseeable user demographics, 2) HCI and UCD principles, 3) insights from current interfaces employing pen-input and 4) proposals found in the literature for a better pen-input interface.

The end-users for this proposal are expected to be touch-tablet and touch tablet-hybrid-machine users who interact with their devices via pen/stylus input. The author aims to create an interface experience that not only allows users to use their pen input to simulate pencil/pen and paper writing, but to also use their pen input to interact with the underlying OS for a more pen-centric and ubiquitous interaction experience.

The problem this proposal aims to solve, is the lack of intuitive interaction affordances for OS level tasks on tablet and tablet-hybrid devices. These devices have done an excellent job in making pen-input enjoyable when interacting with a drawing, notetaking, or presentation application, but the interface experience when trying to multi-task or interact with the machine at the OS GUI level is not as polished.

The author believes this work is important, because as devices become more ubiquitous and integrated into our lives, a need for seamless interaction across devices will emerge. This problem is already apparent in hybrid models today that aim to accomplish more than being just a laptop, or phone, or tablet. The author imagines a future where users will interact with their tablet as a notepad and then move to their TV to interact with it as a painting canvas, all with the same input device. Building a system that allows the user to not only interact with the immediate foreground tasks of notetaking or painting, but also with the underlying OS for system level tasks, will be a key feature required for this future; the author proposes, that gap of execution across devices will simply be too large without this.

2. User Interviews

For the survey, the author conducted eighteen in-person interviews with students at the University of South Florida who currently use a pen-input device as their main computing device. There were seven men and eleven women interviewed for this proposal. The interview consisted of five quantitative questions and two qualitative questions.

2.1 Questions

The questions asked the user to 1) indicate the device they use, 2) to choose a Likert scale answer indicating how satisfied they are with the pen input interface of their device, 3) to choose a Likert scale answer indicating how useful they subjectively feel the device is across their various workflows, 4) to rank various input methods for their device in order of preference, 5) a qualitative description of any features that would make their pen input more useful and 6) a qualitative answer of any frustrations they have with their pen input.

2.2 Results

This survey served as an indicator of Apple's excellent user interface design process, as 70% of surveyed iPad users indicated they were incredibly happy with their pen input experience on the iPad. 60% of iPad users felt that the pen usable across all their workflows with the device. However, only 40% of iPad users and 33% of the total users surveyed indicated that the pen input is their preferred way of interacting with the device.

Regarding Windows and Android device users, their feelings towards their pen input interface were not as enthusiastic but was nevertheless positive. 62.5% of this group were satisfied with their pen interface but felt that it could be better. Additionally, 12.5% of this group of devices felt that pen interface was usable across all workflows but only 25% of them said that it was their preferred way to interact with the device.

Qualitatively, specifically to the iPad, three main themes emerged. Most users felt the pen would be more useful with *technical upgrades* which would allow for better battery life, more accuracy, and making pieces of the pen harder to lose. They also wished that there were user *customization options* of the pen's physical properties and that the pen had a *better erasing implementation or better natural feedback*. The author notes that these issues were consistent across iPad users.

Regarding, the whole dataset, the themes that emerged were better recognition of *user intention* to write versus use touch input, and *technological advancements* in pen technology, for better battery life, design, customization, and better accuracy/sensitivity with the pen input.

Results of this survey are shown in Figures 1 – 11. All figures indicate the number of users that chose a particular answer.

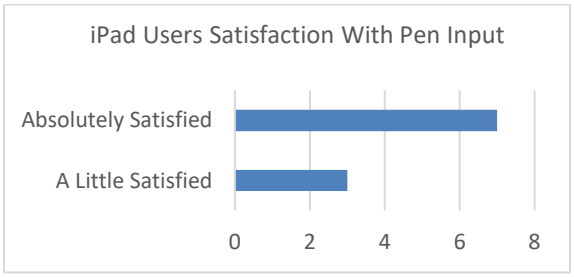

Fig 1. iPad Users' Level of Satisfaction with Pen Input

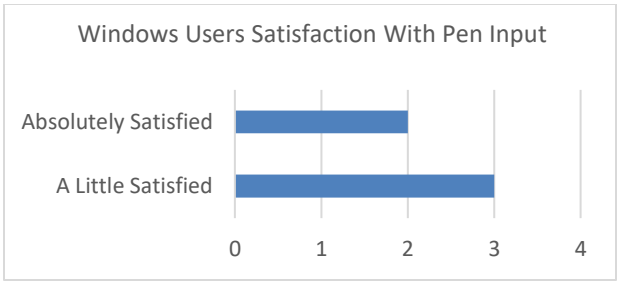

Fig 2. Windows Users' Level of Satisfaction with Pen Input

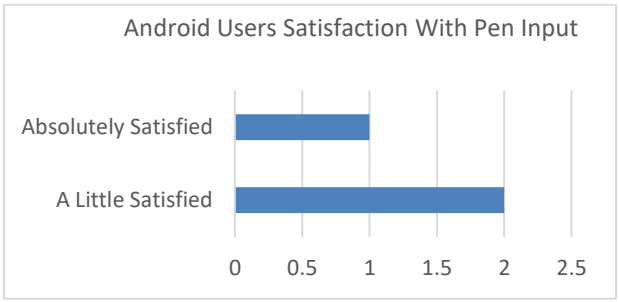

Fig 3. Android Users' Level of Satisfaction with Pen Input

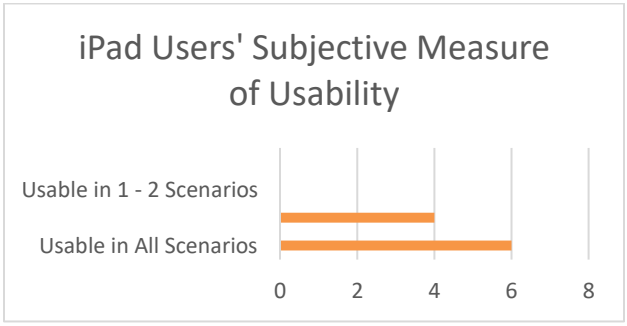

Fig 4. iPad Users' Subjective Measure of Usability

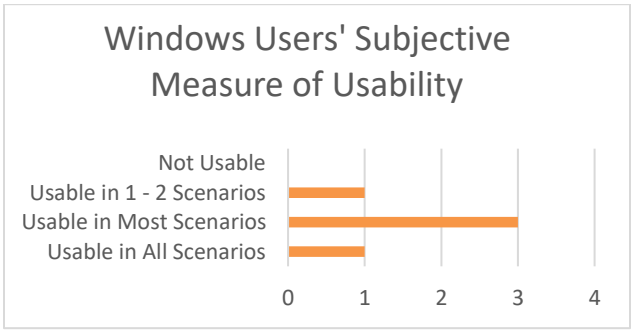

Fig 5. Windows Users' Subjective Measure of Usability

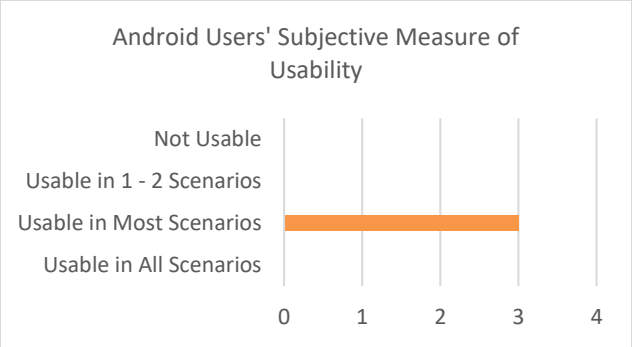

Fig 6. Android Users' Subjective Measure of Usability

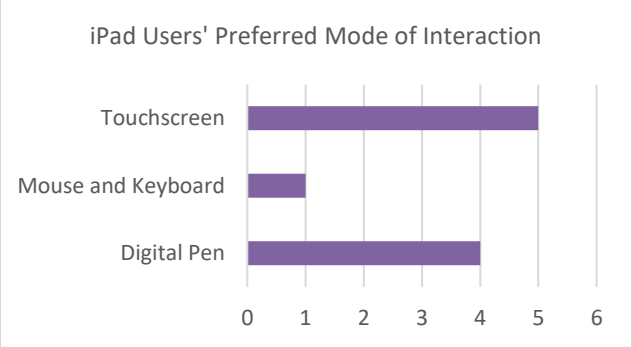

Fig 7. iPad Users' Preferred Method of Interaction

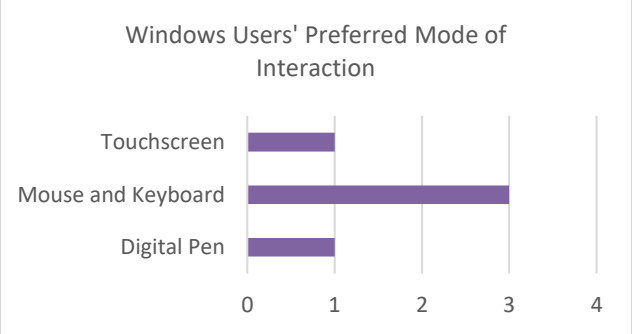

Fig 8. Windows Users' Preferred Method of Interaction

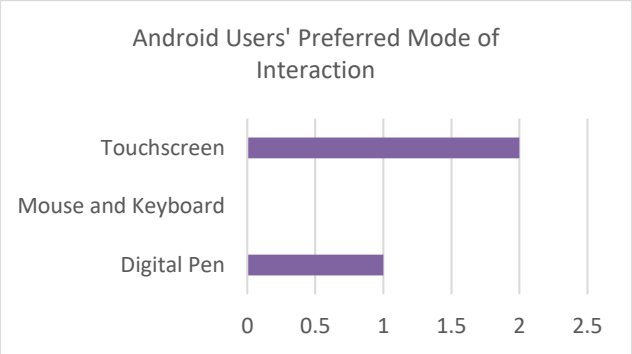

Fig 9. Android Users' Preferred Method of Interaction

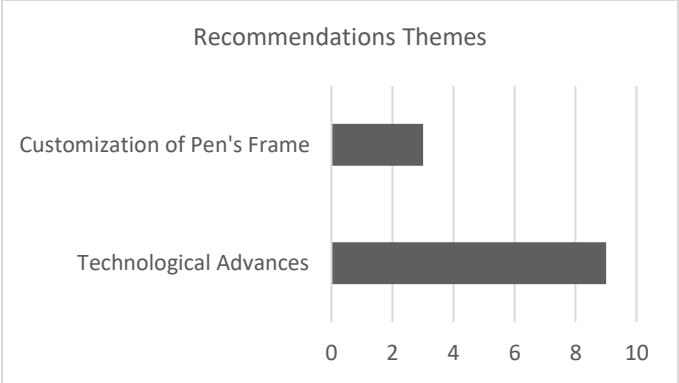

Fig 10. User Recommendations for a more useful digital pen

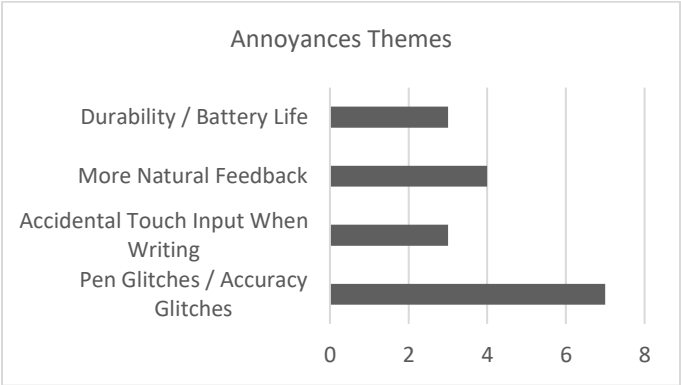

Fig 11. User Annoyances with their digital Pen

2.3 Discussion

Analyzing the data, the author notes that iPad users strongly felt that the pen input on their iPad was extremely useful and also that most of that same group felt that it was useful across all of their workflows. Apple is known for their satisfying user design and this survey reinforces that theme. However, on Windows and Android devices, the experience was not as positive. The author proposes that this discrepancy across devices comes from the constraints Apple applies to the iPad. The author proposes that hybrid devices and less constrained devices such as Windows and Android are giving users less satisfaction with pen input because of weak interface constraints. Additionally, the author argues that because the interfacing technology is not allowing users to powerfully interact with the system, Android and Windows users feel that pen input is not as usable across their various workflows. The author argues, from this, that the design proposal will improve user satisfaction and interaction on hybrid and less constrained devices.

Additionally, directions for future research and proposals would be HCIs that better delineate user intention when using pen input, and technology advances that allow for better accuracy from digital pens and screen surface technology that gives users more natural feedback. In the data, a subset of the users across all devices mentioned frustrations with the device assuming they want to interact with it via touch when really, they want to interact with it via pen input. Additionally, users across all devices also expressed concerns for better battery life of their digital pens. iPad users complained most constantly about pen accuracy glitches.

3. Current Interfaces

Across all three devices, the current interfaces with pen input do not focus on pen input as the foundational interaction mechanism. While various apps interface with the pen input as a natural and primary input source, the underlying OS does not.

3.1 iPad

The iPad is a tablet with a touch-centric interface. The tablet interface is designed with touch interfacing as its primary mode of interaction. When interacting with the pen input, the pen typically acts as a pointer, simulating a finger or tap, instead of a pen or pencil with pen-centric gestures. To search for applications using the pen, the user must tap the search bar with the pen, by tapping it and then they can interact with search on the iPad OS with pen input.

3.2 Windows

Windows previously had a touch-centric OS for their tablets but have reconsidered that design with Windows 11. In Windows 11, the user interface stays the same across desktop, tablet and laptop devices, with the cultural-classic start menu and taskbar at the bottom of the screen. This interface has historically been used with the mouse and keyboard. When using a stylus or pen input to interact with the OS, again the pen mostly simulates the OS's main form of interaction and acts like a mouse pointer. However, like the iPad, the OS allows the user to write in the search bar or text box if that area of the screen is specifically tapped with the pen.

3.3 Android

Android tablets come with a touch-centric interface, like the iPad. The pen input on these devices typically simulates a tap of the finger instead of pen-centric interfacing capabilities.

3.4 Interface Shortcomings

Across all three interfaces, the digital pen is treated as a second-class interaction device. It does not allow for users to powerfully command the device using pen input and it adds unnecessary steps for the user to use pen input to interact with the underlying OS.

3.5 Existing Solutions

Currently, the solutions to enabling the user to interact more easily with the underlying OS comes from NLP powered speech recognition. Speech recognition has been deployed on all of these devices, with each having its own voice activated personal assistant. Speech recognition acts as a moderately convenient way to interact with the device while using pen input as users do not have to switch to touch or another form of input to execute more powerful commands on the device. This form of input, however, is inappropriate in classrooms, libraries and other locations where social customs require that participants be quiet.

4. Current Solutions

In [2], Aslan et al. present a prototype that allows users to supplement pen input by using the space above the screen (mid-air) and the space besides the screen as an interaction area. The authors implement this prototype by using a Microsoft Surface Laptop, a Leap Motion 3D mid-air controller, and an Arduino board. Aslan et al.'s work presents a potential solution by adding another convenient interaction space. Regarding solving the problems listed in Section 3, these additional interaction spaces could have gestures mapped to powerful OS interactions which could be a potential solution to the problem.

In [3] Annett et al., investigates unintended touch during pen interaction. Annett et al.'s work does not present any solutions to the problems listed above in this work, but it does attempt to quantify a problem that our survey respondents indicated was an annoyance; namely, unintended touch input. Their work captures this annoyance in an extensive investigation of potential solutions to it at various stages in device interactions and with various solutions. Their work additionally supplies some related information to the proposal by investigating Operating System Pen Interaction Behavior.

In [4], Vogel et al. presents a comprehensive paper investigating the very problem this proposal aims to partially address. They investigate interfacing with the Windows Vista operating system using pen input. Though the Windows Vista OS is out-of-date now, the problems discovered in this work are still relevant today. Vogel et al. indicates that these problems come from the desire to have a standardized graphic user interface that can accommodate multiple input and interfacing methods (they argue that this is a good decision). Vogel et al., propose technological advances in pen input technology and screen technology, base interactions and gestures that generalize across input devices, and adding pen specific interaction widgets to the OS as potential solutions

Finally for this review, Kyung et al., in [5], propose a "wUbi-pen" which is a sensory feedback stylus for interacting with the GUI. The pen has a variety of movements that attempt to feel natural and allow for intuitive interaction with the GUI. The pen employs haptic feedback to provide more immediate feedback to the user for a more natural pen interaction experience.

5. Proposed Interface Design

5.1 Proposed Interface

Synthesizing the research and the user survey, we propose an interface for tablet and tablet-hybrid devices, which allows users to interact with their GUI interfaces with greater affordances, powerful gestures, and a more intuitive conceptual map. This proposed interface is to be like an invisible sketchpad or sheet of paper over the GUI that selectively processes written commands from the user.

In the literature, specifically in [2] and [5], the author learnt that there is potential in implementing an interface that can use natural pen movements, such as lifting the pen from the screen, to allow for OS level interactions. For example, from [5] the author learnt how an exaggerated raising of the pen and then pressing it to the screen could simulate a double click. The author also learnt from [2] that an attempt to create an interaction environment in the space above the display may be useful with modern pen input devices.

Regarding the interface proposal, the author intends that the invisible sketchpad 1) implement hand-writing recognition to translate user commands written on the screen, 2) implement a fading input when writing on the desktop or home-screen of the device, and 3) in the case of processing commands during foreground pen-input tasks, delete the handwritten command when it was written on a drawing, painting, or notetaking application.

The proposed value add of this interface can be shown through an example. Suppose that the user wants to open an app, instead of tapping multiple icons to bring up search or swiping multiple screens, the user can simply write the name of the app on the home-screen, desktop, or pen app that they are using, and the application will open. This kind of interaction would allow for pen-input to be a more intuitive and powerful interaction capability.

This interface will require the delineation of intention when writing so we will discern user intention by requiring them to use write double symbols such as "??", "..", ",,", "!!", or double underlines to indicate that they entered a system level command. Additionally, the author proposes that a machine learning model could be used to further delineate user intention in fuzzy scenarios, however, as noted in [3], this design would be better suited with an integration into the OS for a more responsive experience.

5.2 Technical Implementation

5.2.1 Languages

The languages required for this technical implementation will be XAML, C# and possibly Python.

5.2.3 User Interface

The UI will be implemented using the XAML UI Platform along with the InkCanvas, InkPresenter, InkToolbar and InkD2DRenderer components from Microsoft. These will allow for the creation of the sketchpad UI elements and user pen-input interfacing. Modifications to the handwriting recognition for specific double symbol tokens will be required to implement the functionality.

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APPENDIX

Interview Questions:

Please circle the devices you have in mind when answering these questions:

iPad Android Tablet Windows Tablet

Other (Please Write It): _____

Questions:

1. **On a scale of 1 – 4, how satisfied are you with pen input and interactions on your tablet? Please circle your response**
2. **On a scale of 1 – 5, rate how useful you find the pen input of your device in the variety of ways you use it. Please circle your response.**
3. **Could you order these inputs based on your preference for using them on computing devices (i.e. 1, 2, 3, 4 ,5):**
4. **Could you describe anything that would make using the pen input on your device more useful for you?**
5. **Are there any frustrations you have with using pen input and if so could you list or explain them?**

User Interview Answers

Participant #	Device	Level of Satisfaction with Pen Input	Subjective Measure of Pen Usability
1	iPad	Absolutely Satisfied	Usable in All Scenarios
2	iPad	A Little Satisfied	Usable in Most Scenarios
3	iPad	Absolutely Satisfied	Usable in All Scenarios
4	Windows Tablet	A Little Satisfied	Usable in Most Scenarios
5	Android Tablet	Absolutely Satisfied	Usable in Most Scenarios
6	iPad	Absolutely Satisfied	Usable in All Scenarios
7	iPad	Absolutely Satisfied	Usable in All Scenarios
8	iPad	Absolutely Satisfied	Usable in All Scenarios
9	Android Tablet	A Little Satisfied	Usable in Most Scenarios
10	iPad	Absolutely Satisfied	Usable in Most Scenarios
11	Windows Tablet	A Little Satisfied	Usable in Most Scenarios
12	iPad	Absolutely Satisfied	Usable in Most Scenarios
13	Android Tablet	A Little Satisfied	Usable in Most Scenarios
14	iPad	A Little Satisfied	Usable in Most Scenarios
15	Windows Tablet	Absolutely Satisfied	Usable in Most Scenarios
16	Windows Tablet	Absolutely Satisfied	Usable in All Scenarios
17	iPad	A Little Satisfied	Usable in All Scenarios
18	Windows Tablet	A Little Satisfied	Usable in 1 - 2 Scenarios

Participant #	Device	Mouse/Keyboard Preference	Touchscreen Preference
1	iPad	4	2
2	iPad	4	2
3	iPad	3	2
4	Windows Tablet	2	1
5	Android Tablet	2	1
6	iPad	1	4
7	iPad	3	1
8	iPad	3	1
9	Android Tablet	2	1
10	iPad	3	1
11	Windows Tablet	1	2
12	iPad	4	2
13	Android Tablet	2	3
14	iPad	4	1
15	Windows Tablet	2	3
16	Windows Tablet	1	3
17	iPad	5	3
18	Windows Tablet	1	2

Participant #	Device	Pen Input Preference	Touchpad Preference	Speech Preference
1	iPad	1	3	5
2	iPad	1	5	3
3	iPad	1	4	5
4	Windows Tablet	3	4	5
5	Android Tablet	4	3	5
6	iPad	3	2	5
7	iPad	2	4	5
8	iPad	2	5	4
9	Android Tablet	5	3	4
10	iPad	2	4	5
11	Windows Tablet	4	5	3
12	iPad	1	3	5
13	Android Tablet	1	4	5
14	iPad	3	2	5
15	Windows Tablet	1	4	5
16	Windows Tablet	2	4	5
17	iPad	4	1	3
18	Windows Tablet	3	4	5

Datasheet Available Here: Data.xlsx