IntGUItive: Developing a Natural, Intuitive Graphical User Interface for Mobile Devices

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Abstract

Daily life has experienced a sudden increase in mobile device usage. One needs to only look around to find several tiny devices packing power and function. This is all thanks to exponential advances in technology in recent years; each year technology companies around the world introduce their products; smaller, lighter, faster – state of the art. However, as these devices increase, so do their users and contexts of usage. People use them more and more in different situations, on the move, with different styles, tastes and constraints, such as time. In these cases, using a device whose interface is complicated, cumbersome and non-intuitive, ends up costing precious time and perhaps money, and most definitely causes frustration.

There has been much research into this field of design, called by various phrases but perhaps best summed up by the term "user experience" or "UX". Several concepts within exist, such as gamification, haptics and natural user interfaces, or NUIs. Native system applications of today's mobile devices do not seem to be very intuitive or easy to use as they get more and more complicated. This research attempts to provide a solution to that problem by focusing on depth perception and a novel way of designing a user interface that provides said depth as the user navigates the system and through applications. The metaphors of a camera zoom lens, a rifle scope and binoculars are loose inspirations which form the basis for the prototype application developed.

Despite the prototype application lacking many features due to time and technical factors, the user study revealed highly positive results, with users enjoying the intuitive and natural feel of the new design. Users also expressed a great interest in using an application with such an interface in the future with improvements and thus have prompted further research, proving that such a design opens up endless possibilities for improvement in an otherwise stagnant field.

Key words and terms: depth, perception, perspective, zoom, haptic, feedback, intuitive, natural, real life metaphor, touch, gestures, mobile phones, GUIs, native, NUIs, gamification.

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1. Introduction

The invention of the digital computer saw the dawn of a new technological age. Where technology was always the involvement of large, time-consuming, mechanical contraptions, the computer changed all that. Operations could be *coded*; the computer could be conversed with in languages that it understood. While very early in its life, computers did include large switches, buttons and sometimes levers, this quickly disappeared as digitisation made things smaller and smaller.

Modern life, as a result, is extremely reliant on technology. Almost everything is digitised. All products and services are, in one way or another, dependent on computers and this is only going to increase as the sheer efficiency of computer technology continues to advance and provide advantages to businesses and consumers. People are constantly interacting with devices, most recently mobile devices, such as smartphones and tablet computers in order to carry out their daily tasks at work and home. Naturally, this results in a high demand for creating applications that are not just easy to use, but provide a pleasant aesthetic interface to interact with; both of these come together to form what is called user experience (UX) and it is something subjective (Hassenzahl, 2005). It can be understood that a lack of either one leads to an unpleasant user experience, which often results in users moving away and using competing applications that offer a much better user experience.

Mobile devices are perhaps the most demanding of platforms when it comes to design due to smaller sizes and less processing power (Tarasewich, 2003). Ballard (2007) goes into great depth dealing with a myriad of programming and design challenges concerning mobile devices (Ballard, 2007). The recent past has seen the gradual shift to entirely touch-based interactions, doing away with keyboards and trackpads, which can be understood as the primary driving force behind the need for meaningful and useful graphical user interfaces. Important to note are the advantages of touch-based interaction. The most important being the greater degree of interaction, whereby instead of pressing a key that corresponds to an action, label or item on the screen, users directly interact with the screen to manipulate said items. However, this means that users need to be able to understand what on the screen is interactive mainly through the use of good design languages and easily-understandable design cues (Tsai and Lee, 2009).

While mobile devices have seen a massive improvement in interface design in the past few years, thanks to unified design languages and standards (such as design standards

released by Apple, Google and Microsoft for their mobile device ecosystems), the *sense of depth* in nearly every graphical user interface design is missing. That is, communicating the user's position in the hierarchy of the system back to the user effectively, such that the user is able to tell how far deep into the system he or she is and how many steps one needs to take in order to return to the original state. Most work is largely based on using more haptic approaches, such as tactile feedback as in the case of Yatani et al. (2009) and input-specific, such as Nilsson (2009). In order to achieve this, design language and visual cues need to be exploited in an effective manner that not only uses pleasant visuals that engage the user and provide a meaningful experience, but to do so in a manner that makes the most efficient use of the limited real estate of screens offered by mobile devices.

1.1 Scope and Goals

This master thesis is set to investigate into a new kind of graphical user interface design for mobile devices that allows for a highly intuitive and engaging user experience. This mainly involves the use of visual representation of the levels in a system's hierarchy, which should allow a user to understand his or her current position with regards to the context. The user should also be able to navigate back and forth by interacting with the displayed levels in a random-access manner, as opposed to serial-access which is far more common.

In order to reduce the overall complexity of the task and the implementation of the system, the system is limited to only one application design, as the same design and animation set is to be applied to any application that should be run in the environment.

2. Background

The advent of mobile devices, specifically smartphones, can be traced back to many early inventions. However, perhaps the most famous and well-marketed device is the iPhone by Apple Inc. in 2007. The iPhone was one of the earliest to offer a multi-touch interface that did not require a stylus. This directly spawned the sudden rise of multi-touch devices from its competitors, battles that have been going on to date. In manufacturing terms, perhaps Samsung is the only one company that stands on equal footing to Apple's mobile market today (Ezeh and Al-Azzawi, 2012). Many who have tried or used to be dominant, such as Nokia and Blackberry, are no longer in the running, as majority no longer use their own proprietary operating system and instead run their flavour of Android – Google's operating system for mobile devices. As a result, while hardware has its place, software is the real battlefield, as features most looked for are developed in update after update in the operating system. This section will journey into usability, what defines a usable product and how it relates to the software-based goal of this thesis.

2.1 Usability and Gamification

Usability has been an important objective in the development of any product, but despite this, has been subject to much confusion (Bevan, 1995). That is, depending on the approach, usability can take different meanings to different projects. For instance, a product can be "usable, but not useful". This implies that while the product is inherently easy to use (a proof of its good design), it may not be fulfilling any need that would make it a useful product (Bevan, 1995).

Jakob Nielsen is one of the most respected and pioneering of researchers in human-computer interaction. He laid down the extremely popular "10 Usability Heuristics for User Interface Design", which are as follows (Nielsen, 1995):

1. Visibility of system status – system should provide feedback within reasonable time to keep users informed.
2. Match between system and the real world – user's language and familiar phrases and linguistics should be used instead of system-oriented and/or technical and difficult jargon.
3. User control and freedom – cater to common user mistakes and let them leave unwanted states easily. Undo and Redo are a must-have.

4. Consistency and standards – Follow platform conventions; users should not have to figure out if different words might mean the same thing.
5. Error prevention – Design carefully so as to prevent problems from occurring. Confirmation options should be available to users before they commit to any action.
6. Recognition rather than recall – Users should not have to memorise actions, options or information.
7. Flexibility and efficiency of use – Allow users to customise frequent actions through the use of Accelerators that speed up interaction for experienced users.
8. Aesthetic and minimalist design – Dialogues should only have the most relevant information.
9. Help users recognise, diagnose and recover from errors – Error messages should be in plain language and accurately indicate the problem and constructively suggest a solution.
10. Help and documentation – System should be able to be used without documentation, however, some may be necessary, in which case it should be easy to search and understand without being too large and cumbersome.

Gamification is a term that is used to group together practices where elements of video games are used in non-video game contexts and systems in order to improve the user experience (Dixon et al., 2011). While not inherently explored in detail, it is particularly interesting for this research in order to acquire an overall understanding of creating engaging user interfaces. Creating a user interface that gives a sense of accomplishment to the user is almost always a positive, as confirmed by several major studies on gamification (Hamari et al., 2014).

2.2 Natural User Interfaces

Raskin (1994) argues that something is intuitive when it is familiar (Raskin, 1994). He was one of the original designers on the early Macintosh project and supports his argument by citing observations, indicating that users find something intuitive as long as it resembles or identifies itself with something from the user's past learned experiences, therefore making "intuitive" synonymous with "familiar" (Raskin, 1994). This is a powerful concept, one that leads us to what is called "Natural User Interfaces", or "NUI". A Natural User Interface is one that allows the designing of products that appear and feel

more natural, especially when it comes to the senses such as touch (Wigdor et al., 2011). The purpose of these natural user interfaces is chiefly to replace the complexities of interfaces with interactions that relate closely to human behaviour that is common and natural, thus rendering the product easy to use (Broy and Rümelin, 2012). A popular example of a product that is natural to use is Microsoft's Kinect, which is interacted with by users through the use of only gestures, which the device then detects using an infrared camera.

The concept of natural user interfaces is of significant value to this thesis, in terms of how it has the potential to dictate much of how depth should be communicated in an interface. It is important that each level of the interface gives a feeling of how deep into the hierarchy the user is and how the appearance and positioning of a button meant to transport the user to another level should reflect this.

2.3 The Argument for Depth

The main argument of this thesis is the lack of depth available in most GUIs, especially when it comes to mobile operating system user interfaces. In his book, The Essential Guide to User Interface Design, Wilbert O. Galitz lays out some important guidelines for conveying depth of levels, or giving the interface an appearance of three-dimensions through the use of (Galitz, 2007):

- highlighting and shading
- assuming a static light source in the upper left corner of the screen
- displaying command buttons on top of the screen plane
- displaying screen-based controls below the screen plane
- avoiding a lot of detail, avoiding using perspective for elements that cannot be interacted with and avoiding the overuse of perspective

Research by Loretta Staples is a great example of applying techniques from other fields to the design of user interfaces (Staples, 1993). Her paper describes traditional techniques that have been discovered and used by artists throughout history and applying them to graphical user interface design, such as perspective and light effects, in order to provide a sense of depth to the interface space (Staples, 1993). Indeed, art history mirrors many of the developments in the recent past of techniques used by user interface designers. For instance, in the following sections are references to how skeuomorphism was heavily used by Apple and like-minded designers, but the shift has now, in the modern era, come to a mix of skeuomorphism and minimalism, coined skeuominimalism (Page, 2014).

Similarly, in the history of art, there was a time when hyper-realism was abounding, but in recent times there have been efforts to bring together both photographic detail and painted representations, which afford the inclusion of the imagination (Staples, 1993). The three main factors that affect depth are: perspective; light and shadow; and transparency and opacity (Staples, 1993). Perspective defines the overall scene, providing various cues to the viewer of an object's place, such as its nearness or farness (Staples, 1993). Light acts as a reinforcing agent that amplifies depth of a scene by providing appropriate illumination to an object (Staples, 1993). Shadows work in conjunction and, since they can be cast at various lengths by objects, they can further influence the space (Staples, 1993). Finally, transparency and opacity work when everything comes together, contributing to an object's definition providing a means of viewing everything simultaneously; for instance, stacking or layering can be achieved by manipulating the transparency and opacity of the involved objects (Staples, 1993).

Many consumers who shop online have complained of the difficulty in navigation on retailing websites, something that Maldonado and Resnick (2002) explore the importance of through the use of design patterns such as hierarchies and breadcrumbs (Maldonado and Resnick, 2002). While these consumers were mostly focused on internet websites, it is nonetheless of great value considering the core issue is regarding navigation, which affects all complex applications no matter the platform. The study showed that expanded hierarchies actually degraded the experience and breadcrumbs only marginally improved the user experience when using the websites (Maldonado and Resnick, 2002). Based on this it can be understood that merely using links or structures for navigation that do not offer some sort of natural experience is not enough to communicate hierarchical depth.

Thorndyke and Goldin (1983) have defined how human beings' spatial orientation is the combination of three types of knowledge, namely survey, route and landmark knowledge. Based on this it can be argued that in a user interface, it is important to give respect to these three types of knowledge. For instance, when accessing an application, it is important to give landmarks that the user recognises so that the user has some points of recognition. According to Ziefle and Bay (2006), these three types of knowledge will occur together naturally, so it is another important point to take note that navigation within the menu should ideally make use of all three types of knowledge at the same time. Adding to the aforementioned example, the landmarks would be of much more use if the route to them would be visualised through the use of survey knowledge (e.g. tree-view,

Ziefle and Bay, 2006). In light of this, one can see how implementing these methods can result in a strong sense of depth attributed to an interface.

3. Literature Review and Related Works

3.1 Overview

In order to understand the context of this research, it is imperative to go through related efforts and works in the past and those today. These will help justify further the importance of this thesis' aims and goals. This section and the following sub-sections journey through different research efforts in the development of graphical user interfaces, especially with regards to achieving more intuitiveness.

3.2 Development of GUIs

Early on, mainstream computer interaction had not much other than a terminal in which commands would be typed in order to use the computer. However, while terminals are still used, the graphical user interface is now primarily used in general interaction with computers, resorting to terminals only for specific, contextual work where it is either more efficient, or the preference of the user.

Ivan Sutherland is perhaps the name standing tallest when it comes to the graphical user interface, called the "father of computer graphics" by the National Inventors Hall of Fame (Ivan, 1972). His 1962 PhD thesis, called "Sketchpad", was the first of its kind in the world and a revolutionary breakthrough in user interface design (Sears et al., 2007), being the first to use windows, non-procedural programming and thus being the first object-oriented program, able to dynamically accomplish complex tasks (Key, 1987). Sketchpad can be easily considered the first of its kind when it comes to what we consider applications that use a graphical user interface as we understand it today. The application is the earliest example of intuitive human-computer interaction, as the only real difference in method of interaction is the type of pen; light-pen versus today's modern tactile pen (see Figure 1).

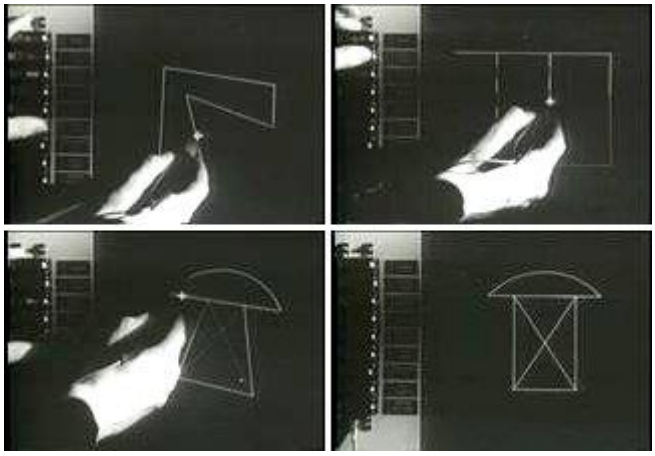

Figure 1. Sketchpad being demonstrated by Sutherland himself in 1962 (Key, 1987)

In the early 1970s, Xerox PARC introduced the Altus and STAR systems (Galitz, 2007). These were the first to make use of one of the most basic and still commonly-used gestures: pointing and clicking, where the user would point and click using a mouse (Xerox had also patented a mouse with wheels in 1970) (Galitz, 2007). While Xerox's marketing of the STAR system wasn't successful, Apple came along and picked up from where they had left the concept (Galitz, 2007). Apple began using the concept of graphical user interfaces and mice in their Macintosh line of computers, successfully mass-marketing the product (Galitz, 2007).

An important milestone worth mentioning is NeXT's NeXTStep, a UNIX-based operating system released in 1988, the first of its kind to simulate a screen in three dimensions (3D) (Galitz, 2007). A few more UNIX-based graphical user interfaces were released in the following years, such as AT&T's and Sun Microsystems' Open Look, until the beginning of the 90s and now into the 2000s where Microsoft and Apple have dominated in desktop graphical user interfaces with various upgrades and flavours of their core desktop environments (Galitz, 2007).

3.3 The World Wide Web and Mobile Devices

In the 1990s, the World Wide Web was created. The Internet, in its great ubiquity, has fostered the spread of knowledge and eased the way in which research can be carried out, resulting in faster development of new and radically different concepts and designs of the things we commonly use today. Perhaps the greatest example of such development is web applications and mobile devices (which make use of their own applications not so different from web applications).

Mobile devices have seen a quick transformation in size thanks to rapid development of hardware technology. They are now ubiquitous, with a market that is prevalent on a global scale (Kim and Lee, 2005). What first began as a bulky, tiny-screened mobile phone has now become a powerful device, a pocket computer dreamed of by many over the years when technology wasn't there to match. Today, the mobile phone is more commonly known as a smartphone, with varying form factors; the smartphone itself, the tablet computer and the phablet, which is a size wedged between those of smartphones and tablets. With such form factors comes difference in power and application of use. For instance, while one can write documents on a smartphone, it is still difficult due to the size of the screen and the capacities of its battery. This makes the usability in terms of work unpleasant. On a phablet the experience is much better and a tablet computer simply outperforms them all as it offers the mobility of the smaller form factors and the power and size of larger form factors such as notebooks and laptops, without being too much for travel.

While size is apparently the major issue for the devices when it comes to accomplishing various tasks (Jones et al., 1999), it is not alone. Indeed, the design of the user interface is what can tilt the balance, to a certain extent and create a much better experience than if the design was bad. In fact, many of the tasks that are better done on larger devices can still be easily carried out on smaller devices with good graphical user interface design.

Generally speaking, mobile device user interfaces need to conform to much higher standards compared to desktops, most importantly because of the lack of space, followed by the nature of input – either pen or touch – and by the other resources available such as battery life and processing power. The mobile form factor also introduces the possibilities of use in different environments and contexts (Eisenstein et al., 2000). An example is how a mobile device may be used by a train passenger and the train enters a dark tunnel; such a scenario should be taken care of by automatically dimming the device's screen brightness (Eisenstein et al., 2000).

Hurtienne and Blessing (2007) take a highly academic approach and test image schema theory for the use of intuitive user interface design. Bodily interactions with the world lead to recurring patterns that help us understand the world; image schemas are the abstract representations of these patterns (Johnson, 1987). A simple example of an image schema in practical application is that of the UP-DOWN or LEFT-RIGHT schemas, which can be represented as a small joystick on the remote control of a toy vehicle

(Hurtienne and Blessing, 2007). Moving the joystick left will correspond to the vehicle turning left; joystick to the right will lead to the vehicle turning right; same applies to up and down (Hurtienne and Blessing, 2007). However, the UP-DOWN image schema has more to offer. For instance, in metaphorical and linguistic terms, it can lead to concepts such as (Hurtienne and Blessing, 2007):

- Quantity: "sales are *up*"; "errors are *low*" (MORE IS UP – LESS IS DOWN)
- Quality: "The product is of *high quality*" (GOOD IS UP – BAD IS DOWN)
- Virtue: "He thinks he is *above* us all"; "That would be *beneath* me" (HIGH STAUS IS UP – LOW STATUS IS DOWN)
- Happiness: "Her mood is *up* today"; "He's really *down* today, really *depressed* lately" (HAPPY IS UP – SAD IS DOWN)

These can easily be mapped to an interface control or object, such as a slider that moves up and down for controlling speed; up would correspond to a positive increase in speed and down would lead to lowering speed; this example makes use of the MORE IS UP metaphor as aforementioned in the list (Hurtienne and Blessing, 2007). Indeed, we can see how subconsciously embedded such interaction is, how it mirrors our understanding of the world and how we almost always see interface controls represented in intuitive interfaces to correspond to our image schemas. The researchers concluded that image schemas offered great prospects in providing guidelines and design language for intuitive user interface design (Hurtienne and Blessing, 2007).

In the last few years, mobile device and web user interface design has seen the introduction of skeuomorphism. According to Greif, skeuomorphism is a design that makes use of a past design feature even though the feature's original function is not necessary anymore (Greif, 2013). This is particularly most recognised in Apple's iOS operating system, used in its mobile devices such as the iPhone and iPad (though the original Mac OS is where they borrow their design cues from. No doubt, many have criticised the overuse of skeuomorphic design techniques (Downer, 2012), which has led to the subsequent trend of 'Flat Design', with Microsoft's Window 8 OS family being the most relevant example (Page, 2014).

While both approaches have attempted to enhance usability, Riley argues that neither can be considered a solution to the usability problem (Riley, 2013). Due to the overuse of skeuomorphism (see Figure 2) by Apple and designers of similar mind, the design community has expressed distaste for the technique (Page, 2014) that has pushed for the rise of flat design (Gruber, 2013). On the other hand, flat design strips away all of

the gradients, subtle shadows and colours that skeuomorphism makes use of (see Figure 3) (Page, 2014). This leads to a dangerous situation where everything is on the same plane and thus makes it harder for the user, who cannot figure out how to interact with the interface anymore, as focusing on any one particular section becomes difficult (Greif, 2012).

Figure 2. An example of skeuomorphic design that is overdone (Page, 2014).

Figure 3. Microsoft's Windows 8 Flat UI (Page, 2014).

However, Google took both these ideas and combined them something that can be described as “almost flat” or “skeuominimalism” as shown in Figure 4 below.

Figure 4. Google applications shown with their “almost flat” approach to UI design across a range of devices and platforms (Page, 2014).

As Page (2014) argues, the best solution is often in the middle. This is what Google developed; by using skeuomorphism’s favourite elements like gradients and shadows in an efficient and minimalistic way (Page, 2014). Skeuominimalism is therefore the middle point as aforementioned, whereby its simplification does not affect usability in a harmful way, nor does its skeuomorphism ruin the beauty that minimalism offers (Sanchez, 2012).

Page’s research included the study of the opinions of design students with regards to skeuomorphism’s relevance in UI design (Page, 2014). The research concluded that indeed, skeuomorphism only had a place in UI design when used in conjunction with minimalism (Page, 2014), in much the same way as Google revamped its products’ designs. From this we have a good idea of how mobile operating system interfaces need to be able to communicate different layers of hierarchy to users, but without falling into the trap of skeuomorphism.

Kim et al. at Samsung Advanced Institute of Technology developed a novel user interface for mobile devices (Kim et al., 2006). The interface uses capacitive sensors placed in the frame of the mobile device to detect various hand grip styles (Kim et al., 2006). The team also built a hand grip classifier, which would be fed the data from the sensors and then go on to match against defined grip classes for recognition (Kim et al., 2006). For instance, the grip style when writing a text message or when playing a game are discrete and consistent whenever someone intends to do either of those and this interface attempts to launch the appropriate application by recognising one of these grips

(Kim et al., 2006). Preliminary studies revealed that the largest challenge is filtering out unintended hand grips, which was found to not be filtered at an acceptable level by traditional recognition techniques employed by the research (Kim et al., 2006). Nevertheless, an important feature to take not of from this research is how various users have consistent hand grips for certain applications and activities and that is important to consider when designing intuitive interfaces.

Mitchell and Kennedy (1997) presented an interface that made use of the 'perspective tunnel'; an information visualisation structure that maps information onto the walls, floors and ceilings of a tunnel graphically illustrated (Mitchell and Kennedy, 1997). In simple terms, it is projecting a 3-dimensional space onto a 2-dimensional plane (Mitchell and Kennedy, 1997). Various implementations of perspective tunnels exist and a brief explanation of some those described by Mitchell and Kennedy that are most relevant to this thesis is given.

First, The Video Tunnel; this technique involves dividing each surface into several divisions (Mitchell and Kennedy, 1997). The example for application is of showing television channels by placing each within a subdivision of each surface. As the amount of available channels increases, so does the complexity in determining which programmes are of interest (Mitchell and Kennedy, 1997). In this technique, however, through the use of depth offered by the perspective tunnel, the more recommended channels are closest in perspective. As far as space is concerned, closing off the end of the tunnel offers yet another plane to use; Figure 5 shows how nearly 300 channels are shown (Mitchell and Kennedy, 1997) whilst maintaining information that is valuable to the consumer.

Figure 5. Displaying meaningful television information using the video tunnel.

The second relevant implementation is The Warren; a recursive projection technique where each wall acts as another plane onto which the 3D space – the perspective tunnel – is recursively projected (Mitchell and Kennedy, 1997). The recursive projection on each wall has the potential to act as a branch to display further, deeper levels, thereby allowing even more relevant information to be displayed (Mitchell and Kennedy, 1997). An example implementation is shown in Figure 6, where an author's previous published papers are displayed in a tree structure, such that there is a hierarchy of root, paper and images (Mitchell and Kennedy, 1997). In every node of the tree, the furthest panel represents that particular node's data in the tree; in the figure this is shown as an image or a name with a date (Mitchell and Kennedy, 1997). The adjacent walls show children of that node and in the case of a node without any children, the node's data fills all the walls (Mitchell and Kennedy, 1997).

Figure 6. Using the perspective tunnel to show an author's published work.

We can see that in the perspective tunnel technique there are various applications to user interface design for mobile phones as it offers to use up the maximum of the real estate offered by mobile devices whilst maintaining a strong and natural sense of depth. An example may be showing a settings page with related settings shown within adjacent walls.

Häkkinen (2006) discusses how mobile applications such as music players that show playlists, contain simple buttons such as "Back" and "Next", which are discoverable but provide not much in terms of accessibility and any indication of the overall structure (Häkkinen, 2006). While the paper is concerning accessibility of disabled people, the fact that simple buttons such as "Back" and "Next" on their own hold no indication of structure visually is something that holds true on all interfaces and this is included in his conclusion.

On a related note, the iPhone early on had attempted to provide some visual meaning to navigating a list of albums and playlists (Figure 7), whereby each album art would be

shown in 3D; much like in real life if one were to browse a shelf of album CDs (Hao and Zhang, 2007). However, this approach becomes cumbersome to use as the list grows larger, especially when searching (Hao and Zhang, 2007).

Figure 7. Browsing a playlist on an early iPhone model (Hao and Zhang, 2007).

4. IntGUItive – Intuitive User Interface for Mobile Devices

The aforementioned chapters discussed how mobile devices not only provide new avenues of usage, but with those also new challenges, especially with regards to designing the user interface. In addition, several pieces of related research were referenced and analysed; they indicated a lack of efforts that involve illustrating hierarchical depth in interface designs and also methods and ideas that are potential solutions.

The application prototype in this thesis, named 'IntGUItive' (a portmanteau of the words 'intuitive' and 'GUI'), is a novel way of displaying the aforementioned hierarchical depth in the mobile device's operating system.

4.1 Conceptual Overview

The concept devised for this thesis takes a certain amount of inspiration from the previously mentioned perspective tunnel concept (Mitchell and Kennedy, 1997). The general idea is making use of zooming animations and concentric borders of each app with the label of the previous state.

An early concept involved mimicking the view one would get from looking into a zoom scope or binoculars, where the different zoom levels can be seen as the scope progressively narrows (see Figure 8 below).

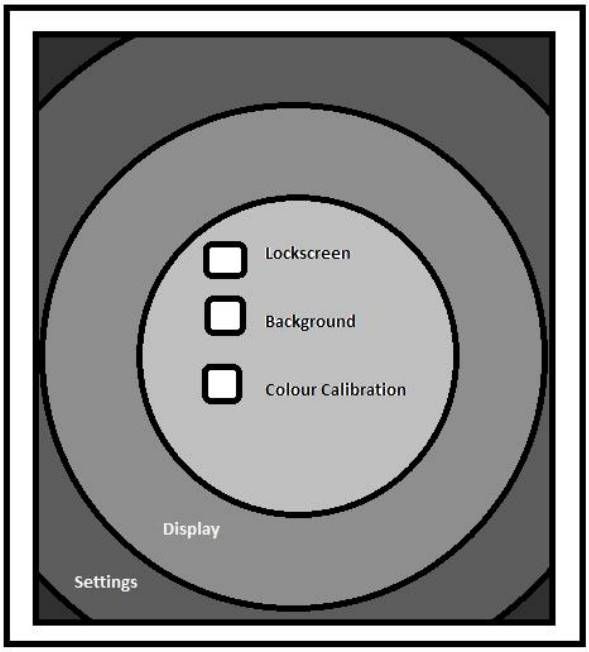

Figure 8. An early concept design, showing an accessed "display settings" screen with appropriate breadcrumbs in each of the bordered circles.

4.2 Transitions and Animations

Let's say a user wishes to launch the Settings application from the home screen. When the user taps on the Settings app icon, the system launches the application and this launch is shown as a zoom-in animation; the app icon expands to the size of screen and also reduces in transparency, while at the same time the next screen expands and increases in transparency from its own zero state. This gives an intuitive feeling of entering the application as the animation takes the user literally into the application. Whenever the user goes back to a previous state or screen, the animation of zooming out takes place.

The usage of such animations is highly intuitive. In fact, all of the major mobile operating systems (Android, iOS and Windows Phone 10) have included zooming animations in their latest releases – though they stop short at that by changing or removing the animations from further hierarchical levels as the user progresses in the app.

4.3 Breadcrumbs, Hierarchy and Perspective

Once the application is launched, its contents are shown, which may very well be further applications. In this example, Settings includes many specialised applications that deal with specific functions, such as Display Settings. If one looks around, the borders of the screen now have a faint gradient, which gives a "scoped in" or "zoomed in" feeling, much like the perspective tunnel aforementioned and at the bottom is the title and link to the previous screen, "Home".

The user wishes to change display settings, so a tap on the Display Settings icon launches the respective app and the zoom-in animation is played once more, to finally show a list of options that can be changed. The border once again is a slight gradient, but this time it is nested within the larger border, leaving a view that shows an even more zoomed in or scoped in state. The title of the smaller border appropriately reads "Settings" and as before, the larger border's label is "Home". Tapping either one will take the user back to the respective screen; "Settings" will take the user back to the general settings page and "Home" will take the user back to the device's home screen. There is no serial access in this state, as the user can go directly to the home screen or settings page, much like breadcrumbs.

5. Technical Implementation and Prototype

The initial goal of the implementation was to create a cross-platform prototype. This would offer the advantage of being free from any platform dependency and many users of different platforms could try it. Due to many operating systems working differently, this also has a potential challenge of making sure that overall, everything would run as expected. Using the Qt Framework (5.3), this goal has been mostly achieved; the application is written in Qt's own QML language, which is a combination of JavaScript and CSS and this allows implementation on any platform, any device. The application was tested on a Nokia Lumia 930 running Windows Phone 10.

5.1 Home Screen

Since the application is a prototype of an operating system rather than a separate application, it would have been far too time and effort consuming to create a detailed operating system. To remain in scope, the development focused on simplicity. The home screen is a simple screen that looks similar to the major operating systems out there, with apps displayed as icons and a background set as wallpaper. The app displayed is the Settings app, as shown in Figure 9 below.

Figure 9. Home Screen, not much different from what is seen commonly.

5.2 Transitions and Hierarchical View

As mentioned earlier, transitioning between applications triggers zooming in and out animations; Figure 10 below shows a mid-transition screen capture after a user taps

on the Settings application to access it. Another screen capture shows what the Settings application contains. While early concepts included either completely concentric circles or nested rectangles, it was decided to merge the two for the final implementation, due to small usability considerations discussed in the next section.

Figure 10. The screen on the left shows the animation in mid-sequence, as the Settings app is launched. To the right, the Settings app is completely opened.

If a user taps on the icon for Display Settings (titled “display” in Figure 10 and 11), an identical transition will play and the the deepest hierarchical level of the application will be shown.

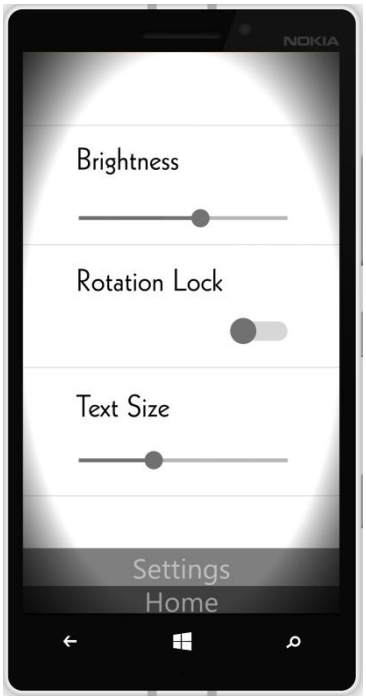

Figure 11. The deepest level in the hierarchy.

In both Figures 10 and 11, one can note the vignette around the screen and also a rectangular tab, one titled “Settings” and the other “Home”. This is the merger of the concentric circles and nested rectangles aforementioned. The vignette gives the sense of being “scoped in” and is slightly darker around the edges of the screen in Figure 11 than Figure 10, as the level is deeper in Figure 11. Similarly, the rectangles with the breadcrumb links to go to previous states are also slightly different in opacity, with “Home” being darker to show a level further away. Tapping either of the labels will lead the user to the respective screens, with a similar transition as before, as shown by Figure 12 below.

Figure 12. Going back to the "Settings" page leads the user back to the previous state. Here is a screen capture showing mid-transition of going a step back, with the screen minimising back into the "Display" settings icon, i.e. the zooming out.

5.3 Technical Issues

Early on, certain issues led to changes in platform and features of the final application version.

5.3.1 Platform

In the beginning, since the available test device was a Nokia Lumia 930, the intention was to develop on the application. However, Windows Phone as an operating system went through several dramatic updates from Windows Phone 8.1 to Windows Phone 10. Microsoft also has been shifting to their model of a unified platform, whereby anything developed using their system would run on any Microsoft platform (desktop, phone and Xbox). This meant re-learning a vast amount of material and time constraints meant this was not possible. This was in sync with the decision to create something cross-platform and thus Qt framework, which made use of C++ and their own QML markup language, was chosen. QML is very similar to a combination of JavaScript and CSS, so learning it was personally easier than re-learning and re-adjusting to changes in the Windows Phone platform. Furthermore, QML offered the ability to quickly write code and run it, compared to other languages such as C++, C# and the like.

5.3.2 Transitions

The initial intention was to create highly appealing and immersive transitions and animations when launching an application or transiting to another state of the application. However, since QML compiles back into C++, it is slightly slower than if coded in C++ and thus the difference in performance is noticeable. However, the skill and time required to implement immersive transitions in any language is quite high and this combined with the performance difference meant that the final transitions implemented have a slight stutter during their first pass, but thereafter are smooth, though less realistic than initially intended. Nonetheless, they do communicate the most important feature, which is going in and out of an application.

5.3.3 Illustrating Levels of Hierarchy

The level at which the user is in the application is communicated to the user through the use of concentric vignettes; the darker and larger they are, the deeper the user is into the application. As mentioned earlier, the initial goal was to represent the level using circles with visible boundaries between each circle (see Figure 8). However, it became quickly apparent that this method consumed far too much real-estate after just two levels. The rings could be made thinner, but this meant that the labels on the rings would also be smaller and that meant sacrificing legibility of the text. Overall, there was not much leeway between the two and thus the idea was abandoned for rectangular representation; though it should be noted that the circular rings may be more usable at larger screen sizes, such as those of phablets and tablets.

The rectangular representation offered much more efficient use of real estate, since it matches the rectangular nature of mobile device shapes. However, this too had an issue, whereby the feeling of being scoped-in or zoomed-in was lost.

Vignette effect was attempted next and this offered the advantage of efficient screen real estate usage with the feeling of being zoomed-in, both due to the gradient nature of vignettes. Better still, more layers did not need to be sized smaller as was the case in the circular rings; instead, they were made the same size as the previous layer with the gradient colour extending slightly more towards the centre. This resulted in darker a darker vignette as the layers increased and the larger gradient of the new layer reinforced the feeling.

The one issue with this technique was that the text of the breadcrumbs, or labels, would blend too much into the gradients. To solve this, the labels were given rectangular

containers of similar opacity as of the vignette, thus merging the vignette and rectangle methods and making the text legible with a feeling that it was indeed a button and also making efficient use of screen real estate.

5.3.4 Shadows

Shadows underneath the labels were first intended to be implemented, as they would give a very clean and easily understood effect of height for each of the levels. However, using shadows caused performance to take quite a large hit with small artefacts appearing. As a result, while it was dropped for the prototype, they are definitely a valuable addition for a more polished and finished product and the user study reflected this.

6. User Testing and Evaluation

Despite many of the technical challenges and the time spent learning a fair bit of QML, a stable prototype application for testing was developed. While the prototype is not feature-rich, as would be ideal, it is still enough to showcase some of the main issues that concern this thesis. Please refer to **Appendix A** for the test details, including supplementary questionnaire forms.

6.1 Test Participants and Setup

Since IntGUItive is concerning the intuitive nature of mobile devices, irrespective of any specific platform, the prototype is meant to introduce its mobile device user interface design language compared to any other platform in the market today. In other words, it did not matter whether the user had a device running Android or iOS or Windows Phone. However, the testing procedure required users to first go through the tasks on their own mobile device so that when testing began on the prototype, they would be able to contrast and experience the features in a much better way. In this way, the differences between familiarity and genuine intuitiveness or ease of use would stand out.

As aforementioned, the application prototype is not a polished or finished version. Therefore, the main and overall objective of this test was to determine the concept and intuitiveness of the application; was it pleasing to use? Did it make sense to use the zooming and layering metaphors? These are some of the questions that were asked, as opposed to anything related to speed or efficiency.

Participants were selected by contact through social media (Facebook, WhatsApp) and selected their time slots.

Total number of subjects was ten (10). The participants' age ranged between Eighteen (18) and Sixty-Two (62). There were eight (8) males and two (2) females.

Most of the participants were employed and degree-holders with excellent skill level in operating mobile devices. Only two stated good skills and just one stated a basic level of skill.

Four participants stated they used their devices all the time, three stated they used their device more than their desktop or laptop and three stated they used their mobile device secondary to their computer.

All participants were seated in a comfortable living room, were presented with snacks and were presented with a short introduction to intuitive graphical user interface concepts. Their use of navigating through their devices was discussed very briefly in order

to bring about an understanding of the test and prototype. Once they understood the general idea, they were asked to complete a few tasks (see Appendix A) on their own devices and then on the prototype. Once the test was complete, the participants were asked to fill in a short questionnaire to quantify their experience and then a short verbal interview was taken from them in order to discuss their experience of the prototype in their own words and any suggestions they may have had.

6.2 Test Case Plan - Introduction

The usability of IntGUItive will be evaluated in this test case. The goal of the evaluation is to provide the developers with a general evaluation of the usability of the system as well as ideas for improving its usability.

This report will describe the system under evaluation and a detailed plan for its usability testing.

In the usability test, the participants will be briefly introduced to mobile operating system norms the users are already familiar with and then the application under evaluation that is intended to be served as a replacement. The participants will then be provided with pre-formulated test tasks (prepared so that they will target the issues that are on the focus of the evaluation). In addition, data will be collected with interviews and questionnaires.

According to the ISO-9241-11 standard, the criteria for usability are effectiveness, efficiency, and satisfaction. The following measures will be used to evaluate different aspects of usability:

1. Evaluating effectiveness
    - % of tasks successfully completed
2. Evaluating efficiency
    - Task times
    - Errors per task
3. Evaluating subjective satisfaction
    - How often and in which circumstances does the participant express signs of frustration or pleasantness (think-aloud and the behaviour of the participant)
    - Interview results
    - Questionnaire results

6.3 Description of IntGUItive and its Users

6.3.1 Overview of the Application and Focus of Testing

IntGUItive is a prototype application developed for my Master's Thesis. The application is intended as an alternative interface design for mobile operating systems. By being developed using the QML language created by the Qt Company, it is platform-independent. As a result, it will be able to run on all major platforms, such as Android, iOS and Windows, regardless of screen size. The application makes use of perspective-inducing techniques such as perspective tunnels. It can also be considered to use a real life metaphor of zooming in, in the form of a zoom lens or, as aforementioned, a tunnel. Each level of zoom represents the level at which the user is in the application.

The usability test will focus on evaluating the following:

- Navigation and general structure of the application
- How easy and natural it is to launch an application
- How easy and natural it is to navigate within the application
- Overall level of satisfaction while interacting with the application
- What changes can be made or implemented to improve the application

6.3.2 User groups

IntGUItive is not a thoroughly complete and polished product; it is a prototype that is built around the core ideals and the underlying theory that defines it. As a result, it may not be as appealing to users as its intended goal in the visual department, for example. However, the application is still easy to use as it is not complex in its conception, so it should be easy for any age group.

The users will be selected from the students and staff of University of Tampere and those that belong to other institutions. Some of the users will be working professionals that are not students.

6.4 Usability Testing

Due to the nature of the application, which focuses on intuition and what is natural, pilot testing will take place in an environment that is unchanged and as-is. In other words, users will be tested at times and conditions which are appropriate for them; this means that they can be expected to be relaxed and comfortable situations, but may easily be something else. An uncontrolled environment is best suited, as navigating mobile devices

often takes place in varying environments and consistent performance of the application would prove to be highly valuable irrespective of when and where.

6.4.1 Division of Labour

Since I am the sole developer and author of this thesis project, I will be the only one conducting and moderating the test. The simplicity of the test also does not require any other member to be present.

6.4.2 Technical context

The test will be run on a Nokia Lumia 930 running Windows Phone 10. The device dimensions are 5.39 x 2.80 x 0.39 inches, weighing 167 grams and the screen is 5.0 inches. The resolution of the screen is 1080 x 1920 pixels, with a density of 441 pixels per inch.

The application will also be attempted to run on the Android platform after compilation for Android. The application is expected to run irrespective of Android version and device size, but it is expected that the Android firmware would be one of the latest stable builds (4.4, 5.1, 6.0, 7.0).

6.4.3 Participants

Participant selection will be aimed between the ages of 18-60. They will be of varying backgrounds, ethnicities and skill levels, with a minimum requirement of some familiarity in using mobile devices.

6.4.4 Test Tasks

All participants are expected to be able to navigate mobile device interfaces and, due to the similar ways in which they all work, the familiarity will inevitably be registered as easy for them. However, IntGUItive is quite a departure in mobile interface design from current practices and thus will be briefly introduced to the new concept and controls. The following tasks will be first carried out on their own personal device and then using IntGUItive.

Practice task	**Launch any application from the home screen.**
Start state	No applications open.
Rationale	The purpose of this task is to gently direct the participant's attention to the most basic interaction gestures between humans and mobile devices using touch screens.
End state	The participant has successfully launched an application.
Estimated task time	Less than 30 seconds.

Task 1	**Launch the Settings application.**
Start state	The application's main interface is open displaying the home screen.
Rationale	The purpose of this task is to launch the Settings application and enter the first level of the overall interface.
End state	The Settings application is successfully launched.
Estimated task time	Less than 30 seconds.

Task 2	**Go back to the home screen.**
Start state	The Settings application is open.
Rationale	The purpose of this task is to make the participant go back to the initial state without being told how to do so and to see if the Home label at the bottom will be used, suggesting its intuitiveness.
End state	The application's home screen.
Estimated task time	Less than 1 minute.

Task 3	**Launch the Settings application and then the Display Settings application.**
Start state	The application's main interface is open displaying the home screen.
Rationale	The purpose of this task is to make the participant navigate through the application.
End state	The Display Settings application is open.
Estimated task time	Less than 1 minute.

Task 4	**Go back one level.**
Start state	The Display Settings application is open.
Rationale	The purpose of this task is to make the participant navigate through the application.
End state	The participant is back to the Settings screen.
Estimated task time	Less than 1 minute.

Task 5	**Go to Display Settings and then go back to the home screen directly using the Home label.**
Start state	The Settings application is open.
Rationale	The purpose of this task is to make the participant navigate back to the home screen without going through the main Settings interface; this will illustrate the ability to directly navigate to the initial state.
End state	The participant is back to the home screen.
Estimated task time	Less than 1 minute.

6.4.5 Interview Frame

After the usability test, the users will be interviewed. The interview type is a semi-structured interview. The interview can take 10 minutes at most.

The interview will cover the themes listed below.

Theme 1: The participant's views on the concept of IntGUItive.

- What do you think about the current state of mobile device user interfaces? E.g. too steep of a learning curve, cluttered, easy, intuitive, etc.
- Do you believe that IntGUItive is interesting and engaging?
- Do you think the menus are properly placed? Did you feel any difficulties navigating through the menu items?
- What do you think about the vignette effect? Does it feel like they give a feeling of focus and levels?
- What do you think about the direct navigation using labels?
- What do you think are some of the drawbacks?
- What are your suggestions for improvement?
- How would you like it if it used some new haptic features in mobile devices, such as tactile feedback, 3D-touch (pressure sensitivity) and the like? For example, pressing on a label would show a thumbnail preview of that screen, so one would know what is in that screen or what it looks like, without actually leaving the current screen, similar to Windows Taskbar Thumbnail Previews.
- Do you believe that IntGUItive can be used as a replacement for mobile user interfaces in its current state or in an improved version?
- Was there any difficulty or distraction you felt in performing any task?

6.4.6 Questionnaires

All participants will be asked to fill a background questionnaire (Appendix A) and a user satisfaction questionnaire. The following questionnaire asks users to rate their experience for both; their own mobile device's operating system and IntGUItive. The scale is between 5 values ranging from positive experiences to negative experiences.

1. How pleasant was the interface?

Very pleasant	Pleasant	All right	Not very pleasant	Very unpleasant

2. How easy was it to navigate between applications?

Very easy	Easy	All right	Difficult	Very difficult

3. How effective were the vignettes in communicating depth?

Very effective	Quite effective	All right	Quite ineffective	Very ineffective

4. Did you feel a sense of depth when navigating within the application?

Yes	Somewhat	Neutral	Not really	Not at all

5. How pleasant was the overall experience with the application?

Very pleasant	Pleasant	All right	Not very pleasant	Very unpleasant

6. Do the metaphors of zooming in and zooming out and looking through levels of depth make sense? Should levels of hierarchy and depth be communicated in such a way?

Yes	Somewhat	Neutral	Not really	Not at all

7. Would you like to use this type of interface after smoother transitions, effects and overall better quality?

Would love to	Yes	Perhaps	Not really	Nope

6.4.7 Collecting and Analysing the Data

All information recorded and collected by the questionnaires and interviews will be processed and presented through the use of tables and diagrams.

6.5 Results

The following table lists the statistical results from the user satisfaction questionnaire. The table only lists the chosen answers and their tallied amounts; the full list of choices is listed in the test document in Appendix A. In addition to the table, pie charts in the evaluation section illustrate the results in a visual form with percentages to match.

6.5.2 User Satisfaction Questionnaire Results

Question	Answer	No. of Responses
1. **How pleasant was the interface?**	Very pleasant	3
	Pleasant	5
	All right	2
2. **How easy was it to navigate between applications?**	Very easy	5
	Easy	4
	All right	1
3. **How effective were the vignettes in communicating depth?**	Very effective	3
	Quite effective	4
	All right	2
	Quite ineffective	1
4. **Did you feel a sense of depth when navigating within the application?**	Yes	5
	Somewhat	4
	Neutral	1
5. **How pleasant was the overall experience with the application?**	Very pleasant	4
	Pleasant	3
	All right	3
6. **Do the metaphors of zooming in and zooming out and looking through levels of depth make sense? Should levels of hierarchy and depth be communicated in such a way?**	Yes	6
	Somewhat	1
	Neutral	3
7. **Would you like to use this type of interface after smoother transitions, effects and overall better quality?**	Would love to	3
	Yes	5
	Perhaps	2

Table 1: Results of the user satisfaction questionnaire.

6.5.3 User Interview Results

After each participant had filled completed the test and filled in the user satisfaction questionnaire, they were asked a series of questions verbally. The purpose of these questions was to have a brief discussion, in their own words, of their experience and what

they thought about the application. While some users had different perceptions on intuition (as reflected in a couple of responses in the questionnaire results table above), almost all users had similar answers.

Q1. What do you think about the current state of mobile device user interfaces? E.g. too steep of a learning curve, cluttered, easy, intuitive, etc.

The aim of this question was to learn about the general ideas and perception that users had of today's user interface designs for mobile devices. This is particularly relevant as technology is moving extremely fast, with changes, especially in user interfaces, coming and going every so often. Unsurprisingly, responses to this question varied. However, there was a certain pattern according to age; older participants found that interfaces were becoming more and more cluttered and difficult to learn, whereas younger participants were all right with how interfaces were designed. Even so, both older and younger participants agreed that the interfaces can be designed in a much better way and that a lot of beneficial design might be ignored for the sake of branding and "how it's done" by a certain company.

Q2. Do you believe that IntGUItive is interesting and engaging?

The answers to this question clearly indicate a positive response to the new design. All participants agreed that the concept of IntGUItive was highly interesting, if not engaging. Despite the application prototype not being feature-rich, discussions with users quickly lead to the overall understanding of the concept and they genuinely wished to see more development in this direction.

Q3. Do you think the menus are properly placed? Did you feel any difficulties navigating through the menu items?

Participants generally responded positively to this question. All participants quickly realised that the concept could become problematic if there were too many levels in an application or if the screen size was smaller; the labels/menus might end up taking too much screen real estate. It was duly explained to them that this was indeed understood when formulating the idea. One participant felt that due to the familiarity of current interface designs, the menus should have been at the top rather than at the bottom. Some participants thought that the buttons should have been a bit larger with the text size larger as well. A few also would have liked different colours. Regardless, there was no real

difficulty when navigating beyond the initial discovery of the menu labels and found the overall experience intuitive and natural.

Q4. What do you think about the vignette effect? Does it feel like they give a feeling of focus and levels?

Participants were generally positive to using the vignette effect, with only one participant believing them to be ineffective. Initially they did not quite notice it, but during discussions participants quickly understood the usage of the vignette effect, saw its use and agreed that it played a role in illustrating the feeling of focus and being positioning at certain levels.

Q5. What do you think about the direct navigation using labels?

An overwhelmingly positive response to this question indicates how important a feature direct navigation is and places a significant amount of importance on the design of the menu labels. Participants loved the idea of being able to switch to any state of the application immediately from any starting point and agreed that this was almost impossible to accomplish in current mobile applications using their interfaces. This also highlights how mobile interface designers are overlooking a massive issue of convenience and ability.

Q6. What do you think are some of the drawbacks?

Unsurprisingly and similar to question 3, participants understood that deep into hierarchy, the labels and menu items might end up taking too much screen real estate, something already quite scarce on mobile devices. Some thought it might really make sense to use the menu and label design when the application was significantly complicated, whereby the direct navigation and stacking to communicate depth levels would help save precious seconds of usage time. While the screen real estate usage was the main concern of participants, there were still some that did not agree to this as well and found no drawbacks. Some thought that the prototype suffered from a lack of colours and one response mentioned there being a lack of clues that suggested the direct linking nature of the labels. However, this was discussed and is understood to be part of the learning process of any application and this is why one of the tasks in the test specifically asked for navigating to the home screen using only the home label.

Q7. What are your suggestions for improvement?

Responses generally centred on how the menu and labels looked. The main suggestions were to use different colours font sizes for the different labels to distinguish levels, while a few commented instead on using different backgrounds for the different levels. Some also suggested different ordering of the menu items and this was discussed in light of how the ordering should change when an application has deeper levels, similar to how perspective tunnels work (Mitchell and Kennedy, 1997).

Q8. How would you like it if it used some new haptic features in mobile devices, such as tactile feedback, 3D-touch (pressure sensitivity) and the like? For example, pressing on a label would show a thumbnail preview of that screen, so one would know what is in that screen or what it looks like, without actually leaving the current screen, similar to Windows Taskbar Thumbnail Previews.

Participants generally responded positively to including haptic features such as tactile feedback, pressure sensitivity, or both. Two participants felt that it might perhaps overcomplicate things and therefore did not wish to include such features, but suggested their own versions. For instance, one participant felt that instead of using pressure sensitivity for the thumbnail preview of the previous screen, the preview thumbnail can be shown on the label. Participants agreed that gesture usage, if included, must be made obvious to let users know of their existence, otherwise they should not be implemented.

Q9. Do you believe that IntGUItive can be used as a replacement for mobile user interfaces in its current or in an improved version?

Participant responses were generally divided on this question. One half of participants agreed that an improved version could easily act as a replacement. The other half believed that instead of a complete replacement, the features used could be implemented in order to change existing interface designs appropriately enough to make them far more natural and intuitive.

Q10. Was there any difficulty or distraction you felt in performing any task?

Due to the nature of the application that challenges navigation familiarity with current user interfaces entirely, participants generally found themselves using the “back” hardware button on their devices. However, this was quickly resolved after they realised the intention of the application. Otherwise, participants felt no difficulty or distractions.

6.6 Evaluations of Results

It is clear from the overwhelmingly positive and satisfying results that the concept put forth by IntGUItive is one of significant importance and relevance in the world of design for user interfaces and user experience as a whole. In this section, the results of the user satisfaction questionnaire and interview are looked at, evaluated and discussed in detail, along with pie charts for visualisation purposes.

6.6.1 Pleasant Interface

All participants found the interface design of IntGUItive. Eight responses were either “very pleasant” or “pleasant”, with only two responses of “all right”. No participant chose any of the negative choices of “unpleasant” and “very unpleasant”. Worth mentioning is that some participants were so impressed by the overall design, that they were surprised to learn that it was an unfinished prototype and developed by a single person.

Despite the fact that some responses suggested better use of colours and background images, overall participants loved how natural it felt to use IntGUItive.

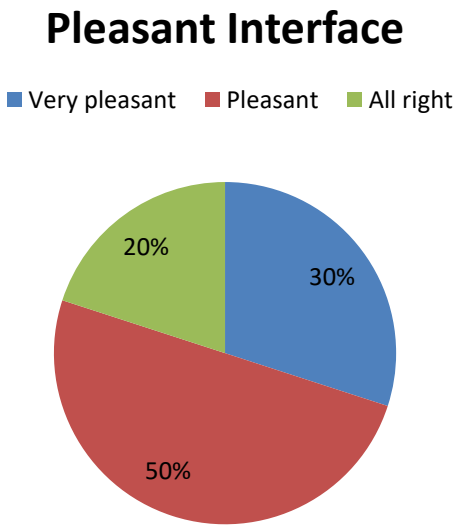

Figure 13. Pleasant Interface

6.6.2 Easy Navigation

Participants once again overwhelmingly responded positively with five responses for “very easy”, four responses for “easy” and just one response for “all right” regarding easy navigation. While it is true that the application did not have more than one app to interact with, as discussed in the verbal interviews, it still became apparent that even with more features, the application would continue being easy as the proof of concept was fairly obvious and satisfying.

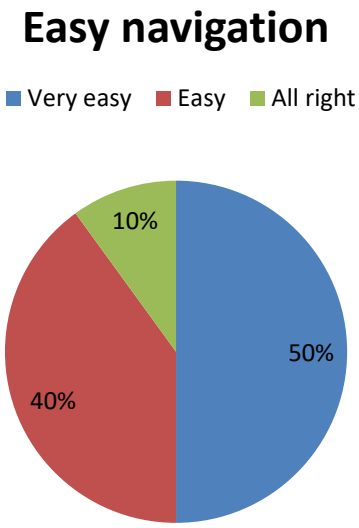

Figure 14. Easy Navigation

6.6.3 Effectiveness of Vignettes to Show Depth

With four different answers, participants clearly responded to this question in the most diverse way, with different perceptions and experiences. As is apparent, 40%, or four of the ten respondents found that the vignettes were effective in communicating some sort of depth in the application hierarchy. Three found it ideal and had no issues, with two respondents choosing it to be “all right” and one response considering it “quite ineffective”. This was quite interesting as there is an opportunity to learn from a particular perspective; the participant with this response cited that while he found it an interesting idea, in his mind, he did not associate a sense of depth with the effect. Had he not been made aware of it purpose, he would not be able to figure out its significance. According to him, memory and spatial awareness plays a larger role in communicating depth and believed that visual cues such as the vignette effect would be more required to assist memory in a much more complex application with 4-5 levels. He also mentioned that such cues would be more difficult to implement using only lighting and shading. This is

extremely insightful, as it gives a detailed look into the possible solutions to this problem; the vignettes' purpose was to provide a visual cue to stimulate spatial awareness, yet here it seemed to not make an effect for the participant.

While overall responses testify its use and significance, further research is necessary to find an ideal way to implement this in a more natural and intuitive fashion.

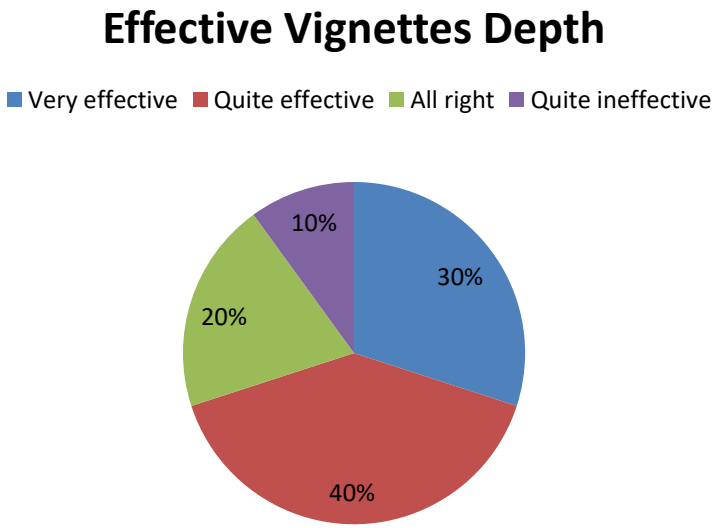

Figure 15. Effective Vignettes Depth

6.6.4 Feeling a Sense of Depth Whilst Navigating

Most of the responses (five of ten) perceived a sense of depth while they navigated through the prototype. However, a large number (four of ten) were not entirely sure, responding with "somewhat" and one response was neutral. Indeed, as discussed in the previous sub-section, it is apparent that more needs to be researched in order to create and implement effective visual cues. Nevertheless, it is satisfying how even in such a primitive form; the prototype was able to communicate a sense of depth, which is at the core of its concept.

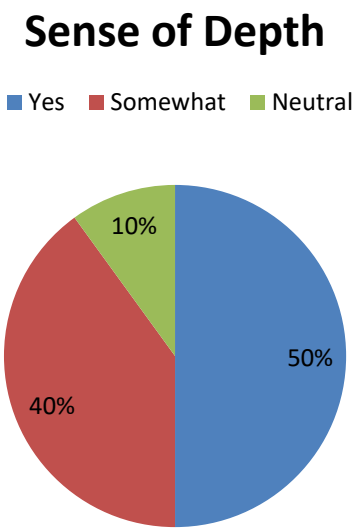

Figure 16. Sense of Depth

6.6.5 Did the Metaphors of Zooming-in and Zooming-out Make Sense?

Participants responded with the maximum positive answer ("yes") the most to this question, with 60% (or six of ten) responses, indicating a highly successful concept. Participants immediately related to and agreed with zooming transitions when entering and exiting applications and believed a basic sense of depth requires this. However, quite a few (30%) were neutral to this effect and one participant (10%) felt that the metaphors somewhat made sense. Overall, participants enjoyed how natural and intuitive the application felt.

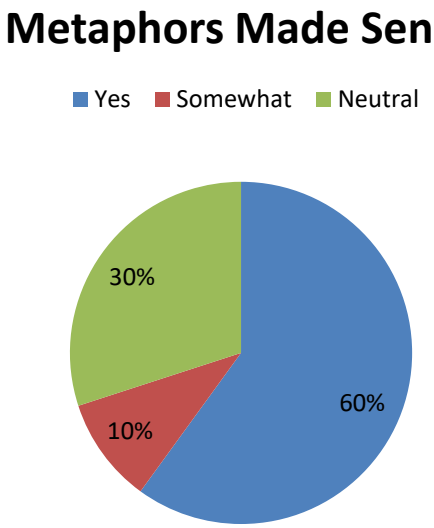

Figure 17. Metaphors Made Sense

6.6.6 Pleasant Overall Experience

A fairly equally divided set of responses, as evident in the pie chart, indicates that the overall experience with the prototype was generally positive. Indeed, “very pleasant” received the most number of responses, at four out of ten, with “pleasant” and “all right” chosen by three participants each. It is satisfying to see that despite its bare-bones state, the prototype did not give any participant an unpleasant or difficult experience, which is confirmed by all responses discussed so far.

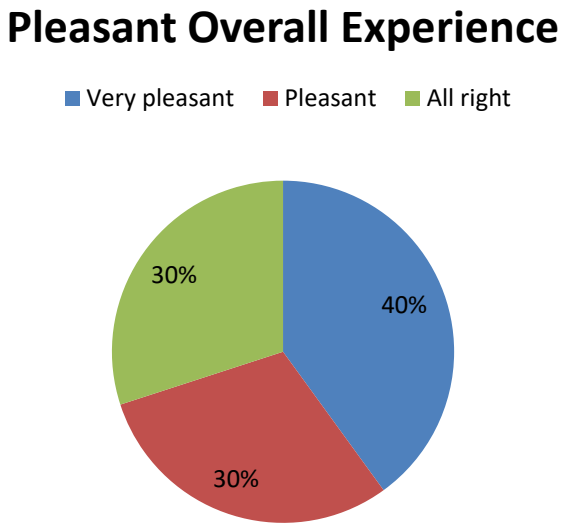

Figure 18. Pleasant Overall Experience

6.6.7 Willingness to Use Again After Polishing or in an Improved Form

Participants were very welcoming to the notion of using the design concept again in a more polished and improved form. Corroborating this is how many felt that the introduction of haptic features, as discussed in question 8 of the interview, would be a great addition and more engaging.

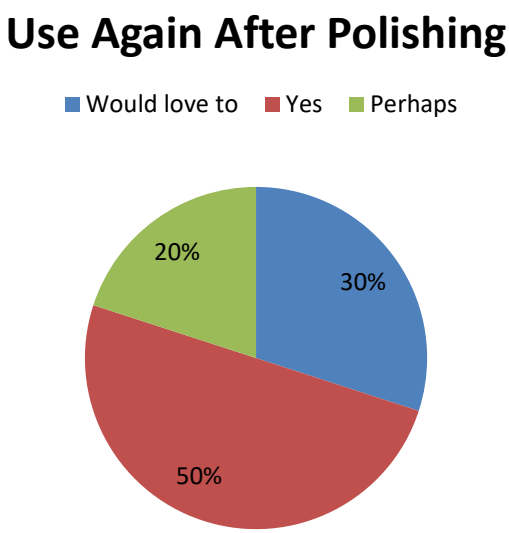

Figure 19. Use Again After Polishing

7. Discussion and Further Development

The usability study, while being of a small scale and featuring a primitive prototype as proof of concept, managed to produce interesting results. Despite there being an overall favourable and positive response from participants, it must be stressed that some of the answers that indicated a difference of opinion and perception should be thoroughly investigated and researched. These responses have indicated a few points of interest, discussed below.

7.1 Points of Interest

The research results showed that the main points of particular interest are:

Vignette Effects – During the conceptualisation of the application, it was thought that using a vignette effect for each level of depth would induce a sense of depth akin to what one perceives as they look down a scope of a rifle or look through the zoom lens of a camera, increasing in opacity proportionally to how deep a user is in the application's hierarchy. This is in light of the guidelines discussed by Galitz (2007), which involved making use of shadows, highlights and light sources (Galitz, 2007). However, the vignette effect appears to be an ambitious idea, as the results suggest a mix of positive and neutral perceptions, with some participants not noticing or realising the vignette's use until indicated or otherwise explained in discussions.

Menu / Labels – Participants mainly commented on different positions, colours and font and label sizes, indicating that there is a great number of ways in which the design can be improved and made to feel more user-friendly and intuitive. However, as it stands, the approach alone proved to be much more natural than what is currently available.

Transitions – While almost all participants preferred having the animations and transitions, there is no doubt that they could be much more improved in terms of fluidity and blending.

7.2 Future Work

This research has shown to produce a fruitful outlook and playing field for native mobile device user interfaces, where it seemed as if efforts to reimagine the interaction techniques had mostly stalled or slowed down. Future work should definitely focus on designing the menus and labels in a far more efficient manner, perhaps by incorporating more of what perspective tunnels do (Mitchell and Kennedy, 1997). The most readily understandable concept is using more surfaces available than simply stacking menus and

labels at the bottom or top and the content in the centre. For instance, the menus and labels can be shown stacked as they are now, but switch to horizontal stacking once the levels become too deep, making sure to maintain shadows and other visual cues to continue the effect of being physically deep in a structure.

Content of the applications, such as further sub-categories of settings in our case, can be shown in the screen with a more efficient layout. For example, the overall view can be as the perspective tunnel technique works, with all of the walls containing several sub-categories (Mitchell and Kennedy, 1997). This can be further enhanced by showing more relative information closer in perspective. An example of this is being in a search app and the closest matches come up closer to the screen on the walls, thereby appearing larger in perspective. This is similar in concept and theory as how when one searches on a Macintosh computer, the search highlights the different sub-categories first instead of listing matches as text.

The adjacent walls can also be used for showing contextually relative information and this is a great opportunity to make use of gestures. An example is being in the pictures application; its contents would be on the main wall in front of the user, but the adjacent walls would have access to similar applications. The right wall can have the contents of the videos application and the left wall can have the camera application UI visible. The user would simply use a gesture to navigate, such as a swipe to the left or to the right, in order to access these applications. This means that the user has no need to go back to the main screen, find another application, tap it and launch it.

Ideas can also extend to larger devices, such as tablets and even desktops. A scenario might be where the Explorer window on a Windows system or a Finder window on a Macintosh system can, instead of using multiple windows, use the menu and label design of IntGUItive; the title of each level appearing on the bottom or wherever else, but continuing with the perspective effects such as shadows and slight skewing.

Haptics are definitely something that cannot be ignored. Ideas can revolve around using the staple effects in varying capacities, such as using the traditional tactile vibration effect upon menu label interaction. The varying capacity can include lighter vibrations as one goes deeper into the application and heavier as one goes back out, or vice versa. In fact, this opens up a possibility for researching what strength of vibration users perceive as or relate to which level in a hierarchy. Similarly, sound can also be implemented, with a heavier or lighter sound, with similar research required to identify which is ideal in perception, all to make it more natural for users interacting with the device, which is in

line with the philosophy of natural user interfaces (NUIs); that is, to create a product whose method of interaction is “natural”, in the sense that while it may not mimic real nature, it will be considered “natural” based on how the user expects it to work (Wigdor et al., 2011). Of course, as asked from participants in this user study, pressure sensitivity can also enable some interesting interactions, such as preview screens upon a high pressure touch, or perhaps opening up a context menu when pressing a menu label which allows navigation to yet another, related screen. The possibilities are quite numerous indeed.

8. Summary

In this thesis, an ambitious and very unorthodox approach to designing mobile device user interfaces was discussed. As is apparent, many obvious issues immediately became apparent, such as device performance, screen sizes and organisation of information. The primary idea revolved around creating an environment of perspective and spatial dimension around the user. This was attempted by loosely basing it on a number of real life metaphors, such as a zoom lens of a camera, a rifle scope and binoculars – all focused on the idea of zooming into information and zooming back out.

The results proved that despite a primitive prototype, users responded positively. Participants in the research enjoyed interacting with an interface that gave them a new sense of perspective, felt natural and related to their ideas of navigation intuitively. However, it is far from perfect and further work is indeed required to produce something of higher fluidity and quality, alongside the elimination of issues such as lack of screen real-estate, colour and visual cues. Though a finished product may not realistically be an easy replacement for current user interface styles, it is without a doubt that the research results from this work can help to at least influence current design patterns to incorporate more depth, direct navigation and displaying relative information to provide a highly intuitive and natural user experience.

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Appendix A

10. APPENDIX A: BACKGROUND QUESTIONNAIRE

BACKGROUND QUESTIONNAIRE

Background Information

Age: _____

Gender: [ ] Male [ ] Female

Occupation:
[ ] Entrepreneur
[ ] Employer
[ ] Employed
[ ] Student
[ ] Retired
[ ] Unemployed or on leave

Education:
[ ] Comprehensive or elementary school
[ ] High school
[ ] College / University degree
[ ] Else:
_____

Mobile Device Use

How do you evaluate your mobile device skills?
[ ] Excellent, I understand how mobile devices function
[ ] Good, I use mobile devices often and fluently
[ ] I can use basic functions such as email
[ ] I am a novice in mobile device use
[ ] I don't use mobile devices at all

How often do you use your mobile device?
[ ] All the time; I need to or want to use it for everything
[ ] More than my computer
[ ] As much as my computer
[ ] Secondary to my computer
[ ] Hardly; only when I have no other choice