WebGL on Mobile Devices

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Abstract—The abstract goes here.

Index Terms—WebGL, mobile computing, teleseminar.

1 Introduction

The technologies which allow people to interact with the world around them evolve constantly. Whereas it was common to simply display information in a static form in the early days of the web, at present an ever increasing amount of content is presented in dynamic and interactive ways.

In the effort to expand internet browser functionality to natively support three-dimensional graphics, HTML5, WebGL have been developed. Many web sites already offer functionalities which were previously only found in native applications, e.g. word processing using Google Docs [1] or creating presentation using 280 Slides [2], thus narrowing ″the gap between them″ [3]. A native usage of 3d-functionality enhances these ″web applications″ even further.

″Augmented Reality (AR) has been defined broadly as combining real and computer-generated digital information into the users view of the physical and interactive real world in such a way that they appear as one environment, thus providing a bridge between digital information and the physical world″ ([4], [5], [6], [7] via [8]). Application areas of AR can be as broad as ranging from health care [9] to education [10] to tourism [11]. The topic has gained momentum thanks to the rise in smartphone usage. ″To make the world itself the user interface [...] may revolutionize the way information is accessed and presented to people in the future [4], [7].

The rise of smartphones is growing with a fast and still accelerating pace, enabled ways of displaying information in a new way in a truly mobile context to many people [12], [13]. They offer a much higher power than feature phones and even claim to offer the ″real web″ experience with ″real browsers″ [14]. There are differences, however, between the way information can be accessed from a desktop system and a mobile device, influenced by factors like screen size, processing power, and input methods.

3d-support on mobile devices is still in an early phase. Adobe abandoned Flash in late 2011 [15], leaving WebGL as the main (method) of providing interactive 3d content on the mobile web, even if it is still in an initial phase.

This paper analyzes the status quo and potentials of WebGL on mobile devices (regarding performance and human-computer-interaction), and answers the following questions:

1) **Are Augmented Reality applications possible on mobile devices using only**

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the browser?

2) **Is 3d-augmentation of these applications possible using WebGL?**
3) **How fast is WebGL on mobile devices?**

The paper is structured as follows: Chapter 2 gives background information on relevant topics, i.e. augmented reality, WebGL, and human-computer-interation (HCI) with mobile devices and their evaluation criteria; Chapter 3 gives implementation details of the the WebGL environment used to capture the status quo; Chapter 4 presents the evaluation as well as limitations to this study; and Chapter 5 gives a summary of the results and presents future research opportunities.

2 Background

2.1 WebGL

In 2009, the *WebGL Working Group* was formed with the mission to "bring hardware-accelerated graphics to the internet" [16]. WebGL is a software library and extends Javascript to allow it to natively generate websites with 3D content. The first version of WebGL was released in 2011 [17].

2.1.1 Design

"WebGL is based on OpenGL ES 2.0 and provides an API for 3D graphics. It uses the HTML5 canvas element and is accessed using Document Object Model interfaces. Automatic memory management is provided as part of the JavaScript language.... Renders of GPU, which muss support shader rendering" (Wikipedia) It is based on Canvas 3D, which was developed at Mozilla [18]. "WebGL is a context of the canvas HTML element that provides a 3D computer graphics API without the use of plug-ins." (Wikipedia)

2.1.2 Desktop WebGL

2.1.3 Mobile WebGL

Although support for WebGL is available on the desktop computers within all major browsers WebGL (FireFox 4+, Safari 5.1+, Chrome 10+, Opera 12+), except of Microsoft's Internet Explorer [3], browsers on mobile devices supporting WebGL are still very rare.

Apple has added WebGL capabilities to iOS with iOS 4.2 [19], [20]. However officially WebGL is only available to be used on Apples iAd platform [19], [21]. With an hack discovered by Nathan de Vries [19] WebGL can also be enabled in a UIWebView. Using this way it is possible to build a custom WebGL viewer for iOS. However since this method of enabling WebGL on iOS requires the use of non-public APIs it cant be made available to end users due to Apple's App Store Review Guidelines [22]. The built-in Safari browser on iOS does not support WebGL and due to Apples App Store Review Guidelines [22] third party browsers are required to use the WebKit rendering engine provided by Apple. So until Apple officially supports WebGL in Safari on iOS there is no way available for the end user to run WebGL content on iOS.

As the desktop version of InternetExplorer does not support WebGL [3] and Microsoft is considering WebGL "harmful" [23] we probably wont see WebGL support on Windows Phone 7 in the near future.

With Firefox 4 a WebGL compatible browser is available on Android.

Also RIM's tablet, the BlackBerry PlayBook, supports WebGL in web applications.

2.1.4 Security Issues

Although the support of WebGL seems to be widespread, there are also critical voices, with Microsoft probably being their most prominent spokesperson. Microsoft believes "that WebGL will likely become an ongoing source of hard-to-fix vulnerabilities" [23], because WebGL allows direct access to the computers hardware from the web. WebGL security therefore relies on graphic card drivers and other third party components. [23]

Context, an information security consultancy, which recommends to disable WebGL in the browser, published and demonstrated two possible attack scenarios both initiated from a malicious website [24], [25]. They were not only able to perform a successful Denial of Service attack, which leads to operating system crashes and freezes of the desktop, but also to gather possible confidential information by stealing the content of the graphic memory with which they were able to reconstruct screenshots of the desktop. As stated by Context, these issues are inherent to the WebGL specification and can't be resolved without major changes in WebGL's architecture. Although there are countermeasures in development, which could resolve these issues, at the moment WebGL allows malicious programs access to the graphics hardware and software. [24], [25]

2.1.5 Status Quo

2.1.6 Evaluation criteria

In the literature, WebGL implementations on mobile devices have been technically evaluated using various methods and range from checking support of official WebGL desktop browser examples to typed array conformance tests to performance tests [3].

2.2 Augmented Reality

Application areas of AR can be as broad as ranging from health care [9] to education [10] to tourism [11]. The topic has gained momentum thanks to the rise in smartphone usage.

2.2.1 History

2.2.2 Categories

AR applications can be categorized in two classes, *AR browsers* and *image recognition-based AR applications* [26].

2.2.3 Native apps and web applications

2.2.4 WebGL usage

2.2.5 Evaluation criteria

User-oriented issues critical for AR evolution and adoption [8]. "AR research still lacks evaluation methods" [27] [12]. Metrics are still very abstract [26]. Obstacles for evaluation the usability of mixed reality systems ("lack of, for example, a common testing platforms and benchmarks")[28]. Thus, low user evaluation rates in AR research, though, many evaluate only early tech demos (cf. [29]). Some evaluation oriented towards user experience [28].

2.2.6 Impact on Human information behavior

Human behavior towards information is influenced by new technologies. recommendation agents - reducing the consumers information overload and search complexity [30]. acquiring product information in in-store settings has often been linked to consumer decision making and information processing [31], [30], [32]. social aspects of mobile image recognition - attaching digital storytelling to physical products - affective influence [33], e.g. trust, engage consumers to communicate and receive information about products [31]

2.3 UI and UX Research

"User experience (UX) is regarded as a holistic concept describing the subjective experience resulting from the interaction with a technological product or service. Both instrumental (e.g. utility, usability, and other pragmatic elements) and non- instrumental (e.g. pleasure, appeal, aesthetics, and other hedonic elements) elements are covered in the UX literature [34]. A recent ISO standard [35] defines UX holistically as a person's perceptions and responses that result from the use or anticipated use of a product, system or service. Recently, pleasurable user experience has become the principal goal in the design of novel interactive systems. Hence, the emphasis on UX has moved the design focus from removing usability and functionality problems or other negative factors to offering possibilities for positive and satisfying experiences that exceed the users expectations."

Research on human-computer interaction (HCI) has been traditionally been rooted in cognitive psychology, engineering, and computer sciences. Besides these fields, research on emotional factors of design is growing [36], which marks a shifts from *usability* to *user experience* analysis.

Academia evaluates user experience oftentimes by looking at the emotional state of the user [37], e.g., by letting users fill out pen-and-paper questionnaires during the course of the usage or by capturing user-made video diaries [38], [39].

3 Implementation

Although data from a gyroscope is accessible with JavaScript and could be therefore used in a WebGL application, we only used data provided by a devices accelerometer, as not all of our test devices had a gyroscope included.

3.1 iOS WebGLViewer

As mentioned in section 2.1.3 there is no official WebGL support in a browser on iOS available. Therefore a simple iOS application, called WebGLViewer, was implemented based on the method and instruction published by Nathan de Vries [19]. WebGLViewer consists of a UIWebView, a reload button and an address bar. The UIWebView was modified to show WebGL content (compare section 2.1.3 and [19]).

If you shake the device while running WebGLViewer the app shows information about the battery consumption. The current battery level, the battery level when the loading of the current page finished as well as the delta of these two values is shown as percentage. In addition the time the website is shown as well as the battery consumption per minute is shown. Unfortunately the battery level is only updated in 5 % steps. To get a more accurate result the battery information pop-up will automatically be shown if the battery level changes.

The app WebGLViewer was used to view and evaluate WebGL content on iOS.

3.2 Room

4 Evaluation

5 Conclusion

The conclusion goes here.

Appendix A

Appendix one text goes here.

Appendix B

Appendix two text goes here.

Listing 1: Hello World Code Snippet

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System.out.println("Hello World!");
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