

Embedding Augmented Reality Experiences in E-books

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Abstract. E-books marketplace is evolving faster than ever. New devices and technologies are coming into scene almost every month. In this paper we are going to review the main devices available for e-book publishing and rendering and their associated formats, with special attention to the EPUB3 format, which is called to be adopted as the standard for the industry. We will explain the new possibilities offered by this specification, with special focus on the scripting capabilities that will allow to implement augmented reality (AR) experiences inside e-books. We demonstrate also how to embed this AR experiences in the e-book thanks to new javascript libraries.

Keywords: Augmented Reality; e-books; EPUB3; Radium

1 Introduction

E-books marketplace is evolving faster than ever. We see new devices and technologies appear into market very quickly, showing new capabilities in order to make e-books more attractive to potential readers.

The first e-readers started to gain attention few years ago. Kindle¹, from Amazon, was the e-reader that revolutionized the market. But these first devices offered almost the same characteristics as a paper book, with few little improvements. Maybe an integrated dictionary and the possibility to search a word through the text. With this short capabilities, the possibility to create new content by users to enrich the e-book was scarce and thus their adoption by educational sector.

Nowadays, e-books technologies have evolved towards a more dynamic and multimedia experience. The new EPUB3 specification[1] offers the possibility to embed audio, video and multimedia animations into the e-book in a standard fashion. This specification offers also the possibility to write scripts using well known technologies (javascript), which opens the door to interactivity and content creation inside the e-book. Another capability specified by EPUB3 is the TTS (Text-to-Speech) feature, which allows e-books to become more accesible for blind people.

¹ <http://www.amazon.com/kindle>

In this paper we are going to review the main e-reader devices and technologies, showing their main features and weaknesses to be adopted by educational sector as a key tool for the learning process. We will show also how the new specifications (mainly EPUB3) can serve to create immersive e-books thanks to scripting, which allow the inclusion of augmented reality[2] experiences. The inclusion of this technology in e-books can have a direct impact on students behavior, making the learning process more engaging and motivating, as stated in[3].

Our intention is to include the AR experiences inside an e-book that could be used by students to learn not only the theoretical aspects of a subject, but also do practice thanks to AR exercises. We aim to create a new way for learners to face the learning process, doing it more attractive and complete thanks to these developments. This conception of the e-book as a whole, which includes both theory and engaging exercises with AR, fits well with the concept of Situated Learning[4], designed to bridge the gap between the theoretical learning in the formal instruction of the classroom and the real-life application of the knowledge in the work environment.

The paper is organized as follows: In section 2 we present the main e-reader devices and their associated characteristics. Section 3 will show the potential of EPUB3 specification to create AR experiences inside e-books. Conclusions and future work will be depicted in section 4.

2 E-reader devices and formats

From the beginning of e-books, many technologies and devices have appeared. Some of them have never gained users attention, while others have become top-seller worldwide. Nowadays we are seeing that multimedia tablets (e.g. iPad, Kindle Fire, etc.) are winning the match against dedicated e-readers, maybe due to their capacity not only to render e-books but also to run other 3rd-party apps.

In education, and for the purpose of this study where we want to introduce AR in e-books, we are going to center our attention only in multimedia tablets due to the possibilities that these kind of devices offer to present richer content to users. In order to be able to deploy AR experiences in e-books, we need that the devices meet some characteristics, including the ability to play multimedia content, support for open source specifications for e-book publishing like EPUB3, and of course the presence of a camera to capture the real world image.

Among the most remarkable devices we can mention the following:

- **iPad**. The iPad is a multimedia tablet launched by Apple first time in January 2010. Since then, two new versions of the device have appeared in a yearly basis. Among its main features, we can mention the ability to render multimedia e-books thanks to iBooks² app. This app allows to read digital books enhanced with audio, video and animations. The supported e-book formats by iBooks are ePub and PDF. As of version 2.0, iBooks also supports

² <http://itunes.apple.com/en/app/ibooks/id364709193?mt=8>

a proprietary iBook format (IBA), which is based in ePub but with some proprietary modifications which make it not fully compatible with EPUB3 specification.

- **Kindle Fire.** Kindle Fire is a multimedia tablet which runs Android as operating system. This tablet allows not only to read e-books but also to run thousands of apps developed for Android platform. Regarding e-books, the Kindle Fire doesn't support EPUB3 spec. Content formats supported are Kindle Format 8 (KF8) and Kindle Mobi (.azw).
- **NOOK Tablet.** The Nook Tablet is a tablet computer sold by Barnes & Noble, and is intended to compete with both e-book readers and tablets. It supports multiple file formats, including ePub, but not the new specification EPUB3.
- **Nexus 7.** The Nexus 7 is a 7-inch tablet, primarily competing with similar devices such as the Kindle Fire. The Nexus 7 shipped with the latest version of Android, 4.1, and with Chrome as its web browser. For the purpose of reading e-books, you can choose any app available in the Google Play Store for that purpose, which means that file formats supported are app dependant.
- **Samsung Galaxy Tab.** The Samsung Galaxy Tab is an Android-based tablet computer produced by Samsung. Regarding e-books, the behaviour is the same as for Nexus 7: you can install any app available for that purpose.

One critical aspect that is absolutely necessary when trying to develop e-books with AR is the presence of a camera to capture the image of the real world. From the devices listed above, only iPad and Samsung Galaxy Tab come with rear-facing camera. Nexus 7 has only a front-facing camera, which is not suitable for AR applications. None of NOOK or Kindle Fire come with camera integrated.

For our purpose, apart from the rear-facing camera, we need devices that can render e-books defined following the EPUB3 specification. EPUB3 is the only file format specification for e-books that allows the use of sophisticated scripts and is not proprietary. The use of some kind of code inside the e-book (in our case, the use of scripts) is completely necessary to develop AR applications with some kind of interaction between the user and the e-book.

Taking these considerations into account, the only available device to accomplish the objective of integrating AR functionality into e-books would be the Samsung Galaxy Tab.

3 Augmented Reality in e-books with EPUB3

EPUB3 specification was approved by the International Digital Publishing Forum (IDPF)[5] membership as a final Recommended Specification effective October 11, 2011. Due to the fact that it is a very new specification, there are hardly any implementations out there.

3.1 Radium Project and EPUB3

None of the devices analyzed above has native support for EPUB3 e-books, although an app providing that support could be installed in some of them. Among the few implementations of EPUB3 that we have found, one of them has caught our attention above all others. That implementation is called Radium[6].

Radium, a project of the IDPF and supporters, is an open source reference system and rendering engine for ePub publications. The latest version, EPUB3, is based on Web Standard technologies such as HTML5, CSS, JavaScript, SVG, and the DOM. The overall aim of the Radium project, as stated by themselves, is “to ensure that open source software for handling EPUB3 publications is readily available, to accelerate adoption of EPUB3 as the universal, accessible, global digital publishing format”.

Radium project is still in a very early stage. The first outcome from the project developments is an initial beta release of an extension that adds EPUB3 support to Google Chrome browser. This extension is far from providing full support for all the EPUB3 specifications, but serves as a proof-of-concept prototype.

Recently Google has released their Chrome browser, currently in beta, on Android[7]. These are good news for the purpose of having AR enhanced e-books in e-reader like devices. This way, installing the extension provided by Radium project in the Chrome browser of a tablet running Android (in our case the Samsung Galaxy Tab), we are able to render EPUB3 e-books in an e-reader like device.

3.2 How to embed AR experiences in e-books with EPUB3

As we have mention before, EPUB3 specification allows to include javascript code in the e-books definition. This fact opens the door to a new world of possibilities for interaction with e-books. With javascript we can create complex animations and sophisticated interactions, making the e-book more attractive for students and readers in general.

To create AR experiences, the first thing we need is to gain access to the device’s camera. Once we have the real world image in a frame of our e-book, we can superimpose 3D models and animations to create the AR experience.

In order to gain access to the device’s camera, javascript provides a new experimental API[8]:

```
navigator.getUserMedia()
```

which allows web apps to access a user’s camera and microphone.

With *navigator.getUserMedia()*, we can finally tap into webcam and microphone input without a plugin. But this is still a very new API and in some browsers may not be yet implemented. We have found that in Chrome < 21, you need to enable the feature by visiting *about:flags*. Chrome 21+, Opera and Firefox do not need a flag.

So, the first thing we need to assure is the existence of *navigator.getUserMedia* in the browser:

```
function hasGetUserMedia() {
  return !(navigator.getUserMedia || navigator.webkitGetUserMedia ||
    navigator.mozGetUserMedia || navigator.msGetUserMedia);
}

if (hasGetUserMedia()) {
  // Good to go!
} else {
  alert('getUserMedia() is not supported in your browser');
}
```

An example of how to include a functional code in our e-book to gain access to a stream containing the real world image could be the following:

```
<video autoplay></video>

<script>
var onFailSoHard = function(e) {
  console.log('Access to media stream rejected!', e);
};

window.URL = window.URL || window.webkitURL;
navigator.getUserMedia = navigator.getUserMedia || navigator.webkitGetUserMedia ||
  navigator.mozGetUserMedia || navigator.msGetUserMedia;

var video = document.querySelector('video');

if (navigator.getUserMedia) {
  navigator.getUserMedia({audio: true, video: true}, function(stream) {
    video.src = window.URL.createObjectURL(stream);
  }, onFailSoHard);
} else {
  video.src = 'somevideo.webm'; // fallback.
}
</script>
```

At this point, we have a stream contained in *video.src*, which can be analyzed to find patterns and markers that indicate where to superimpose the 3D objects and animations that will conform the AR scene. We are using JSARToolKit[9] in order to find and trace these markers.

4 Conclusions and Future Work

In this paper we have shown how to embed AR experiences in e-books using open source technologies and standards, so anyone can benefit from it. We have demonstrated how combining new javascript APIs with EPUB3 specification and e-reader devices can bring all together a new and exciting way to attract and motivate students when using e-books for educational purposes.

Technologies presented here are still in a very immature stage. For example, Radium does not implement all the features defined by EPUB3, but is expected to do it in the following months. Another drawback that needs to be solved in the near future is the use of Google Chrome browser for Android, which is also very unstable. We hope that these technologies evolve fast enough to be able to have real AR experiences embedded in e-books soon.

By the moment, we have implemented a proof-of-concept to demonstrate that AR experiences are possible inside a web browser. We have developed an e-book for Radium that contains a script to access the webcam. We have used

Chrome browser for Windows in a desktop PC. The next step is trying to develop the same prototype in a Samsung Galaxy Tab tablet with Chrome for Android, modifying the Radium extension if necessary to make it runnable in this browser.

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