Augmented Reality Applications in the Engineering Environment

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Abstract. In the area of engineering, we can move much in the way clients generally can interact with models or designs for new products, so we are developing various alternatives for visualization, such as Virtual and Augmented realities based on accurate models with no need of using specific software. In order to have a better and global knowledge of the possibilities we show in this paper the situation and capabilities of these technologies. From models developed with commercial programs and tools for industrial design, we propose a workflow to give everybody a chance to interact with these models. The sectors where these technologies are applied and the services offered are grouped in Industrial production systems and Learning of related disciplines. At the end conclusions will be given with every reference used. With everything, ideas for improving these technologies and the correspondent applications could be suggested to the reader.

Keywords: Collaboration technology and informal learning, Augmented and virtual Reality, engineering, models.

1 Introduction

In this paper we try to analyze the different options we have to represent an object in augmented reality, from 3D design programs and engineering, such as Catia, Solid Edge, Solid Works, Autocad, etc., with the objective of product design or do it more accessible to all potential customers.

Augmented Reality (AR) [1, 2] is a technology in which the vision for the user in the real world is enhanced or augmented with additional information generated from a computer model. The improvement may consist of virtual devices placed in a real environment, or the display of "non-geometric" information about real objects.

The AR allows the user to work with and examine real 3D objects, while receiving additional information about these objects. The AR adds information to the real world of the user. Allows the user to stay in touch with the real environment. This is a clear difference from the Virtual Reality (VR), in which the user is completely immersed in an artificial world, completely separated from the real world. In VR [3, 4] systems there is no possibility for the user to interact with objects in the real world, the AR,

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however, does allow users to interact naturally with a world that is a mixture of virtual and real. The AR systems carry the computer to the real world of the user, while the VR systems have the real to the computer world.

However, such applications impose demanding requirements. To combine models actually states that these models are very accurate. This realistic mix requires objects that are introduced in the real scene behave in a very realistic way. To achieve this reality the AR requires a very detailed description of the physical setting.

2 Software CAD

The Computer Aided Design (CAD) software, which we will discuss in this article, refers to the most widely used in the field of both mechanical as aerospace, automotive engineering and many other fields of engineering mainly manufacturing.

What we intend to show in this article, first, is the use which has been given so far to the designs in CAD [5], and different outlets that we provide such software to work at a later stage display through AR.

This kind of software is always expensive and there are students, customers and partners that can't afford to buy licenses. Sharing 3D contents using websites and AR/VR apps based on open standards offers a great chance to make public know our products with no specific investment. There are open technologies to diffuse 3D contents but there are not widely used nowadays because producers of plugins to visualize 3D contents on the web are in advanced. But most used web browsers include native possibilities to visualize 3D contents, it is only a question of developing special websites or adding the needed modifications to the actual websites. There is where the aim of our project lies in.

Basically we will focus on CAD programs [6], we have at our disposal and that has allowed us to see all the possibilities for the AR environment.

In **Table 1** shown below can be seen, the software used and the different extensions that we provide for further treatment in AR.

Table 1. Software CAD and extensions

Software CAD	Main extension	Other extensions
CATIA v5	*.part; *.product	*.stp;*.vrml;*.3dmap;*.3dxml;*.cgr;*.iges;*.model;*.Navrep;*.stl;*.x3d;*.wrl;*.hcg;*.icem
NX 9	*.prt	*.iges:*.stp:*step:*dxf:*dwg:*.model(catia):*.catpart(catia)
Autocad 2014	*.dwg;	*.dgn;*.dxf;*.dws;*.dxx;*.bmp;*iges:*.igs;*.dwf;*.3ddwf;*.pdf ;*.fbx;*.wmf;*.sat;*.stl;*eps
Solid Edge ST5	*.par;*.asm	*.model;*.plmxml;*.prt:*.dwg:*.dxf; *.x_t;*.xgl;*.sat;*.jt:*.part;*.igs;*.step;*.stl;*.3dpdf;*.u3d
Solid Works	*.sldprt;*.sldasm	*.stl;*.iges;*.stp;*.proe;3D XML; *.dxf;*.dwg
Skectup 2013	*.skp	*.mtl;*.obj;*.wrl;*.xsi:*.fbx;*.dwg;*.3ds;*.txt

From the different extensions that provide us with CAD programs, we try to transfer to AR software, making the appropriate changes, and rendered application layers, lighting and even movement, to try to get the effect of visualization features is as real as possible and the user can manipulate as if it were in your hand. Such supplements are obtained from other specific porgrams [7] for it such as the Autodesk 3DStudio, Maya or Blender, the latter of Open Source, and they are specialized in toods rendering, animation or ilumninacion scenes.

3 Web3D

Even more and more websites are tridimensional. This will be generalized when our smart phones and tablets will be able to visualize these characteristics. Having specific hardware to do this is the intention of project AREngine [8]. Several standards like VRML and X3D have been designed by Web3D Consortium [9] but there are also works in progress for AR. For example, ARML [10] is a proposal. Also standardization of a 3D compression format is a must. The big challenge is to compress and stream 3D assets using an effective and widely adopted coder – decoder (codec), in the same way as MP3 is the standard for audio, H.264 for video and PNG/JPEG for images. Then we will see a popular application for 3D transmission on the way as there are popular applications for audio, video and images (see Table 2).

Table 2. A Standard 3D Compression Format?

Audio	Video	Images	3D
MP3	H.264	PNG/JPEG	X3D, MPEG4, COLLADA
Napster	YouTube	Facebook	?

Uses of Web3D could be those proposed by John Vince in Table 3 but related to engineering environment we can consider:

(1) Visualization of product and data, reducing cost of sending samples to the customers, etc.

(2) E-commerce and B2B applications, improving detailed information about products offered.

(3) Learning and training, giving a better approach to the tridimensional appearance to the learners without using authoring tools.

(4) Web improvement, giving 3D to the web.

(5) News and Ad improvement, giving 3D to advertising and commercial web-based reports.

Table 3. AR/MR/VR applications (Vince, 2004)

GROUPS	AR/MR/VR applications
Industrial	Visualizing engineering concepts, Training personnel, Evaluating ergonomic issues, Visualizing virtual prototypes, Visualizing virtual weapons, Exploring servicing strategies, Simulating the interaction of assemblies, Simulating the dynamics of articulated structures, Stress analysis, Distributed product development management, Simulating manufacturing processes, Collaborative engineering on large AEC projects, Machining and pressing simulation, Concurrent engineering, Ergonomics, Virtual prototypes, Visual engineering, Spatial visualization.
Training Simulators	Medicine (Soft body modeling, Minimally invasive surgery, Virtual therapy), Civilian flight simulators, Teaching, Learning, Military simulators (Flight, etc.), Strategic simulators, Train driving simulators, Vehicle simulators, Emergency services
Entertainment and Cultural Heritage	Computer and Video Games, Recreational games, Experiences at Thematic parks and Museums, Tourism and Advertisement
VR Centres	Architecture, Indoor Design, Urban Development, Airport Design, Bridge Design, Human Movement Analysis

Several options have been used to develop Web3D, the most popular are:

(1) Commercial Plugins: Adobe Director [11], Adobe Flash [12], Microsoft Silverlight [13], Cortona [14] and others.

(2) Java Plugins, applet based solutions developed with Java or Java based APIs like Java3D [15].

(3) Ajax3D [16]: X3D based and plugin needed with JavaScript.

(4) WebGL [17]: several JavaScript libraries for HTML5,

(5) X3DOM [18]: that is our choice because of the great community supporting this JavaScript and CSS library with no need of plugin and widely implemented natively on most popular web browsers.

4 X3DOM

While X3DOM community is still working hard to make it a reference for Web3D [19], we have tested several desktop and mobile devices to know the possibilities to access 3D contents using desktop/laptop based systems and mobile based systems.

4.1 Desktop / Laptop Support

The current implementation of the X3DOM fallback model needs an InstantReality plugin, a Flash11 plugin or a WebGL-enabled browser. WebGL-enabled web browsers are available for most platforms. We tested the most usual web browsers on a Microsoft Windows 8.1 Enterprise 64 bits machine and an Apple Mac OS X 10.9.1 (Table 4).

- Internet Explorer: Latest version needed and installing of the Instant Reality plugin, Flash 11, or Chrome Frame.
- Google Chrome [20]: Starting with version 9.x of Google Chrome, WebGL is natively supported.
- Mozilla Firefox [21]: Supports WebGL natively, latest version recommended.
- Safari [22]: Mac only, version 5.1 and newer on OS X (10.6 and above) include support for WebGL but manual enabling is needed.
- Opera [23]: Despite of having no information about support for X3DOM, we tested that it works on Mac OS but it doesn't work on Windows.

Table 4. Desktop/laptop browser support for X3DOM

Web browser	Windows	Mac OS	Linux
Internet Explorer	NO	N/A	N/A
Google Chrome	OK	OK	N/A
Mozilla Firefox	OK	OK	N/A
Safari	NO	NO	N/A
Opera	NO	OK	N/A

4.2 Mobile support

We tested the most usual web browsers on an iOS based device and an Android based device (Table 5):

- iOS: The standard Safari browser does not yet support WebGL. However, there are various ways to enable WebGL via 3rd party solutions, there is no way to visualize 3D content on any web browser without special configuration.
- Android: Sony Ericsson delivered there 2011 Xperia Phones with WebGL support. By doing so, Sony Ericsson is the second mobile phone manufacturer to support WebGL for the default (Android) web browser and standard HTML content. Firefox mobile for Android supports WebGL natively. We improved it works on our Android device and also Google Chrome does.
- Windows Phone: No tests done yet.

Table 5. Mobile browser support for X3DOM

Web browser	iOS	Android	Windows Phone
Internet Explorer	N/A	N/A	N/A
Google Chrome	NO	OK	N/A
Mozilla Firefox	N/A	OK	N/A
Safari	NO	N/A	N/A
Opera	NO	NO	N/A

5 From CAD to AR

As mentioned above, the information transfer from CAD [24, 25] models to the AR is done sometimes in a direct way, through specific software of AR or through intermediaries such as could see Sketchup, Maya or 3DS that allow models to be interpreted by the AR software.

Our proposal allows 3D designers to export their contents developed with usual author tools like Catia, Autocad, etc. to be shown on the Internet inside websites with no need of downloading plugins or any special configuration for the users. On Figure 1 where this process is shown.

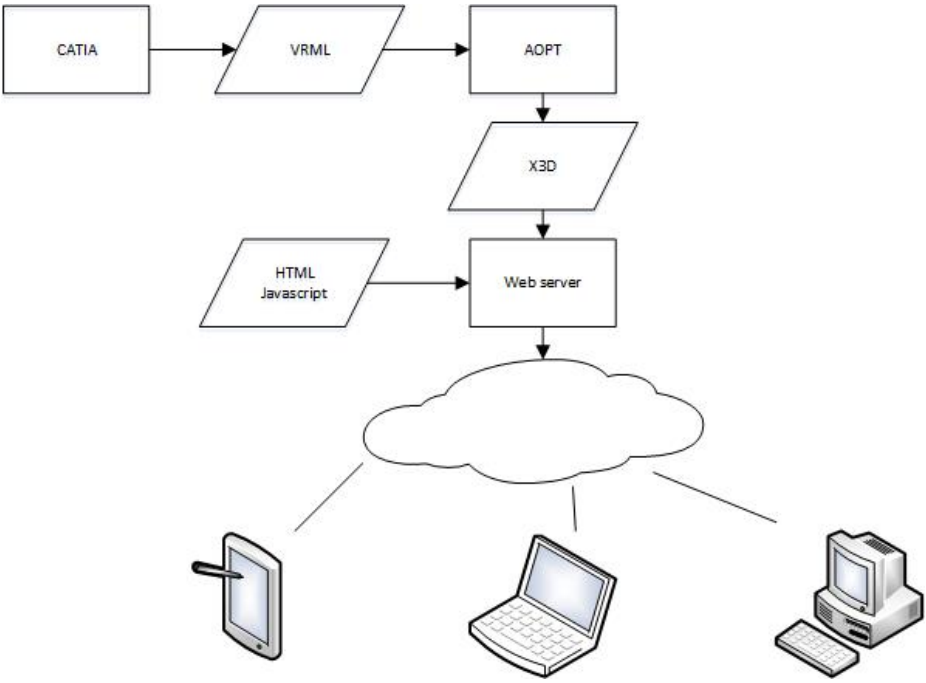

Fig. 1. CATIA to X3DOM

Once the 3D content is exported to standard Web3D format (VRML, X3D, etc.) a customized HTML and JavaScript code is created to display the 3D content in usual Web browsers on PCs, laptops, tablets or mobile phones where users can interact with this 3D content resizing it, changing perspectives, etc. 3D content can be shown as VR or AR. For visualizing as AR more development is needed depending on being location based, marker based or even Oculus Rift [26] based but always using JavaScript and HTML with no commercial plugins.

Once we are able to show our 3D models through the Web3D, 3D printing could be the next step and this could be done with a similar process where instead of producing web pages file formatted for 3D printing are put to be downloaded (STL, stereotype layered, etc.)

6 Conclusions

With the above, we show that the world of AR is very powerful and can have many applications [27] in engineering and that this junction can be very beneficial for all parties involved, both the designer and the potential customer, which the information will reach a more realistic and intuitive way, as it can interact with the model in some cases. At other times we may be of assistance to the formation or maintenance [28] of equipment, both aeronautical and automobile field.

In the area of education, we can see that the interactive with the design can be more realistic, although still alignment errors or loss of information are in place, the AR [29, 30] can provide us a breakthrough in spatial ability student, unimaginable recently time.

In the field of aeronautics and automobile production, major companies like Boeing and Airbus are already making significant evidence for the use of AR in the training of their workers, as well as field maintenance.

There is a promising future for Web3D technologies. Despite of the investment on training for developing this kind of applications, the solutions that can be reached are less expensive than others, not only relating to money, also talking about sustainability. As an illustrative example, augmented books are cheaper to develop than paper books and there is no need of deforestation, virtual furniture for TV programs is cheaper and more sustainable and including 3D objects in a website could be a perfect way to let our customers interact with our products with no need of sending samples.

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