

# USING BLENDER TO DESIGN AND IMPLEMENT DATA VISUALIZATION COMPONENTS FOR X3D AND X3DOM

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Abstract: We discuss how to use Blender to design and implement data-bound components for Web-based data visualization. The goal is twofold: to use Blender, with its declarative approach based on the *logic brick programming model*, for prototyping data visualization components of Web3D applications, and to test the advanced visualization capabilities of the new X3DOM framework based on HTML5 and WebGL. In order to validate the approach we have extended Blender with a software module able to map both Blender geometries and behaviours (logic bricks) code into X3D and X3DOM code.

## 1 INTRODUCTION AND BACKGROUND

X3D has already been proposed for the design of Web-based Data Visualization with positive feedbacks (Sopin & Hamza-lup 2010), (Anslow 2008). The recent introduction of WebGL and X3DOM (Drevensek et al. 2010) has increased the potential integration between X3D applications and the other Web technologies and it paves the way for a new generation of Web3D applications. X3DOM framework, in fact, aims at extending existing Web applications adding 3D objects in the Document Object Model (DOM) of Web pages without the need of any plugin. Web programmers, in fact, are attracted by 3D but they are often reluctant about changing their production environments or their programming tools. Moreover, Web application designers don't have extensive knowledge about how to design 3D-enhanced applications and how to describe them in terms of low-level geometric primitives, spatial transformations, lighting models, shaders etc. (Sopin & Hamza-lup 2010).

In this context, the specific issue faced in the paper is about the tools to design and implement X3D objects for the Web. It is not straightforward to select the proper tool for this task, since it must include advanced 3D modelling, animations, programming and debugging capabilities. Blender ([www.blender.org](http://www.blender.org)) owns several features of these and it is one of the most rapidly-growing open

environments, with a large supporting community, but it is not able to create interactive components for HTML5. In order to cope with this lack, we extended Blender with GBX, which is a custom exporter tool, also discussed in the paper.

In the next section we begin with an overview of the literature, then we discuss some preliminary aspects about X3DOM and JavaScript performance limitation. In section 4 we present the internal structure of GBX, the main considerations about its effectiveness and limitations and we draw conclusions.

## 2 RELATED WORKS

The most straightforward method to create X3D applications is to write geometric primitives and scripting logic by means of a text editor. This method, however, is time-consuming because of the many low-level aspects required for 3D programming (Sopin, 2010). For this reason, a number of authors have proposed different approaches to support the creation of X3D-based GUIs. In 2004 D. Arendash proposed to adopt a successful videogame editor to export X3D applications (Arendash 2004). The approach is effective for 3D scenes with animated objects and is well-supported with new editor releases, but it's not general purpose. For example, it is not suitable for the creation of data-bound 3D components like the *Cone Tree* (CT), as proposed in this paper. From a

theoretical point of view the adoption of visual techniques for defining both the geometries and the behaviors of a 3D world in a declarative way is explored by (Arjomandy & Smedley 2004), but the same authors state that to be productive the environment used to specify the behaviors must be strictly integrated with the environment used for 3D modeling. For this reason we have decided to adopt Blender, that shows an excellent integration between 3D modeling and ‘logic bricks’ programming approach. In (Pellens et al. 2009) the authors try to facilitate the design of virtual environments and to make it more accessible to novice users by means of behavior patterns and tools for the visual specification of behavior rules. The approach is very interesting for high level behaviors (e.g. strategies in videogames) but, in our opinion, it is less effective for the simple behaviors (e.g. expand, collapse, ...) needed to create the 3D data-bound components, discussed in this paper. The bibliography related to data visualization and database visualization is very rich, starting from (Shneiderman 1996), that defined the cone tree concept, used in this paper, and from (Robertson 1991), that identified important principles and guidelines for advanced visualization applications. Two extensive and useful reviews of techniques for software and data visualization, based on X3D, are given by (Anslow 2008) and by (Sopin & Hamza-lup 2010), that also define the reuse concept. Another relevant step towards Web technologies is about the integration between the AJAX technology, WebGIS and X3D, which is detailed in (Huang & Cheng 2009).

### 3 X3DOM AND JAVASCRIPT FOR DATA VISUALIZATION

A lot of authors have proposed the adoption of X3D for advanced visualization tasks with interesting results, but the popularity of X3D and related plugins is low if compared with other multimedia plugins (e.g. Adobe Flash).

A reason is that the learning curve associated to 3D technologies in general (shaders, physics, 3D-modeling, animations, rendering, ...), and to X3D in particular, is steep, also due to the lack of open source, good quality, well documented examples. We feel that the tight integration between Web3D and the other Web technologies, led by WebGL, and similar initiatives, is central to overcome these problems.

In this strategy, X3DOM plays a central role because of its ability to include xml-described 3D

components within the DOM of Web pages, while interactivity, distribution, security, and scripting are managed through standard web technologies. Moreover, Web programmers can interact with the 3D objects via DOM events and JavaScript and not only via the “sensor nodes” and the “routes” of X3D (Anslow, 2008), or the “shaders” of WebGL. The advantage is twofold:

- Web programmers can read, modify and adapt live pages coming from the Web to their own needs;
- the new 3D extensions are xml-based and, therefore, they can be easily manipulated with popular Web environments and technologies (ASPX, PHP, JSP, ...).

In this scenario, the efficiency drawback of interpreted languages, like ECMAScript (also known as JavaScript or JS, i.e. the interpreted client-side language used to manipulate the DOM) can be critical when large datasets are manipulated. So even if ECMAScript is easy to use for processing HTML events, it is not always suitable for 3D graphic effects, interactions and animations.

In order to estimate this breaking point (i.e. when JS become insufficient for smooth animations or responsive pages), we measure the speed degradation of a JS animated cone trees as a function of the increasing number of nodes. More specifically, we ran a set of randomly generated cone trees with an increasing number of nodes on different personal computers (we used X3DOM v1.0, Firefox v4.0 Beta 6, ten different computers with graphic cards ranging from GeForce Go 6200 to GeForce 9200M GS with OpenGL v7.15 driver and DirectX 9.0c or 10).

In table 1, and in fig. 1, frame per second (fps) and latency trends are shown as a function of the increasing number of vertexes (#Pnts) and triangles (#Tris) in the cone trees. All results are based on the X3DOM built-in performance indicators. The same test, performed with X3D and Octaga Player on the same machines, gives no noticeable latency and no reduction in fps.

This measure doesn’t take into account complex factors like the adoption of shaders, animated textures and other complex aspects, but we feel that it can be useful as rule of thumb for Web programmers.

The test shows that JavaScript can be currently exploited to effectively manage thousands of triangles, already sufficient to manage small to medium data sets. We feel that, since X3DOM is still in its infancy and ECMAScript interpreters are under active improvements, better performances can be expected.

Table 1: Cone tree performance.

Tree size	fps	Latency [s]	#Pnts	#Tris
75	14	0	1800	900
150	10	0,1	3600	1800
300	9	0,1	5400	2700
600	7	0,2	10800	5400
1200	4	0,25	21600	10800
2400	2	0,4	43200	21600

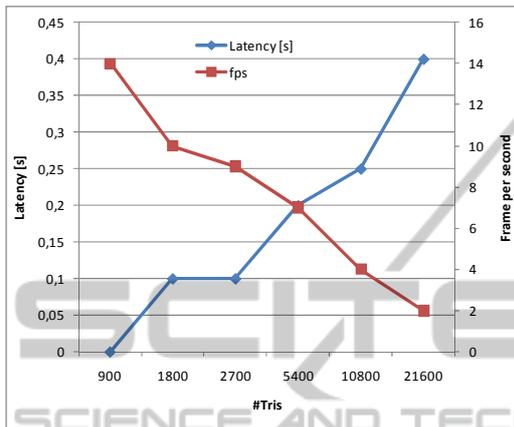


Figure 1: Cone tree performance diagram.

#### 4 IMPLEMENTATION ASPECTS: THE CONE TREE EXAMPLE

Three phases are needed to design and implement data visualization components in Blender. We start to model the root node of the Cone Tree (CT) as a sphere, the other nodes as prisms, and the tree branches as wires. Parent nodes differ from leaves because of the color, whose intensity is proportional to the number of children nodes. This modelling phase is rapid and effective and it's easy to evaluate different geometries for different presentation solutions. The geometric primitives are completed with the desired behaviours, described as networks of logic bricks. In fig. 2, for example, the logic brick network used for *expand* and *collapse* methods of the node class is arranged in three columns: the first column shows mouse events; the central column is for “controllers” which compose the detected events by means of Boolean operators (and, or, ...) and Python scripts; the third column is for “actuators”, in charge to change the visual aspects (and other properties) of the tree components, to respond to the user requests (expand-collapse). Geometric primitives and behaviours are then “packed” as a library of python classes (cone\_tree, root\_node, level, leaf\_node, parent\_node) to enforce the object orientation paradigm and to facilitate the code

maintainability and reuse. The constructor of the cone\_tree class, implemented as a Python script, is in charge to dynamically load the tree nodes from a relational table. For simplicity and portability, the table is created by means of the SQLite DBMS that is part of the standard Blender installation. An instance of the CT is represented in fig. 3.

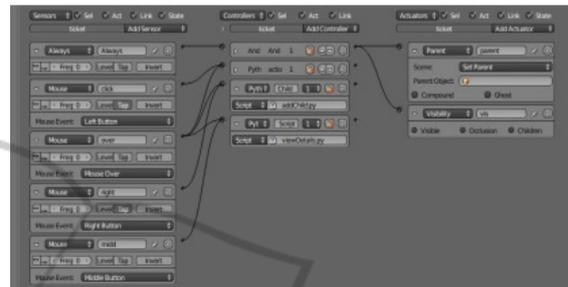


Figure 2: ConeTree: logic bricks network defining the expand and collapse methods of the node class.

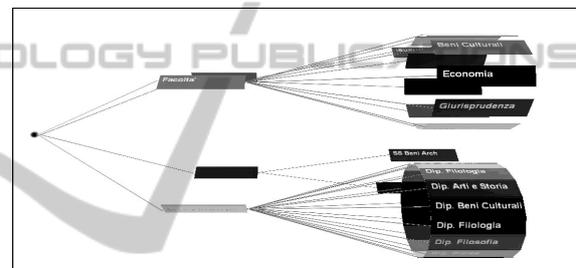


Figure 3: An instance of the ConeTree implemented in 3DBlender.

#### 4.1 System Architecture

Each data visualization component (like the CT), coming from the previously described approach, is saved as a .blend file and can be trans-coded to X3D or XHTML by means of our GBX (Graphics and Behavior Exporter) tool, which consists of a set of software modules developed with different technologies.

GBX parses the geometric primitives and the related logic brick networks and send them to the Mapper module, in charge to generate the X3D primitives corresponding to each blender construct, while preserving the grouping and hierarchy relationships coming from Blender. The generated X3D primitives are therefore transformed in a .xml stream by means of a stored procedure implementing the *LR topological numbering* algorithm (Appelquist 2001).

The output of GBX can be included in any .xhtml file, published by means of any web server and can be directly rendered in 3D by any suitable

web browser. Thanks to the X3DOM integration framework, each geometric primitive and each method of the CT are fully integrated within DOM of the web page, so that it's very easy to use for web applications. As discussed in the previous section, the performance of these kind of Web3D applications is low to medium (thousands of triangles), but yet sufficient for embedding 3D data visualization components in standard web pages.

In conclusion, the current implementation of the GBX tool, which we created to validate the proposed approach, is able to automatically export simple Blender applications, like the CT, in X3D and XHTML. This is useful for prototyping purposes, to test the visualization capabilities of the new X3DOM framework and to embed interactive 3D components in HTML5-compliant web pages.

In the future we will investigate about the implementation of more realistic data visualization components and about its integration with the current technologies for dynamic Web pages (AJAX3D, ASPX, PHP, JSP, ...) and with the main open source frameworks and applications (Joomla, Moodle,...). For the reason that currently the Web largely relies on relational DMBS and dynamic pages, we feel that data visualization could play a central role in the future Web and the proposed components are suitable for creating dynamic and interactive visualization.

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