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Transdisciplinary Multispectral Modeling and Cooperation for the Preservation of Cultural Heritage

First International Conference, TMM_CH 2018
Athens, Greece, October 10–13, 2018
Revised Selected Papers, Part II

Part 2

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Contents – Part II

Inception – Inclusive Cultural Heritage in Europe through 3D Semantic Modeling

Heritage at Risk

INCEPTION: Web Cutting-Edge Technologies Meet Cultural Heritage

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Abstract. INCEPTION project is a research and innovation project funded by the European Commission to realize "innovation in 3D modelling of cultural heritage through an inclusive approach for time-dynamic 3D reconstruction of artefacts, built and social environments. It enriches the European identity through understanding of how European cultural heritage continuously evolves over long periods of time".

In this paper are described some state of the art technologies adopted in developing the cloud web platform that is the core of the whole project.

After a detailed comparison of the features of the INCEPTION platform, compared with 27 other existing web sites, some of the most interesting solutions, based on the match between BIM (Building Information Modeling), Cloud and Semantic Web approach, are described.

This EU project is a clear example of cutting-edge technologies applied to the European Cultural Heritage.

Keywords: Heritage documentation · H-BIM · Semantic web · Cloud · BIM

1 Introduction

The main scope of the INCEPTION project, a research and innovation project funded by the European Commission under H2020-EU - Reflective societies - cultural heritage and European identity is, according to the official website, to realize "innovation in 3D modelling of cultural heritage through an inclusive approach for time-dynamic 3D reconstruction of artefacts, built and social environments. It enriches the European

identity through understanding of how European cultural heritage continuously evolves over long periods of time" [1].

The development of a specific cloud based INCEPTION platform is the key-targeted achievement of the overall project, in order to accomplish the main objectives of accessing, understanding and strengthening European Cultural Heritage (CH) by means of enriched 3D models.

The platform meets the main aim of realising innovation in 3D models "forever", "for everybody", "from everywhere", by developing, collecting and sharing inter-operable 3D semantic models.

It is designed to be used both by the CH site managers/owners and by the end users. While the first will feed the platform with 3D models and semantic information about their cultural sites, the end users will access the platform to navigate inside the European CH world. They will experience both on-site and off-site tools for a complete immersion in the site, also through Virtual Reality (VR) and Augmented Reality (AR) tools. The platform provides all the available semantic information linked to the whole 3D model or to the single geometrical elements.

The whole INCEPTION project is based on the bond between state-of-the-art architectural modeling technologies (BIM, Building Information Modeling) and the latest cutting-edge web technologies. The platform is grounded on semantic web technologies and makes extensive use of WebGL and RESTful APIs.

2   State of the Art

The features included in the INCEPTION platform has been compared to 27 of the major web-based platforms that allow downloading and exchanging 3D models.

While INCEPTION is a semantic BIM platform for CH buildings, we have analysed a wide variety of available web platforms to analyse the specific characteristics of each in relation to the many design constraints that we have set for the user-experience and technical requirements of the INCEPTION platform (such as enjoyment, navigation, interaction, etc.).

The innovative features and application potential of the INCEPTION platform are evident in relation to the major platforms seen as the state of the art. A comparative multi-variable analysis of different platforms is shown in Tables 1 and 2 below. A more detailed comparison can be found in the project deliverables, but cannot be fully disclosed here because of confidentiality constraints.

The comparison shows that the platforms related to Cultural Heritage are few and focused on specific project of documentation/enhancement. They are not highly visited and do not have many 3D models available because they are linked to specific artefacts related to a museum or cataloguing items in an archaeological site. The quality, however, is high because almost always there is a curatorship. The problem (regarding accesses) of these platforms is that their main objective is documentation, cataloguing, and sometimes enhancement.

The most active platforms (in terms of population and visits) are those with a generic vocation and strongly linked to the sharing of 3D models.

Table 1. List of platforms that have some points in common with the Inception Platform

| | Application sector | | |
	Application	Genre	Link
Inception Platform	Architecture, Documentation, Animation, Gaming, Visualization	Architecture, Heritage Preservation	
3D Warehouse	Animation, Gaming, 3D Printing	Architecture, Cars, Furniture, Fanart	3dwarehouse. sketchup.com
3dexport	3D Printing, Gaming, Animation and Graphic Design	DIY, Jewelry, Decoration	it.3dexport.com
3DModelFree	Animation and Graphic Design	Interior Design, Architecture	www. 3dmodelfree.com
3DSky	Animation and Graphic Design	Interior Design, Architectural Visualization	3dsky.org
Archive3d	Animation and Graphic Design	Interior Design, Architectural Visualization	archive3d.net
Autodesk Online Gallery	3D Printing, Engineering, Architectural Visualization	All	gallery.autodesk. com
BIM. archiproducts	Architecture, Animation, Graphic Design	Furniture	bim.archiproducts. com
BIMobject	Architecture, Animation, Graphic Design	Furniture, Architecture	bimobject.com
Blend Swap	Animation, Graphic Design, 3D Printing	All	www.blendswap. com
Cgtrader	Gaming, Animation, Graphic Design	All	www.cgtrader.com
Clara.io	Animation, Graphic Design, and 3D Printing	All	clara.io
CYARK	Documentation	Cultural Heritage	www.cyark.org
GB3D Type Fossils	Documentation	Fossils, Cultural Heritage	www.3d-fossils. ac.uk
Grabcad	Engineering and 3D Printing	Tools, Equipment	grabcad.com
Library Smartbim	Architecture, Animation, Graphic Design	Furniture, Architecture	library.smartbim. com
Myminifactory	3D Printing	DIY, Jewellery, Decoration, Heritage Preservation	all3dp.com
National bim library	Architecture, Animation, Graphic Design	Furniture, Architecture	www. nationalbimlibrary. com

(*continued*)

Table 1. (*continued*)

	Application sector		
	Application	Genre	Link
Ornament3d	Documentation	Cultural Heritage	ornament3d.org
Sketchfab	3D Printing, Animation, Gaming	Fanart, Architecture, Education, Heritage Preservation	sketchfab.com
Smithsonian X3D	Animation, Graphic Design, 3D Printing	Heritage Preservation	3d.si.edu
Syncronia	Architecture, Animation, Graphic Design	Furniture	www.syncronia.com
Thingiverse	3D Printing	DIY	www.thingiverse.com
ThreeDScans	3D Printing, Animation, Graphic Design	Heritage Preservation	threedscans.com
Turbosquid	Gaming, Architectural Visualization, Graphic Design	All	www.turbosquid.com
Unity Asset Store	Gaming, Architectural Visualization	Universal	www.assetstore.unity3d.com
Zamaniproject	Documentation	Cultural Heritage	zamaniproject.org

The INCEPTION platform will be placed on a more generalist level in the Cultural Heritage (all CH heritage) with strong skills in technical/managerial/maintenance/conservation and development, as well as enhancement through the new possibilities offered by the Augmented and Virtual reality. The INCEPTION platform will not look like a closed documentation or cataloguing system, but a space for interchange of information for the dialogue between edutainment and the AEC (Architecture Engineering Construction) engineers, between first-class college students, scholars and tour operators.

Furthermore, the Semantic Web structure allows the platform to be interlinked with external CH available linked data and to be gradually enhanced by specific flexible data structures in the form of project specific ontologies.

None of the scanned platforms currently implements semantics about specific content on individual 3D models nor allows (structured or not) access to metadata or paradigms (if any). None of the scanned platforms implements true multi-user access with information, functions, or different data access modes depending on the different typologies of users.

There are projects that are more similar to the model proposed by INCEPTION, but we wanted to analyze platforms that had a market placement in relation to the number of uploaded and accessed models and their relevance to the AEC market: significantly, the great graphics engine of the Sketchfab platform, also used by other platforms. INCEPTION has chosen the Sketchfab platform for dissemination in this first phase of the project before implementing its platform, in relation to 3D models that can be implemented on the platform and/or products in case studies.

Table 2. Comparison of features available in several platforms

	Features of 3D models					Search		Visualization Tool						Accessibility and social		
	3D Model	3D Bim Model	3D cloud of point data	Metadata	Semantic Data	Search	Semantic Search	3D View	Interactive 3D View	V/R for Pc	V/R for mobile	Editing View	Editing Model	Inclusive GUI	User Feedback	Social media interaction
Inception Platform	x	x	x	x	x	x	x	x	x	x			x	x	x	x
3D Warehouse	x	x				x	x	x	x						x	
3dexport	x					x								x	x	x
3DModelFree	x					x										
3DSky	x					x								x	x	x
Archive3d	x					x	x									
Autodesk Online Gallery	x					x	x							x	x	
BIM.archiproducts	x	x				x	x							x	x	x
BIMobject	x	x				x										
Blend Swap	x					x		x	x	x	x	x	x		x	x
Cgtrader	x					x									x	x
Clara.io	x					x		x	x			x	x		x	x
CYARK	x		x					x	x							
GB3D Type Fossils	x			x		x	x									
Grabcad	x					x		x						x	x	x
Library Smartbim	x	x				x	x									
Myminifactory	x					x	x								x	x
National bim library	x	x				x	x									
Ornament3d	x					x		x								
Sketchfab	x		x			x		x	x	x	x	x			x	x
Smithsonian X3D	x					x		x	x	x		x		x		
Syncronia	x	x		x		x								x	x	x
Thingiverse	x					x	x							x	x	x
ThreeDScans	x					x		x						x		
Turbosquid	x					x	x							x		
Unity Asset Store	x					x	x								x	
Zamaniproject	x					x								x		

3 The INCEPTION Platform

In the cloud based INCEPTION Platform architecture (see Fig. 1), the main input is a BIM model of a CH site. The models can refer to several categories, such as museums, archaeological sites, historical sites and heritage buildings.
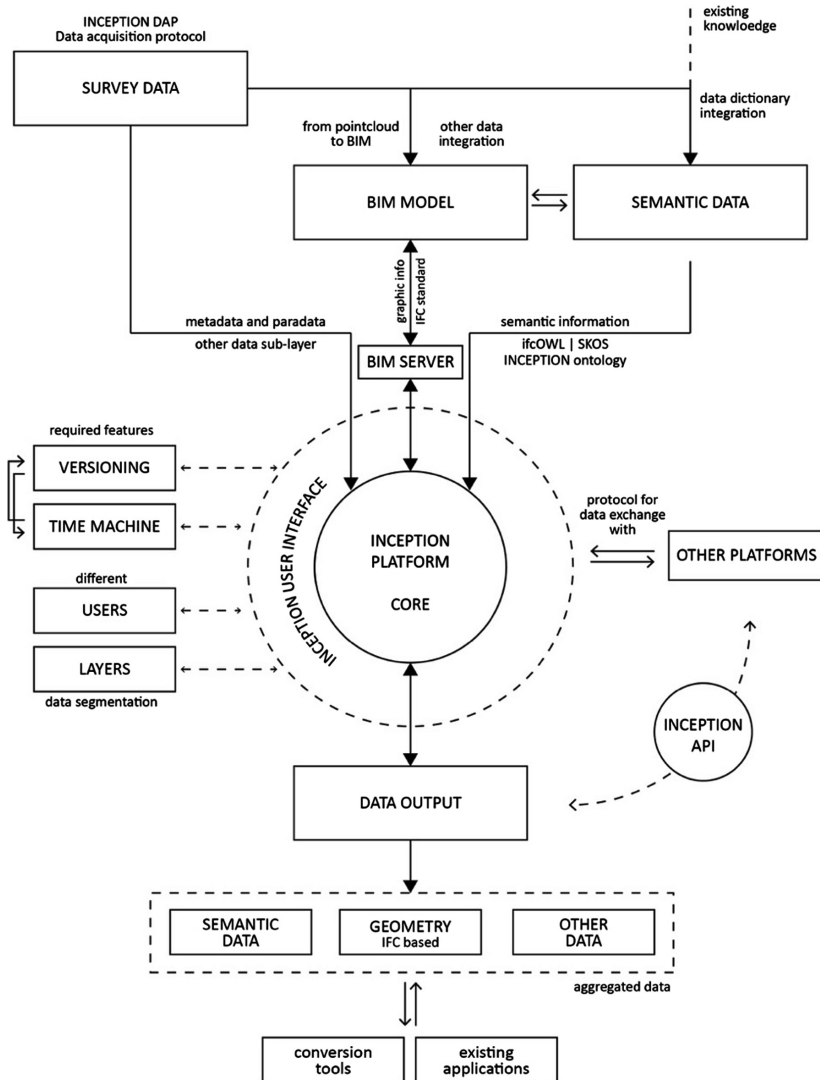

Fig. 1. Links and data flow between the platform's components and between INCEPTION and external tools

These models, that embed geometrical and semantic data, are created following a custom and well codified Data Acquisition Protocol (DAP), designed during the earlier phases of the INCEPTION EU Project. Describing this protocol is out of this paper's scope. All the BIM models are introduced in the platform as IFC (Industry Foundation Class) standard files. The adoption of this standard guarantees that the platform can be accessed regardless of the software used to generate the BIM model (e.g. Revit, ArchiCAD, etc.).

The IFC file is then processed by means of several server-side custom Windows services, that extract all the semantic information (both geometries and metadata) and generate Resource Description Framework (RDF) triples, according to the INCEPTION H-BIM ontology, serialized as Turtle (TTL) files.

All these triples are stored in a semantic triple store, accessed via HTTP through a dedicated Apache Fuseki SPARQL server.

The platform provides the user with the possibility of enriching the models with new semantic metadata. Indeed, the web client allows you to enrich the models with new data (e.g. a date, a value, some textual remarks, see Fig. 2) as well as with some attachments (e.g. pictures, thermographic images, 3D models of specific details, videos, etc.), related to the whole CH site or to a specific geometrical element.
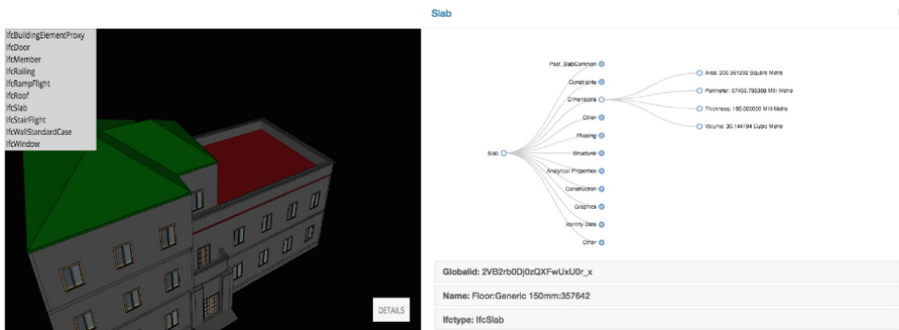
Fig. 2. Every element of the building can be used to perform a live SPARQL query that returns all the details for that element, according to the HBIM ontology. Each value can be updated via web, thanks to the SPARQL 1.1 Update functionalities.

In Fig. 3 it is shown a Collada (.DAE) file uploaded as attachment to a whole BIM model. According to its definition from Wikipedia, "Collada (acronym for COLLAborative Design Activity) is a is an interchange file format for interactive 3D applications. It is managed by the nonprofit technology consortium, the Khronos Group, and has been adopted by ISO as a publicly available specification, ISO/PAS 17506. COLLADA defines an open standard XML schema for exchanging digital assets among various graphics software applications that might otherwise store their assets in incompatible file formats. COLLADA documents that describe digital assets are XML files, usually identified with a .DAE filename extension" [2].

The use of Collada files, together with IFC files can be very useful: although this format lacks in the formal definition of entities, if compared to IFC, it provides an easy

way to incorporate photorealistic textures. Moreover, it is possible to find some libraries, based on WebGL and Three.js, to visualize and manipulate these files through a common HTML5-enabled web browser. Most web browsers, today, support HTML5 both on desktop and on mobile devices. In INCEPTION we made an extensive customization of the above libraries to optimize the visualization of CH sites and exhibits [3].

Fig. 3. An example of Collada (.DAE) file uploaded as attachment to a whole BIM model. Collada files can be useful since they can easily incorporate photorealistic textures.

4 Semantic Web Approach

The INCEPTION Platform interacts with its RESTful APIs by means of the above mentioned SPARQL 1.1 Protocol and RDF Query Language, which provides an SQL-like syntax and can be used to query the RDF triple store. From version 1.1 SPARQL offers full CRUD (Create, Read, Update and Delete) functionalities (e.g. SELECT, UPDATE) as well as a useful FILTER expression. It has been constructed to manipulate semantic web triples and data types and aggregations e.g. numbers, strings and URIs.

Clearly, the end user does not have to know how to perform a SPARQL query, since the platform interface itself converts graphical requests into queries. The following text represents exactly what is embedded in a SPARQL query to get all the WallStandardCase walls from a specific BIM mode, the query returns 121 wall elements:

```
PREFIX HBIM:   <http://www.inception-
project.org/HBIM.ttl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
     SELECT ?subject
     WHERE {
                  ?subject rdf:type HBIM:WallStandardCase
;
     }
     LIMIT 1000
```

The semantic web approach of INCEPTION implies that many of these functions will be accessed by third party developers in back end (through web services) to integrate INCEPTION in their linked data systems.

Nevertheless, the access to UPLOAD and DOWNLOAD to the storage is fully managed by the INCEPTION platform web applications, that integrate functionalities for linking the files to the whole 3D model or to a specific element (e.g. a column or a door), uploading them on the cloud storage, creating the semantic triples to access and link them to the geometries, previewing, downloading, searching etc.

The INCEPTION platform web-applications can also act as a stimulus towards third parties to insert the INCEPTION H-BIM standard in their products, by raising awareness to the INCEPTION Platform capabilities.

One useful approach to start searching for a BIM model is narrowing down the geographic area in which to search. Users are nowadays accustomed to include management of geographic information in their daily activities on the web. The BIM model will be provided with geographic coordinates, thus enabling the use of common open-source GIS standards (such as CityGML and InfraGML) to query the system selecting areas of interest. A nice review on state-of-the-art integration between BIM and GIS is given by Liu et al. [4].

Functions like "search for all the models in Greece" or "select all the models in a 10 km area from this position" as well as mapping models on a GIS map will provide an intuitive and very productive way to start a search. To obtain this functionality, every 3D model uploaded is provided with latitude and longitude (easily obtained directly from the INCEPTION web application, leveraging on a Google Maps API) [5].

The coordinates are then transformed in semantic metadata using the following standard ontology http://www.w3.org/2003/01/geo/wgs84_pos, as shown in the following table:

```
HBIM:/HAMH-Museum/metadata#Building_1

<http://www.w3.org/2003/01/geo/wgs84_pos#lat>

"37.3517659"^^xsd:float


HBIM:/HAMH-Museum/metadata#Building_1

<http://www.w3.org/2003/01/geo/wgs84_pos#long>

"23.46703560000003"^^xsd:float
```

5 Cloud Storage

A cloud storage is dedicated to hosting all the files that complement data for the buildings, such as CAD files, historical documents, images and all the other type of files that could improve the level of information assigned to the object. These files are stored in the INCEPTION cloud storage and managed and organized through dedicated APIs, that also allow users to selectively access this data.

The user will have access to this archive through the INCEPTION platform, by exploiting custom APIs purposely developed for a broad interaction with external components. This open-source object-relational mapping (ORM) system allows thinking to the data model as a set of objects. All the entities created can be exposed as web services, therefore promoting the access to the INCEPTION platform to other solution providers.

6 Conclusion

In this paper we described the INCEPTION platform designed to exploit the concept of the semantic web. We have developed some web APIs to provide the INCEPTION H-BIM Interoperable Platform with a REST interface to access the BIM models allowing users to operate on 3D information as well as its related semantics. This core functionality is dedicated to the end-users as well as to developers and solution providers for interacting with external mobile devices and applications. Mobile phone applications, to be used on site, will access the INCEPTION H-BIM Interoperable Platform through this REST web-service, stimulating a flowering of web based mobile applications from third parties.

The web application, core of the whole platform, allows users to search 3D models using specific keywords contained in the semantic information. It displays a list of results in a textual and graphical form, giving the user the capability of clicking on single BIM objects and get access to specific (semantic) information and to correlate

files and other linked data. This web application also gives third parties a live sample of the INCEPTION Platform capabilities, stimulating the insertion of the INCEPTION H-BIM standard in their products.

A cloud based file storage is dedicated to hosting all the files related to the CH projects, in several formats.

The end-user tools that are under development will strongly interact with the described features (APIs, reference queries and reference apps). These tools (in particular a condition assessment/asset management tool, an on-site AR mobile app and an off-site VR mobile app) will have both general and application-specific implications, as well as implications on the performances of the end-user tools.

References

1. INCEPTION EU Project. www.inception-project.eu
2. COLLADA FORMAT. https://en.wikipedia.org/wiki/COLLADA
3. WebGL Collada Library. https://threejs.org/examples/webgl_loader_collada.html
4. Liu, X., Wang, X., Wright, G., Cheng, J.C.P., Li, X., Liu, R.: A state-of-the-art review on the integration of Building Information Modeling (BIM) and Geographic Information System (GIS). ISPRS Int. J. Geo-Inf. **6**, 53 (2017)
5. Google MAPS Platform Documentation. https://developers.google.com/maps/documentation/