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Aïoli, a Reality-Based 3D Annotation Cloud Platform for the Collaborative Documentation of Cultural Heritage Artefacts

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Résumé

Malgré leurs différentes approches et leurs différents outils d'observation, de description et d'analyse, les acteurs de la documentation du patrimoine culturel partagent tous un même intérêt et une même préoccupation : l'objet patrimonial, celui qui est matériel, qu'il soit un lieu, un bâtiment, une sculpture, un tableau, une œuvre d'art ou un fragment archéologique. Ce dénominateur commun est le point de départ pour le projet « Aïoli », une plateforme d'annotation 3D basée sur la réalité, qui permet à une communauté multidisciplinaire de construire des descriptions 3D enrichies sémantiquement d'objets patrimoniaux à partir de simples images et d'annotations spatialisées couplées à d'autres ressources.

Mots-clés: annotation, documentation, collaboratif, patrimoine culturel

Keywords: annotation, documentation, collaborative, cultural heritage

Moving from a data-driven to a semantic-driven digital documentation approach is an essential challenge today, especially in cultural heritage, where knowledge is always the result of a combination of complementary skills and disciplinary profiles. However, when considering the current state of the art, reality-based 3D reconstruction and 3D information systems are generally considered distinct topics when they each prove to have potential in cultural heritage documentation.

From this context, a question emerges: how to merge geometry, visual appearance, and semantics within an integrated documentation approach? The only stable denominator remains the object itself, which must therefore be at the heart of the structuring, analysis and storage system.

This corresponds to three major gaps:

- The semantic gap underlines an essential need for innovative methods for assisting data processing, sorting and analysis toward effective knowledge-enhancement scenarios;
- The communication gap underlines the need for an effective solution for collecting, storing and sharing data and extracted information, while it is still difficult to bring together (physically or digitally) the multiple actors of this continuous documentation process;
- Lastly, the interoperability gap underlines an essential need for a flexible solution allowing to manage several acquisitions, levels of details, geometry segmentation, annotation layers and data properties according to very heterogeneous observation and analysis scenarios.

Aïoli: An Innovative Approach

That is why our approach puts the heritage object (the physical one) at the heart of the documentation process by considering reality-based 3D and semantic description in a strongly integrated way.

Our solution is to create an informative continuum at all phases of the documentation process, from the acquisition of images and spatial data to semantically enriched 3D representation based on three fundamental features (**Figure 1**):

- The first part is to create a bridge between the real object and its digital representation by introducing a solution for memorising spatialised annotations made by different actors by including photogrammetric 3D reconstruction and a bijective relation between 2D and 3D representations of the object.
- Once this is established, we built a multilayer description model to structure the analysis, the geometry and the correlation of the annotations made on different supports by all the users working on the same object through a flexible data model, allowing us to organise semantic information with a set of freely structured user descriptors and the automatic extraction of geo-visual descriptors.
- To ensure the accessibility to the application, even from *in situ* remote areas, our platform is built on a cloud computing service allowing the gathering, processing and sharing of 3D data.

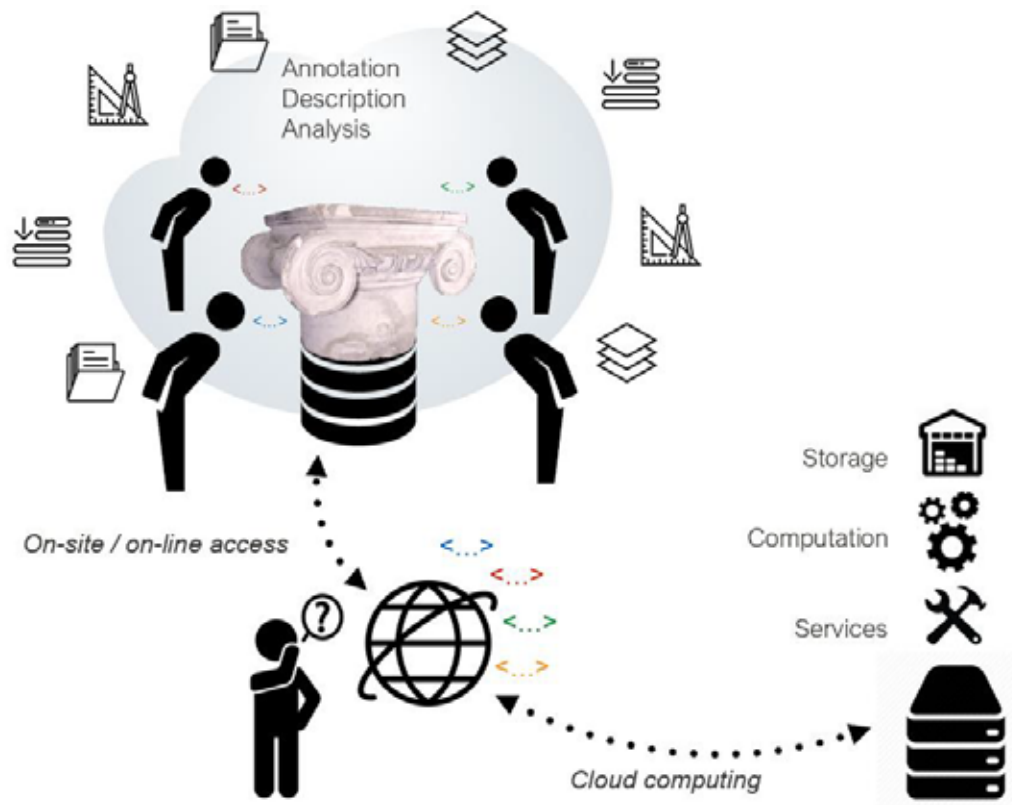


Figure 1. The framework introduced by the Aioli platform

Aioli introduces an original, informative linkage between the physical object space and its digital representation by integrating different features¹ :

- An incremental image-based 3D spatialisation process to manage the geometric merging of several images coming from different actors at different temporal states;
- A 2D/3D annotation framework enabling users to draw, visualise and register relevant surface regions by handling simple 2D images spatially oriented around dynamic 3D representation;
- A multi-layered morphology-based data structuring model to accurately describe real objects in all their geometric complexity and according to multidisciplinary observations.

Users access Aioli through a web interface where they have access to their personal spaces and where their projects as well as collaborators are listed. To create a project,

they load a dataset which is then sent to the server to be processed to reconstruct the 3D model of the object and to create the necessary indexing for propagation. Once the processing is complete, they have access to the project, where they can view both the images used and the generated 3D model. By selecting an image, users can then begin to annotate it by drawing a region. The propagation process starts in the background once the region is validated. Finally, users can describe the region by constructing their own description sheet and by defining fields of various types (free text, number, date, URL, list of values, controlled vocabularies, etc.). Controlled vocabularies are implemented in Aïoli through an already existing web-based multilingual thesaurus management tool dedicated to the management of vocabularies called OpenTheso, which offers interface elements to create, insert and manage lists of concepts. Users can consult and complete annotated projects by viewing the annotations on the images and a point cloud. Each project can be shared with one or more collaborators who can consult and but also annotate the project.

From a technical point of view, Aïoli relies on a thin client, which assures the cross-compatibility of services, on a web server that dispatches requests to the application server and finally, an application server relying on Docker technology which contains all the calculation processes (**Figure 2**).

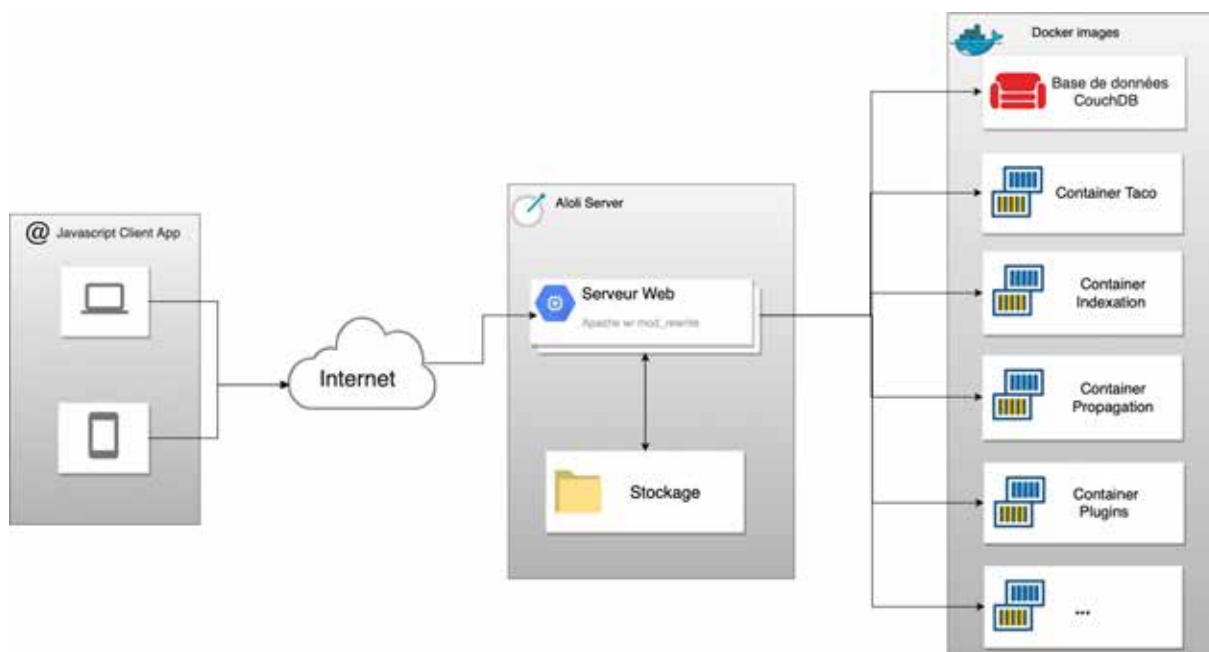


Figure 2. Aioli's architecture

The development of Aioli started in 2016 based on the results of Adeline Manuel's thesis². The platform has since received funding for its development from several national (DGA RAPID BIG 3D, ANR SUMUM) and international (H2020 SSHOC, ERC n_Dame Heritage) projects.

Beta Testing Campaign

From our first prototype of the application, we opened a beta testing campaign that gave us the chance to have real-world issues and users coming from many different usages. During this program, a wide range of heritage artefacts belonging to different scales (archaeological sites, buildings, archaeological artefacts, archaeological fragments and parietal art) have been used for experimenting with the implemented features (**Figure 3**).

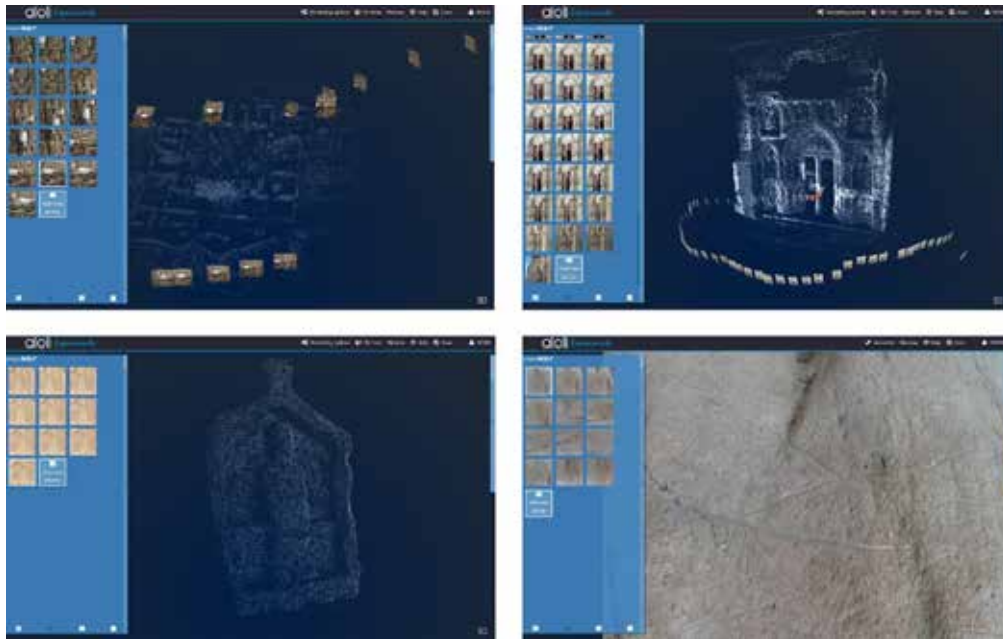


Figure 3. Screen captures of the case studies carried out within the beta testing program

One of the biggest projects was the reporting of the complete diagnosis of the outside of the cathedral of Notre Dame after the fire in Aioli. As it is a huge object, the cathedral has been divided into different projects, and each part has been documented according to a report by experts. The inside of the cathedral is currently in processing.

The sharing and dissemination of an annotated project within a community is a crucial issue for the Aioli project. Collaboration modalities already allow several actors to work on the same project through the management of rights on a project. Each project owner can define a set of collaborators who can integrate their own annotations on a project. However, opening up a project to a community means that it is not necessary to create an account on Aioli for each person who simply wants to consult the results.

Spritz, a specific online viewer, is therefore being developed to allow the sharing and dissemination of Aioli projects on a wider scale. This viewer aims to embed Aioli scenes within a web page. This viewer allows anyone to only visualise and manipulate

the images, the point cloud and all annotations (2D and 3D regions and linked description).

Perspectives

We are today exploring several scenarios in order to start the diffusion of Aioli within the cultural heritage community on a national and international scale. In parallel, we planned to develop new functionalities to offer users a large panel of possibilities in terms of multitemporal monitoring, interoperability and multidimensional correlation.

Some experiments that seem promising concerning multitemporal monitoring, which makes it possible to compare the evolution of the object over time, have been carried out³. This result could lead to a complete process of quantitative change monitoring on a multitemporal data set. Theoretically, all compatibles' images with the photogrammetry pipeline can be used in Aioli and become annotations support. That is why we are now interested in the integration of images from different kinds of sensors like UV, IR, RTI, etc.

The last point is about the multidimensional correlation where the spatial overlapping of annotations would allow the generation of hundred relationships in a spontaneous way. The correlation of qualitative (user descriptors) and quantitative (computed geo-visual descriptors) attributes belonging to overlapped annotations generates a rich environment for analysing the co-occurrence of factors.

Further information about the Aioli project (including demonstration videos, case studies, and a beta testing program) is available on the platform website: www.aioli.cloud.

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