# An Immersive Visualization Kit for Online 3D Objects Databases

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*Abstract*— **The present challenge to preserve cultural heritage, dealing with the rise of new technological advances in terms of spatial data gathering, led to the massive surge of digital content and more than anything, to 3D models. These models, supporting analysis and valuation in archeology, architecture, cultural heritage and furniture design, are often gathered within huge databases. The core question of this presentation concerns the optimal strategy for its distribution and the specific methods involved to access and navigate through its heterogeneous data system. This paper also describes our KIVI[1] hardware and software platform for immersive visualization, defining an original easy-to-use data crawling approach, optimizing its dissemination and exploitation through diverse cultural heritage digital content.**

*Index Terms*— **Virtual reality, multimedia databases, data-mining, immersive visualization, 3D objects handling, ergonomy.**

## I. INTRODUCTION

Present goals in the domain of digital heritage preservation have met recent technological breakthroughs in terms of Structure from Motion algorithmy and advanced 3D representation in the domain of architecture, archeology and cultural heritage. Subsequent models, often combining primitive modeling, laser scanning or automated photogrammetry strategies, contributed to the emergence of wide 3D multi-purpose databases. The usefulness of such a rich resource does not have to be demonstrated; thus, its immersive 3D exploitation becomes today a major issue to enhance the richenss of its experience for purposes of research and dissemination. Nevertheless, the access to these technologies is today significantly slowed by the availability of effective technological resources. This leads to low portability, un-easy overall accessibility and, more than anything, poor sustainability as a consequence.

In this very context, our solution consists in an integrated hardware and software platform, robust and easy to deploy, ready to use within an open-source environment, providing a low-cost solution for immersive 3D database contents: the KIVI project.

## II. RELATED WORKS

Multimedia online databases are a common solution for gathering and broadcasting digital content over the web, for managing, studying, and accompany the heritage conservation process. Many research teams explore interesting approaches for data sharing strategies, offering original interacting and visualizing solutions [1], [2]. Most of them focus on optimizing the diffusion targets, offering a universal accessibility, regardless of their complexity or their structure, to end-users [3]. They are trying to achieve intuitive manipulation sets as part of ready-to-use solutions, with online and cross-platform developments that need no extra plug-ins or software resources [4]. This approach, within the context of sustainable software environments, involves foremost open-source and standardized solutions [5].

Another major aspect concerning the potential use of 3D data - for study and development purposes - concerns the enhancement of the interactive experience and of mediation effectiveness of complex 3D scenes; to do so, virtual reality, deeply involving sensorial immersion and depth perception, achieves the recognition of complex 3D scenes for non-expert users [6], [7]. Thus, present research not only actuates the specific data-transformation necessary to broadcast 3D contents on the web but also focuses on peculiar aspects of user VS model interactions. We must build on ICT (Information Communication Technologies) and exploit their richness to provide specific immersive visualization solutions for the general public [8]. Certainly, recent technological breakthroughs brought to the foreground exciting solutions in terms of real-time immersive interactions and operability (proprietary software-based game controllers, Kinect©, Leap Motion©…) but we think that they are, so far, a major obstacle for sustainable cultural content: current concerns affect optimal compromise between efficiency, convenience, durability and accessibility. Today, the Oculus Rift© is certainly the most common and widely known immersive interface [10]. Nevertheless, such a system needs to be connected to a powerful GPU able to provide a constant 75 Hz frame-rate to a 1080p display unit; it is moreover limited by a screen-door effect given by its 386 dpi screen resolution. We believe that

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[1] **KI**t de **V**isualisation **I**mmersive

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such a configuration lacks some evolutive features that could grant its technological sustainability:

Competing systems take advantage of smartphones wireless display capacity to counteract this particular drawback [11], [12][2]. Some light-weight solutions already exist and seem to quickly spread-out for a short while: as simple as the Google Cardboard or the more expensive Archos or Homido mounts, these new "universal headsets" use recent smartphones as multi-purpose displays, taking advantage of their integrated technology. The increasing computation power of such personal devices creates new and interesting VR opportunities.

Their simplicity and ease of manufacture, in conjunction with the rapid technological improvement of smartphones capabilities, are the reason of their recent massive surge. We mainly focused on this peculiar technological connection to create and develop our integrated VR solution: the KIVI project.

## III. MAIN APPROACH

Our research task consists in enhancing an existing interactive interface within a wide heritage 3D database. The use of the VR paradigm brings new interactive assets in terms of browsing, selecting and possibly enhancing interaction tools, in order to ease the accessibility and the understanding of wide cultural content. To do so, the proposed system - including both software and hardware developments able to handle and visualize 3D objects - must guarantee:

- A quick browsing and finding of existing 3D media.
- A cross compatibility of software developments (Android, IOS, Windows Phone…) with no extra add-ons or plug-ins required.
- A universal accessibility of developed contents, with no need for specialized equipment or expensive devices.
- An intuitive haptic and interactive approach for non-expert users.
- An open-source approach within the major web software standards (W3C, Khronos…) to grant its sustainibility.

## IV. SYSTEM OVERVIEW

### *A. Kit contents*

KIVI comprises two elements: the software environment and the custom headset (Fig 1).

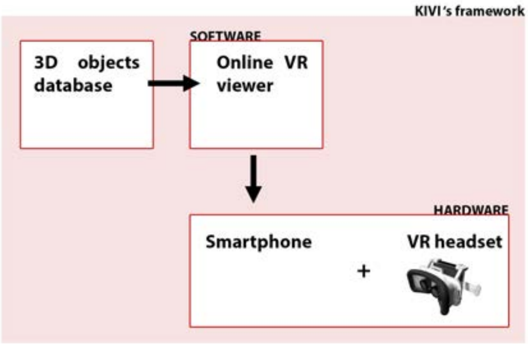

Fig.1: The KIVI framework

The software environment is made of an online portal, designed specifically for all 4" to 6" smartphones screens. Its architecture consists of:

1) The remote database which contains the 3D COLLADA assets, built either from traditional or SfM modeling techniques.
2) A HTML5 page, easing the access to remote data assets and providing the secured gateways between the database and the 3D scene.
3) The PHP Viewer, embedding an empty 3D environment (described below).
4) The empty 3D environment, a built-in empty shell for the immersive display and 3D data interaction.

The passive headset (Fig.2) consists in a side-by-side stereoscopic main-frame, and the smartphone holder. Building the headset is easy and possible through the use of accessible technologies: laser cutting, 3D printing and simple assembly rules.

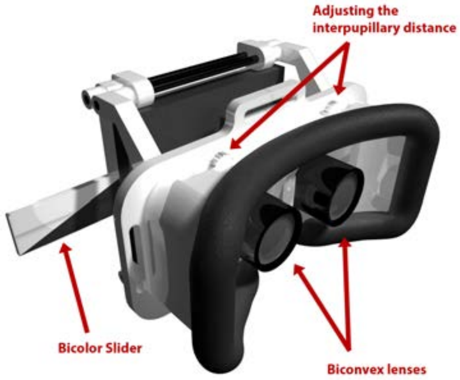

Fig.2: KIVI VR headset

### *B. Getting started with KIVI*

In order to gather a specific 3D content within a database, the user must access to the KIVI home-page within his mobile web browser and encloses his smartphone firmly in place in the headset phone-holder (Fig.3).

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[2] Statistical data from Mediametrie, concerning the use and implementation of media in France, point out the extensive smartphone distribution as high as 50% of the French population, with a peak of 79.2% for those under the age of 25. [9]. GFK anticipates an overall world-wide distribution close to 70% within 3 years. Besides, the handset upgrade cycle is estimated at 18 months in 2014 due to the rapid rise of technological capabilities and the variety of available supply.

Fig.3: Enclosing the smartphone within the KIVI VR headset

The WebGL enabled viewer displays the reached media according to a simple PHP parameter embedded within the flashcode (Fig. 4) : wether the model consists of a small object or a wide immersive scene, the navigation paradigm switches from a centripetal to a centrifugal scheme: centripetal, useful for small objects, places the user virtually around the object and reverses the camera rotation direction when aiming at the target. Centrifugal mode concerns big 3D scenes, where the user is placed at the center of the representation and moves freely in a natural walk-through mode.

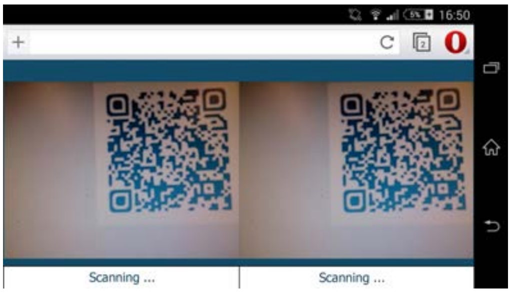

Fig. 4: When the user is immobile for 3 seconds, the flashcode decoder starts.

### C. Hands-Free interaction

Some of the most relevant aspects of our research task consists of ergonomic optimization and mainly focuses on transparent and intuitive methods for virtual content handling.

We noticed that introducing joysticks and game controllers in the interface loop was rather confusing for non-expert users: when walking through a 3D scene, most of the novice users tended to align separately their head - and besides their view direction which naturally follows the wandering path - and their hands, which tends to keep still, a natural scheme when interacting for instance with a mobile vehicle motion control which usually is aligned with the body position.

To perform a displacement in the scene, the rear camera of the enclosed smartphone is involved: wether the user places his hand or the slider colored test-card in front of the view frustum, a random pixel pattern is tracked through a javascript-WebRTC API, every 500 milliseconds: if more than 80% of measured pixels are below a given luminance threshold (Fig.5), the movement starts, and the virtual camera translates in the direction of its point of view. This movement can be stopped when moving the slider or the hand away from the lens: although stopped, the user can freely examine the surrounding 3D scene.

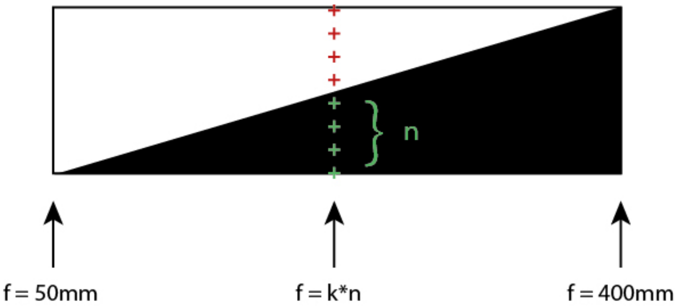

Fig.5: Interpretation of the test-card by the colorimetric analysis script

Our experimental protocol also studied additional alternate features:

- A discrete subdivision of surrounding space combined with a delay function: watching in a fixed direction for more than a given lapse of time enables a forward movement of the virtual camera.
- Choosing of a unique and quite unusual head-position to activate a specific movement, for instance looking straight up or straight down.

## V. PRELIMINARY RESULTS

The present kit was submitted to early performance tests, highlighting the operational potentials and limits. KIVI was tested with many representative samples of third party 3D databases. We submitted two versions of the script environment: one was only 3D viewing enabled, the other implemented the WebRTC API for the video-stream pixel surveying. Two different smartphones were tested, both based upon an Android architecture but built with different technical specifications. This testbed was benchmarked running both scenes and an accurate frame-count was performed for each configuration: these first results pointed out some interesting aspects depending on the involved resources:

- up to 55 fps with the Sony Xperia Z3 running a 20.4 Mb texture-size 7816 triangles 3D scene (WebGL renderer only)
- 20 fps with the same phone and the same 3D scene but the WebRTC function enabled.
- 6fps with the WebRTC enabled function, running a 44000 textured triangles scene.

These first results pointed out interesting aspects of our approach. Depending on the involved resources, some 3D scenes were displayed with acceptable frame-rates, which makes this system very suitable for mobile lightweight immersive solutions, especially for cultural mediation purposes which can be, in some cases, comparable to Oculus Rift© performances. We must say that the tested 3D objects are all low-poly sets, which most of the 3D database elements are not.

Present limits of our system lay on present on-board GPU and CPU performances. To increase the frame rate and the feedback delay we should - when possible and needed - lower the polygon number and the texture size of on-line resources, implying time-consuming 3D models post-processing. So far, our system is not as "ready to use" as we wish.

Moreover, we must say that using WebRTC significantly reduces the system performance: this quite recent API is not optimally supported by tested browsers and our code may still be improved. Despite some structural weaknesses, WebRTC looks quite promising in terms of ergonomic and intuitive interaction potentials, especially in the domain of mediation.

## VI. PERSPECTIVES

This paper briefly describes an integrated solution embedding a recent smartphone within a custom-built headset able to provide a ready-to-use immersive virtual-reality device. The aim of such an approach takes advantage of combining the most recent hi-tech wireless communication solutions with easy-to-build low-cost VR mounts in order to widely broadcast cultural heritage content.

Our exploration brought to the front up-and-coming interactive configurations and lets the imagination wander towards even more unexplored schemes. To put the user in the perspective of a totally hands-free interface we connected the Leap Motion© interface to the smartphone operating system through an experimental gateway built within a specific Android library (Fig.6).

Fig. 6: The KIVI Leap-Motion mount

However, the major issue of such an advancement consists in the difficulty to grant a cross-compatible sustainability between hardware and software components. Moreover, this first KIVI implementation concerns solely textured 3D objects, we wish upcoming developments could consider meta-data embedding and browsing (annotations, audio and video streams, hierarchy filtering, geolocation…) which could be very pertinent in the case of high-level data development for cultural and historical contents.

Evolution perspectives are almost infinite and, in the domain of cultural mediation, we believe that our KIVI project is quite a promising route. Cross-compatible and sustainable environments, in strict compliance with the W3C and the Khronos Group standard sets, gathering multi-format media, within ready-to-use and affordable hi-tech solutions allow a glimpse of the paths that will certainly lead to up-coming challenging experiences in the domain of remote learning and knowledge sharing. We only hope that present and future hi-tech digital environments will be able to narrow the gaps between increasing cultural disparities and give an affordable chance to everyone's curiosity and eagerness to learn.

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