

Exploring 3D Virtual Environments Through Optimised Spherical Panorama Navigation

The application goal is to provide a lightweight environment to be deployed in a web browser for the **interactive navigation** and **browsing** of an ordered sequence of **spherical images**.



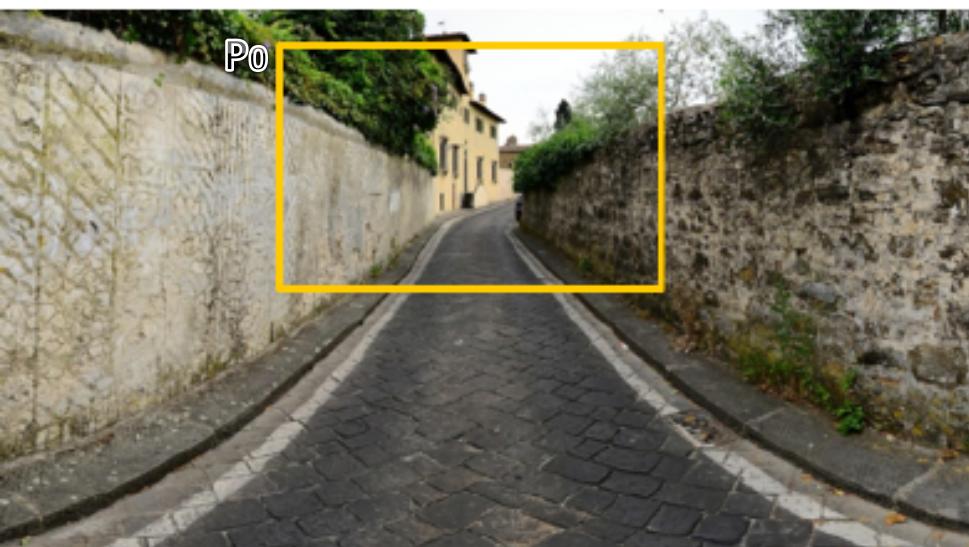
(a)



(b)

An example of a real world panorama: (a) View of the current panorama (zoom 1:1) aligned to the outward direction; (b) next panorama (zoom 1:1) aligned to the inward direction.

The first of the two key features of the system is to **enable a smooth transition** between the adjacent panoramas through an algorithm of **sub-scene matching**.



(a)



(b)

- (a) Operating a zoom on the current panorama results into a reduction of the size of the rectangular area corresponding to the part of scene that is viewed. By zooming the current panorama in the outward direction (in (b) the zoom level is 1:2) the content of the sub-scene P_0 can better approximate the content of the next panorama.

The identification of the rectangular **sub-region of an image I_k** that best matches the content of I_{k+1} in correspondence to the inward direction is accomplished by minimization of the following **cost function** with respect to the three variables (x, y, η)

$$(x_0, y_0, \eta_0) = \arg[\min_{x,y,\eta} D(f(x, y, \eta), I_{k+1})]$$

where:

- $f(x, y, \eta) = Crop(I_k, x, x + \eta w_{k+1}, y, y + \eta h_{k+1})$
- w_k and h_k are the width and height in pixels of the image I_k ;
- $Crop(I, x, \Delta x, y, \Delta y)$ returns the rectangular sub-region of the image I ;
- $D(I_n, I_m)$ returns the dissimilarity between the content of two images I_n and I_m ;
- (x_0, y_0, η_0) defines the coordinates of the bottom-left vertex of the sub-region $P_0 = (x_0, y_0)$ and **the zoom factor** $Z_0 = 1/\eta_0$ to be applied to the sub-region of I_k in order to match the size of I_{k+1} .

We experimentally observed that computation of the dissimilarity function $D(I_n, I_m)$ through the distance of the image histograms provides **higher effectiveness** compared to solutions based on scale invariant local keypoint descriptors such as SIFT.



Sub-scene matching results

Some results: in the first column images of the user **current view** are presented; in the second the **best matching sub-region** of the current image with the optimal zoom factor for the transition is shown; finally, in the third column the **next panorama** is visualised.

The second key feature of the system is an **innovative interaction metaphor** for a better fruition of multimedia materials associated to **interactive hotspots** related to Point Of Interests (POIs). These are distributed along a cultural walk-through and include 3D models, PDFs, galleries of images/videos and indoor panoramas



Visualisation of an interactive indoor panorama in the 3D space

- The interface is built using **HTML5, CSS3, javascript** and **WebGL**;
- navigation among spherical images is obtained **replacing a texture mapped** into a sphere taking into account the optimal zoom factor estimated by the sub-matching module;
- POIs infos and associated multimedia materials are shown in **floating panels** in the **3D space** overcoming the limitation of standard interfaces that use 2D light-boxes zoom factor computed by the sub-scene matching module.



Visualisation of an interactive outdoor panorama in the 3D space

Hotspots' associated interactive multimedia material can be accessed by a **circular menu** represented by four icons for the different types: **PDF, image and video gallery, 3D object, nested panorama.**

The system automatically provides the **best visual arrangement** of multimedia materials with respect to the user point-of-view and allows the user **to drag** the hotspots in order to customise the disposition of elements in the 3D space.

Mini-maps are provided allowing contextual awareness.



The demo will show an **interactive route** based on spherical photos which starts from the current **Via della Ninna** near the **Uffizi Gallery**, to the church of **San Leonardo in Arcetri** in Florence (IT), giving the possibility to experience an important, though little-known multimedia virtual itinerary of cultural and historical heritage.

