Photo-based animations of virtual urban scenes from hybrid 2D / 3D models. The Plaza de la Virgen of Valencia, in the 1870s.

Jose Luis Cabanes Ginés

Department of Architectural Graphic Expression; Polytechnic University of Valencia.

Figure 1. Top: original image (frame 0 of the sequence). Below left: frame 200 corresponding to the end of the oblique camera displacement (position 2). In the 3D model are visible: the façade, that appears closer, and the dome displacement in the background. In the 2D model: displacement and change of scale of the front of private houses on the left, and of the "fountain layer". Below right: final frame 420 of the animation at the end of the camera rotation (position 3). In the complete hybrid model the transformation of the different elements can be seen now matched to a real model, with the notable rectification of the façade of the Basilica.

Abstract

This paper proposes an innovative procedure that takes advantage of the synergies obtained by combining disciplines such as parametric photogrammetry, computer graphics, immersive camera geometry and motion graphics, to achieve advanced visually dynamic scenes from historical isolated images of urban environments. The approach is divided into three stages: generation of a hybrid 2D / 3D model, creation of a virtual scenario, and animation by the synchronized movement of an immersive camera. The first stage deals with the geometric aspect, and is the result of a combination of a partial photo-modeling, by means of parameterized 3D primitives, and other 2D layer-segmented elements extracted from the original image. The second stage starts with the recovery of the pinhole camera that took the original image, to create a virtual scenario with the elements of the hybrid model, while in the third, some projective relationships are used to program an animation adapted to the limits of distortion of the 2D background, synchronizing its transformation with the movement of the sub-objects of an immersive camera. A case study is included of a video sequence made as an example of application of the procedure.

Key words

Virtual Surveying; Parametric photogrammetry; Computer graphics; Immersive camera geometry; Motion graphics.
1. Introduction

Photo-based animations are virtual reconstructions of considerable interest, since they “improve cognitive processes, making the historical and archaeological data easily comprehensible to anyone ...” (Ferdani et al. 2020, pp.142), through various formats, such as video or immersive VR technologies, when only a limited amount of information is available. Some relevant have been published by authors like Tarraubella (2015), or Zakharov (2016).

Up to now, the general procedures for generating these animated sequences from single images, has been by either segmenting them into layers, called the 2.5D effect (Horry, Anjyo and Arai, 1997), or by photomodeling based in 3D primitives (Hudson, 2007), or Galliano, 2018).

2. Research aim.

We propose an innovative multi-disciplinary procedure oriented towards urban historical scenarios, that provides less confined camera movement, with the aim of achieving a similar result to a hypothetical filming of the corresponding original scene.

For this, we have structured the process into three stages (see Figs. 1 and 2). In the first, the original image is manipulated by a partial parametric photo-modeling, normally of the building of interest in the urban scene, together with a segmentation into 2D layers of other motifs, normally of greater formal complexity (like elements of vegetation, sculptures, etc), that do not form part of the background, i.e. of the part that is not transformed. This is why we call this set of three elements a 2D / 3D hybrid model.

3. Procedure improvements.

In this section we comment the basic innovations of our procedure.

3.1. 3D elements and reconstruction of the structure of the scene.

The photo-modeling by parameterised 3D primitives of an architectural element recorded in the basic image, allows us simultaneously to obtain its detailed reconstruction, as well as the basic orientation elements of the photogram (focal distance and position of the main point).

The process starts by identifying the basic motif’s geometry with some “flexible” 3D structures that can be manually placed on the image, while at the same time, laying down a series of syntactic integration rules, to model more complex shapes until the whole element has been interpreted. (Eos Systems Inc., 2017).

3.2. 2D Scenic elements. Analysis of transformations in a pinhole camera system.

Although the visualisation of the partial 3D model in the animated sequence does not alter its real perception, the same cannot be said for the 2D part of the image, when the position of an immersive camera is changed, since the new conical projection generated loses its correspondence with the real scene. (Villanueva, 1996).

However, the perspective of the real scenario will be less distorted if this displacement complies with a basic requirement: instead of being arbitrary, it should be driven in the direction of some visual-limit, since then the edges of the 2D background will conserve the same vanishing point as the original image. But a lack of consistency appears then with the 3D part. In that context, some geometrical transformations can be considered in the 2D part, synchronised with the camera movement (Fig. 3).
3.3. Formation of the virtual scenario for immersive visualisation.

The basic elements in the virtual scenario are: the pinhole camera, the hybrid model, and some de-contextualised elements if necessary to improve the realism.

The spatial positioning of the virtual camera must be precise, recovering the same position of the original shot. For this, either the parametric photo-modeling, or also some projective geometric principles (Mohr and Triggs, 1996), can be used, in order to obtain both the external and internal orientation parameters of the pinhole camera.

After configuring the virtual 3D scenario, an animation process is carried out to achieve a controlled dynamic vision of the spatial perception of the frame, as discussed above.

4. Results

We will now see an example of the above-described procedure applied to a historical photo of the Plaza de la Virgen of Valencia around 1870, kindly provided by Mr. Jose Huguet (Huguet José, personal archive. Image in Fig. 4, kindly ceded) (Fig. 4).

The elements in the 2D/3D hybrid model include:
- the partial 3D parameterisation of the Basilica (Fig. 4), the extraction in a layer of the circular fountain to accentuate the realism of the camera movement, and the front of the private houses on the left, which form the 2D background of the original image. These were used to try out the effect of the various elements described above.
- We aimed to do the animated sequence in two movements of the immersive camera system: an oblique advance along the left visual limit, and then a rotation to the right from the initial position, until the façade of the Basilica turns into a frontal view. (Fig. 5)

![Fig. 4. Left: Parametric survey of the Basilica with “Canoma” (Metacreations, 1991). The nave is assigned to a “box” for its projective reconstruction, as we have seen. The other forms are unblocked from the base plane and make up a unit that contains the metric reconstruction (original image size 782 x 582 pixel).](image)

![Fig. 5. Decomposition of the animation sequence. Top: movement of the camera towards the left-hand vanishing point (cameras 1 and 2), synchronised with the transformation of the 2D background (product of a homothecy by a translation in the front of the private houses, with a good approximation thanks to its coplanarity), and with the rotation of the fountain layer, according to perpendiculars of the bisector of the envelope’s extreme rays in each camera position. Below: rotation of camera 1 until the target reaches the right-hand vanishing point (configurations of cameras 2 and 3).](image)

The first involves a change of perspective and must be synchronised, as we have seen. The second is a rectification of the initial camera setting its target with the vanishing point of the right-hand alignment. (Temiz and Küllü, 2008).

The animation thus gives firstly an illusion of a sideways movement towards the front of the Basilica, due to the private houses and the fountain layer synchronized transformations, and secondly the observer gradually turns until the façade of the Basilica comes into a frontal view. In the attached video we have added an “old video” effect to improve the atmosphere of its time. Video link: [https://media.upv.es/#/portal/video/06216110-6326-11eb-82d2-e1c66231ff06](https://media.upv.es/#/portal/video/06216110-6326-11eb-82d2-e1c66231ff06)

5. Conclusions

In this paper we propose an innovative multi-disciplinary procedure to achieve advanced dynamic visualisations of urban scenes from isolated images, including approaches that have been successful up to now, and adding new ones, in order to increase the realistic effect. The workflow is divided into three stages: (i)
generation of a hybrid 2D / 3D model from the original image, (ii) creation of a virtual scenario, and (iii) synchronized movement of an immersive camera with the transformation of the 2D elements, for implementing an animation.

This process allows to deal with a greater freedom of camera movement than usual in current photo-based animations, and therefore an improved optical illusion of movement and depth is achieved, which represents an advance in this important format of graphic representation of historical scenes.

References


Hudson, A., 2007, Using Canoma to create 3D Models from Virtual Hearth. https://www.youtube.com/watch?v=3EY5kJ5SV92A


Zakharov, A., 2016. This Animation was Created Using Old Photos from the Early 1900s. https://petapixel.com/2016/04/06/animation-created-using-old-photos-early-1900s/

Biographical data of the Authors

Jose Luis Cabanes Ginés
Tenured Professor, Department of Architectural Graphic Expression, Polytechnic University of Valencia, Spain: jlcabane@ega.upv.es

Doctor architect. Tenured Professor. Researcher at the Heritage Restoration Institute (IRP) of the Polytechnic University of Valencia. Research lines: architectural photogrammetry; graphic expression of architecture.