Proposition de thèse de doctorat

Début : 2016-2017

Titre de la thèse : 2D/2.5D/3D matching for tracking in augmented reality

Laboratoire : UMR 1563 AAU

Equipe : informatique - ECN

Localisation de la thèse : ECN et/ou ensa Nantes

Directeur de thèse	**Co-Encadrants**
MOREAU Guillaume	**NORMAND Jean-Marie**
Tél : (+33) 240 37 6847	Tél : (+33) 240 37 1602
Mail : guillaume.moreau@ec-nantes.fr	Mail : jean-marie.normand@ec-nantes.fr

Description du sujet

The principle of augmented reality (AR) consists of inserting digital information (virtual images) onto real images (captured in real time from direct or indirect viewpoint). Adding this synthetic digital information must be made in a way that virtual images are registered with the real ones (it means that both the position and the orientation of the virtual camera must the same as for the real camera).

To register images, it is required to compute the real camera pose (its 3D position and orientation, assuming that its internal parameters are already known). Once the pose is determined, it is possible to display virtual objects *at the right place* onto real images.

Pose computation is a complex problem, especially in augmented reality where computation time must be very short. Several types of solution already exist:

- Black and white markers: since the end of the 1990s, Kato and Billinghurst [KB99] have proposed the ARToolkit system based on a known set of planar black and white markers to compute the camera pose. The main drawback of this approach are the markers have to be entirely visible and occupy a significant part of the image
- Markers based on natural features: more recently, some free or commercial libraries such as Vuforia or Metaio propose to use a set of classical images instead of instead of black and white patterns to compute the camera pose. Those real images must be processed offline to be then detected in real-time. However, those markers require highly textured images and are very dependent to illumination conditions.
- Untextured markers: to overcome the limitations of preparing natural images and illumination problems, it has been proposed to use pseudo-random points sets to compute the camera pose [YNM15].

This last type of techniques is said to be 2D-2D matching: a set of coplanar point is known (it can be extracted from a standard image or from an artificial marker) and the user wishes to match them with the ones extracted from a real camera image. It is possible to use only the spatial layout of points or to use as well texture information (if available and if invariant descriptors are available).

There also exists a set of techniques allowing to perform AR by looking for known 3D objects. This case is called 2D-3D matching: the system tried to find in the 2D camera image a set of points representing the 3D model [RNK15]. These methods usually based on edge tracking or on a partial reconstruction are complex and only work in controlled environments.

The goal of this PhD thesis is to exploit the recent works [YNM15] of our research team to study the possibility to extend them to the problem of 2D-3D matching. Another interesting case is 2.5D-3D matching, i.e. matching between a depth-cam (such as a Kinect) and a 3D object.

[KB99] Kato, H. & Billinghurst, M. (1999) Marker tracking and hmd calibration for a video-based augmented reality conferencing system. Proc. 2nd International Workshop on Augmented Reality (IWAR'99), 85-94.

[LF06] Lepetit, V. & Fua, P., Keypoint Recognition using Randomized Trees. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 2006. 28(9) 1465-1479.

[YNM15] Yang, L. ; Normand, J.M. & Moreau, G (2015) "Local Geometric Consensus: a general purpose point

pattern-based tracking algorithm", Proc. ACM ISMAR, published in *IEEE Transactions on Visualization and Computer Graphics*, 21(11) 1299-1308.
[RNK+15] Resch, C. ; Naik, H. ; Keitler, P. & Benkhardt, S. (2015) On-Site Semi-Automatic Calibration and Registration of a Projector-Camera System Using Arbitrary Objects with Known Geometry. Proc. ACM ISMAR, published in *IEEE Transactions on Visualization and Computer Graphics*, 21(11) 1211-1220.

Compétences requises
MsC in computer science, computer vision