THESIS PROPOSAL

Sparse vs. dense matching

Application to Interaction and Augmented Reality

KEYWORDS

Image Processing, Computer vision, Augmented reality, Video-projection, 3D geometry, Color invariance, Matching correspondences, Robust feature points, Graph matching, Cumulative techniques

The group AMI of the laboratory LIMSI[1] (Laboratoire d'Informatique Pour la Mécanique et les Sciences de l'Ingénieur) in Orsay proposes a PhD topics on image processing applied to augmented reality and interaction. The work will be made in collaboration with the laboratory IBISC in Evry[2].

CONTEXT

The PhD work will be a part of a more global project on Spatial Augmented Reality (SAR, or projector-based AR) and on human-computer interaction using several modules: a global context-aware SAR system, gesture analysis, several mobile devices (when available). SAR consists in adapting a projection to geometrical and/or photometric properties of the surface relying on smart projectors, i.e. video projectors that are enhanced with a camera and inertial or position sensors, to gain information about the environment. These systems can be static or mobile (on smartphones for example). In that domain, the works lead by the team AMI aim to make the SAR system more reactive by offering more input channels through image analysis techniques (scene analysis and users' behaviors) and more interactive. Real-time 3D reconstruction and motion analysis will allow users to be recognized or taken into account by the smart projection system. Finally, SAR should become more collaborative and ubiquitous by allowing multiple people to jointly interact through gesture (selecting, displaying or drawing) or through their mobile devices. This kind of system requires a significant number of image processing/computer vision tools among which: registration, 3D reconstruction, stereovision, motion analysis, tracking. The PhD work lies in this context.

WORK

The thesis will focus on feature matching which is a core aspect of several image processing algorithms. More precisely, the objective is to provide some clear conclusions concerning the comparison between sparse and dense matching methods. Three main stages will be carried out.

First, a theoretical and bibliographic study will be made to extract the main pros and cons of sparse and dense matching in computer vision. The new trends of the domain will be analyzed and a few comparison criteria will be selected or determined in order to get a fair analysis of the two categories of strategies, in terms of noise sensitivity, illumination invariance, errors, complexity.

Second, the study will be applied to several problems among which motion analysis (egomotion), tracking and 3D reconstruction (from stereovision or structure from motion), since these problems can be tackled using variations of the same techniques. Regarding the previous research works made in the team, we propose a few examples of methodologies that could be experimented:

- *Sparse feature matching* using feature graph matching. The vertices of the graph are feature points with color and geometry invariance, and the edges are the spatial and color relationships between points. The matching

[1] www.limsi.fr
[2] www.ibisc.univ-evry.fr

will be performed by minimizing a cost function involving global geometric and photometric constraints.

- *Dense (or semi-dense) matching* with cumulative techniques [Bouchafa 12] or tensor-based techniques [Laguzet 13].

This second stage should lead to clear conclusions regarding the performance of the methods with respect to the problem addressed and with respect to the scene and objects under consideration whether they have rigid motion or not, whether they are textured or not, etc.

Finally, the context can change drastically during an experiment due to changing acquisition conditions. Therefore, a study will be made to automatically switch the type of features and/or the matching method (i.e. sparse/dense feature matching) depending on the knowledge acquired from the context.

Some experiments and demonstrations will be made in human-computer interaction for the project of spatial augmented reality defined in the section "context". Note also that the methods should be generic enough to be applied to the interaction with the iRoom, which is animated at LIMSI by Yacine Bellick (http://iroom.supelec.fr/wiki/Accueil).

A FEW REFERENCES

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PREREQUISITES Some knowledge about image processing and 3D geometry are required. The student has to be able to program in C/C++.

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