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► **To cite this version:**

Guillaume Caron, Damien Eynard. HySCaS: Hybrid Stereoscopic Calibration Software. 2011, 10.1117/2.1201106.003738 . hal-01270686

HAL Id: hal-01270686

<https://hal.science/hal-01270686>

Submitted on 7 Mar 2016

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HySCaS: Hybrid Stereoscopic Calibration Software

Guillaume Caron and Damien Eynard

Abstract

HySCaS calibrates simultaneously perspective and omnidirectional cameras stereo rigs, mixing perspective, spherical or paraboloidal projection models.

Hybrid stereoscopic systems are the combination of different kinds of cameras on the same rig. Stereoscopic systems are generally made of two conventional cameras but others are possible too. In the last decade, omnidirectional cameras, i.e. standard cameras pointed to curved mirrors or using a fisheye lens, have shown their interest, particularly in vision for robotics thanks to their very wide field of view.

Conventional perspective cameras are still useful, even with their limited field of view. Indeed, the spatial resolution of their images is really high compared to omnidirectional images, since the same number of pixels is generally used in both cases, but for a field of view of more than 180° for the omnidirectional camera. So creating a stereo rig with a perspective camera, bringing the precise spatial resolution, and an omnidirectional camera, bringing the very wide field of view, has the potential to merge these advantages (Fig. 1).

Main application fields of hybrid stereoscopic systems are video surveillance and localization or navigation in robotics. For instance, a perspective and fisheye cameras stereo rig is mounted on a UAV (Fig. 2) to estimate its altitude thanks to both images and a plane-sweeping algorithm [1]. The attitude of the UAV is estimated thanks to the fisheye view using the horizon line when possible or 3D



Figure 1: An example of a hybrid stereo rig: perspective and fisheye cameras.

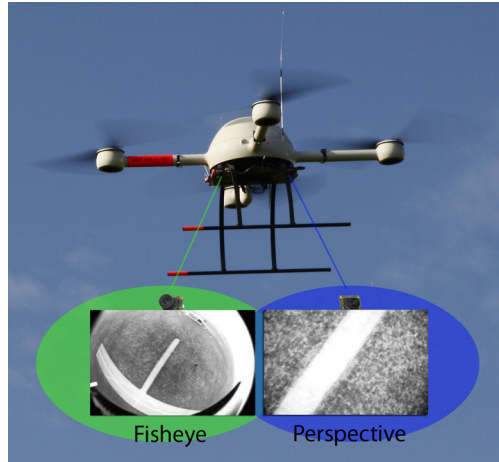


Figure 2: A perspective an fisheye stereo rig embedded on a UAV and their images.

straight lines in urban environments. Recently, interest points from both views are combined to have a precise and robust estimation of the UAV motion, at the good scale [2].

With the development of omnidirectional cameras, a spherical projection model was designed to unify some pairs of camera and mirror. The perspective projection model of conventional cameras is a particular case of this unified model. However, using this unified model for a conventional camera is not always judicious since it makes the projection function more complex and intensity-based motion estimation approaches, such as the Lucas-Kanade optical flow computation, are still more efficient with the standard perspective projection model, for perspective images. The mix of, at least, perspective and omnidirectional cameras, of which images are modeled, respectively, by a plane and a sphere, is then an interesting topic.

To retrieve 3D information on the environment or on the motion of the hybrid stereo rig, it has to be calibrated, intrinsically and extrinsically. It means the projection parameters have to be known as well as the relative poses between the cameras of rig.

We developed HySCaS [3], the Hybrid Stereoscopic Calibration Software (Fig. 3), implementing the general stereoscopic calibration method we designed [4]. HySCaS simultaneously estimates intrinsic and extrinsic parameters of stereo rigs composed by N cameras modeled by N different projection models. The calibration procedure is classical, in the sense that users friendly with existing freely available calibration softwares (*Camera Calibration Toolbox for Matlab*, *Omnidirectional calibration toolbox*, calibration tool of the *ViSP* library) do not need to change their habit. Computation time of HySCaS is also really low since the calibration of a perspective and fisheye hybrid stereo rig takes only 2.5

seconds and 0.5 second for a two perspective cameras rig. Our software accepts chessboard or dots calibration patterns and even a new one composed of rings will be available in a near future. Perspective and unified projection models are available in HySCaS. The ad hoc paraboloidal projection model is also available in the software and other ad hoc models, such as the hyperboloidal one, will soon be integrated.

The software engine is the implementation of the general stereoscopic calibration method we designed. It is the generalization of the Virtual Visual Servoing based calibration method of a perspective camera. Image points, corresponding to reference points in calibration patterns are detected in several images and 3D pattern poses are optimized. Simultaneously, each intrinsic parameters set and relative poses between cameras are optimized, minimizing the geometrical error between the forward projection of 3D patterns in images and detected points. The problem is formulated under the visual servoing framework, for virtual cameras, benefiting from the wide knowledge of this domain.

The method and the software have been evaluated with respect to state of the art methods, for the perspective and unified projection models and for a perspective stereo rig. Results precision clearly validates our approach. Using intrinsic and extrinsic parameters estimated by HySCaS, the perspective and fisheye stereo rig embedded on a UAV (Fig. 2), allowed to estimate the altitude of the flying robot at a precision of about 98%: 3.2 cm mean error with respect to a laser altimeter, between 0.55 m and 2.2 m of altitude [1].

In summary, merging different kinds of cameras is full of interest and we propose HySCaS [3], a new calibration software to compute intrinsic and extrinsic parameters of these hybrid rigs. We chose to present the particular example of a perspective and fisheye stereo rig but our method and, hence, HySCaS, deals with several other configurations, not limited to two cameras. We aim to improve HySCaS in the near future, adding some practical tools (3D visualization of results, integrated image acquisition) as well as more fundamental ones

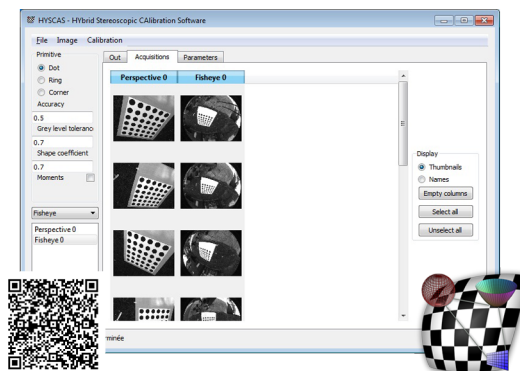


Figure 3: HySCaS: a screenshot with two sets of perspective and fisheye images. It runs under Windows, Linux and Mac.

(hyperboloidal model, distortions, line features).

About authors

Guillaume Caron received his Master's degree in computer science from University of Reims Champagne-Ardennes (URCA, Reims, France) in 2007 and a PhD in robotics from University of Picardie Jules Verne (UPJV, Amiens, France) in 2010. Recently, he joined as a postdoc the Lagadic team from INRIA in Rennes, France.

Damien Eynard received his Master's degree in Electronics, Electrical, Automation and Industrial Computing from University of Picardie Jules Verne in 2007 and worked in parallel in glass industry. He is preparing his PhD degree in Aerial Robotics for 2011, about hybrid vision system to estimate navigation parameters of an UAV.

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