NAO Calibrating itself

Ozan Gönenç+, Ralph Seulin++ and David Fofi++
Email : david.fofi@u-bourgogne.fr

+ VIBOT – Erasmus Mundus Masters in Vision and Robotics, http://www.vibot.org
++ Le2i UMR CNRS 6306, Laboratoire Electronique, Informatique et Images de l'Université de Bourgogne, http://le2i.cnrs.fr

Calibration is the process to estimate the transformation from scene features (in 3D, expressed in meters) to image features (in 2D, expressed in pixels). It is an important task in computer vision and a necessary step to compute three-dimensional information about the real world from two or more images. Among the many techniques developed to calibrate a digital camera [1], we implemented the one published by Zhang in 2000 [2] – because of its flexibility and the user-friendly process it allows. What you only need is a checkerboard and… NAO! (and possibly some skills in computer vision and image processing).

The procedure is divided into two different phases as depicted in Fig. 1: (1) the capture of the checkerboard pattern; (2) the displacement of NAO. A robust strategy has been implemented in order to guarantee that the checkerboard corners are all visible in the images grabbed by NAO. If not, NAO will turn its head and move its body until it attains this target. OpenCV toolbox [3] is used for image processing (corner extraction, for instance) and the built-in functions of NAO are used for moving it. The calibration method has been implemented using Python scripting language and fully ported to Choregraphe, the IDE from Aldebaran for behavior development and robot management.

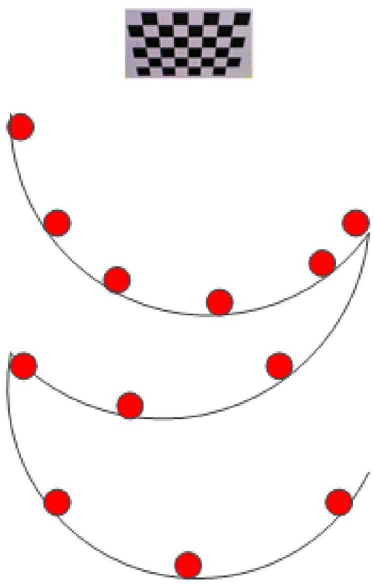

Fig. 1. Motions of NAO in order to capture the checkerboard under different points of views. Red points represent NAO.

The interest of calibration can be demonstrated by computing some 3D information about the observed scene. Without giving too many details, imagine NAO shooting an image, then another one. Points within two successive images that correspond to the same 3D physical points are matched (green dots in Fig. 2). Let's assume that the displacement performed by NAO is either known or estimated (a tricky thing called relative pose estimation, which is currently being implemented into NAO) – so now, the 3D can be computed (see Fig. 3). Depending on the number of points you are able to match, the reconstruction can be either sparse or dense.

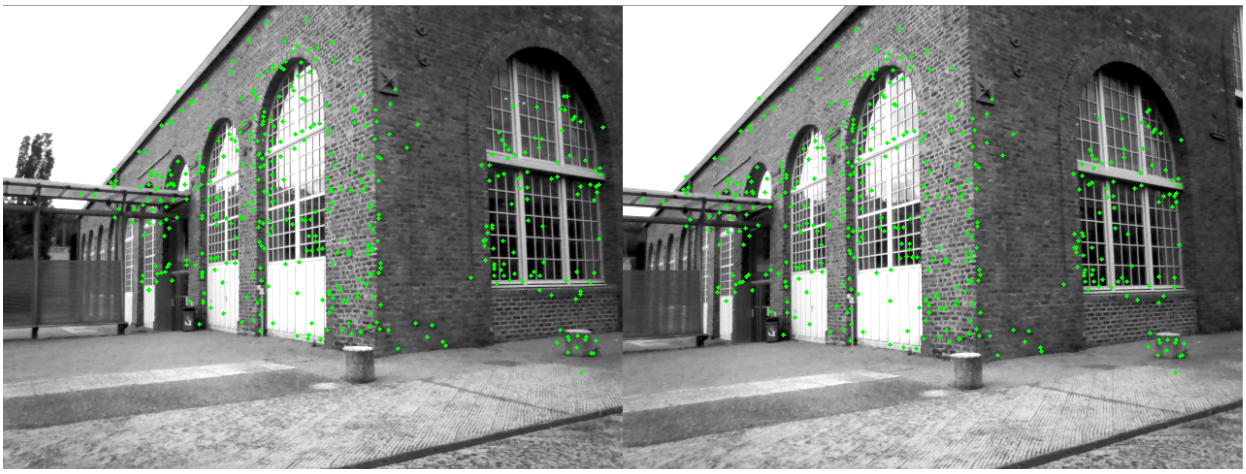

Fig. 2. Two views of an outdoor scene. The green dots represent the matched feature points.

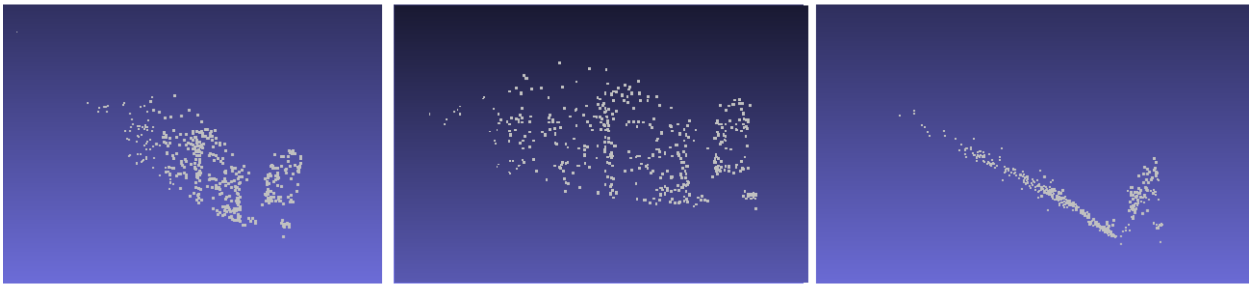

Fig. 3. The 3D point cloud obtained from the images of Fig.2 from three different points of view.

References:

[1] J. Salvi, X. Armangué, J. Batlle, "A Comparative Review of Camera Calibrating Methods with Accuracy Evaluation", *Pattern Recognition*, 35(7), pp. 1617-1635, July 2002.

[2] Z. Zhang, "A Flexible New Technique for Camera Calibration", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 22(11), pp. 1330-1334, November 2000.

[3] OpenCV toolbox and documentations, http://opencv.org/.

[4] A video of NAO calibrating itself, http://www.