CURRENT INVESTIGATIONS AT THE ETH ZURICH IN OPTICAL INDOOR POSITIONING

Sebastian Tilch, Rainer Mautz

Central Idea

The central idea of the new indoor positioning system is based on the fundamentals of stereo photogrammetry. But instead of using a second camera, we replace it with a device (called laser-hedgehog) that projects well-distributed laser spots as flexible reference points on the ceiling, walls and furniture in any indoor environment (Fig. 1). The projecting light source consists of several focused laser-beams that originate from a static, well-defined central point. The 3D directions of the laser-beams are also precisely known through a previous calibration.

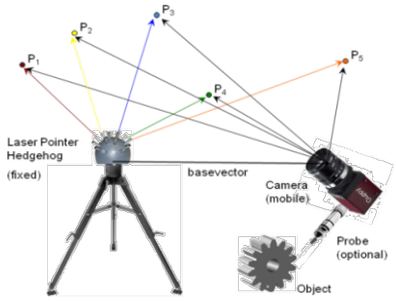

Fig. 1. Central Idea of CLIPS

Since the concept of camera pinhole projection and the projection of laser spots from a central origin rely on the same principle, namely the central projection, the beams of the laser-light emitting device simulate the light path of a camera. Hence, the second camera can be simulated by the projecting device (Fig. 2).

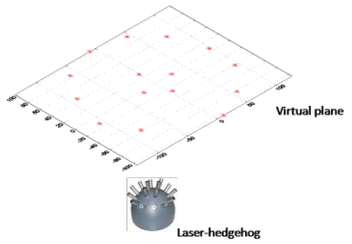

Fig. 2. Concept of the virtual image

During the measurement phase the digital camera observes the reference field. Having carried out the point identification for the individual laser beams in the camera image, the relative orientation can be derived by solving the coplanarity constraint of the epipolar geometry (Fig. 3).

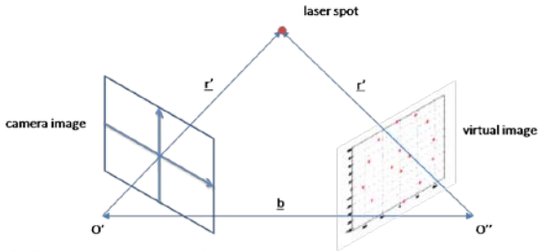

Fig. 3. Epipolar geometry of the camera and laser-hedgehog arrangement

Relative Orientation

For solving the coplanarity constraint a 5-point-algorithm has been chosen. Unfortunately the 5-point-algorithm provides up to 10 solutions for every camera position. In order to identify the correct essential matrix, the algorithm has been embedded into a RANSAC algorithm. Then, the correct essential matrix is decomposed into a translational vector **b** and a rotational matrix **R** and finally refined by a least-squares estimation of the relative orientation parameters.

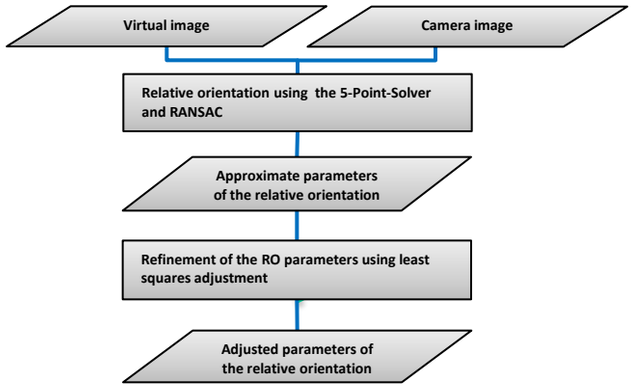

Fig. 4. Determination of the relative orientation of the camera

Introduction of the System Scale

The system-scale cannot be determined by relative orientation. It can be introduced by measuring the distance between the laser hedgehog and the camera. Note that in our case, the distance measurements are carried out only for the first four camera positions.

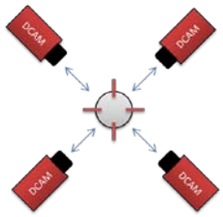

Fig. 5. Introduction of the system scale

Then, the spatial coordinates of the laser points are determined by intersection. Once the 3D positions of the laser spots are known, the relative orientation parameters for subsequent camera positions can be determined by spatial resection.

Evaluation of the System

First tests have shown that the relative orientation of the camera could be correctly determined in all cases. However, the identification of the laser-spots and the introduction of the system scale need to be improved in further investigations.

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Geodetic Metrology and Engineering Geodesy
Institute of Geodesy and Photogrammetry
www.geometh.ethz.ch