Master's Thesis Engineering Technology

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Novel Levenberg-Marquardt based methods for application-specific hardware enabled high-speed, high-accuracy, six degrees of freedom camera-based pose estimation

Michiel Darcis

Master of Electronics and ICT Engineering Technology

Introduction

This Master's thesis is situated in the research area of pose estimation where the position and orientation of an object with respect to a camera needs to be determined in relation to a predefined world coordinate system.

Fig 1. maxillofacial surgery planning [1, p. 5]

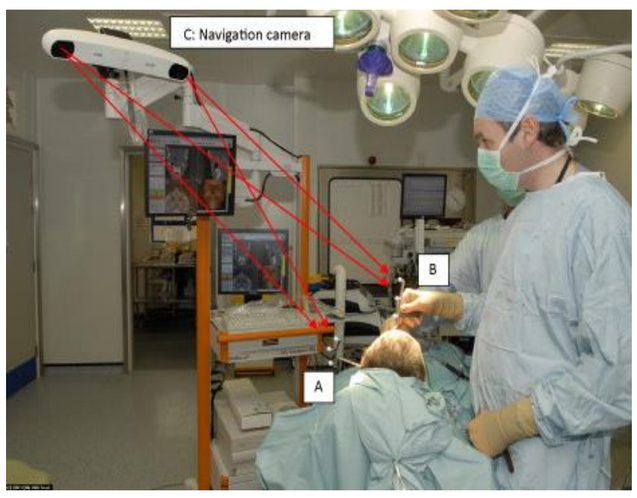

Fig 2. Stereotactic navigation [2, p. 2]

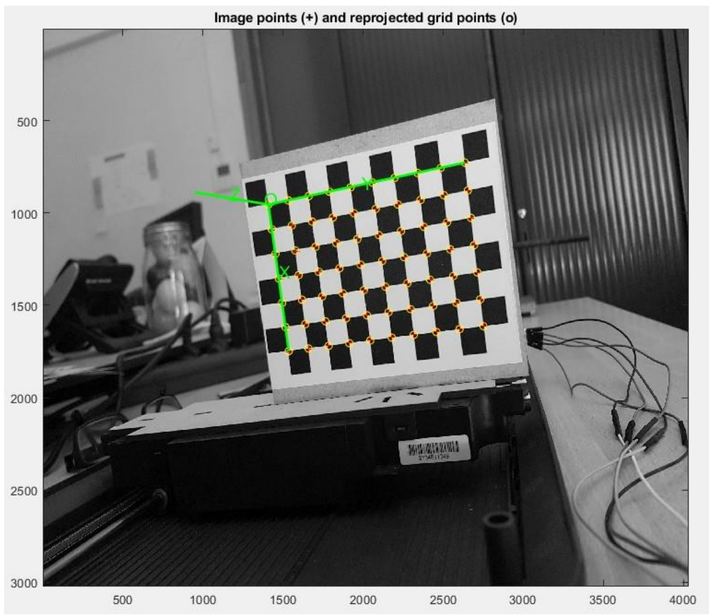

Fig 3. Camera pose estimation using a checkerboard on a linear scanner

Problem statement

Software-based algorithms are too slow for specialized applications such as maxillo-facial surgery planning and stereotactic navigation that are illustrated in figure 1 and 2. They will require dedicated cameras with FPGA based hardware architectures, directly interfacing with and employing all capabilities of modern image sensors.

Objectives

The goal of this thesis is to set up a detailed experimental model for the development of complex algorithms that enables the evaluation of architectural design decisions.

Method

Various pose estimation methods were studied. A prototyping environment 'PoseLab' was made in MATLAB where the Levenberg-Marquardt method was implemented without the use of external libraries. This was further extended by making it possible to take in data during Levenberg-Marquardt iterations which would be possible in a hardware interface to the camera.

Results

The calculated poses were verified by creating a linear motion on a test bench, as shown in figure 3. The 'PoseLab' framework will enable the analyzation of various trade-offs (accuracy, complexity, resolution, …) as it is possible to tune every parameter of the pose calculation.

References:

[1] J. Collyer, "Stereotactic navigation in oral and maxillofacial surgery," *Br. J. Oral Maxillofac. Surg.*, vol. 48, no. 2, pp. 79–83, 2010.

[2] S. H. Kim, D. S. Kim, K. H. Huh, S. S. Lee, M. S. Heo, S. C. Choi, S. J. Hwang, and W. J. Yi, "Direct and continuous localization of anatomical landmarks for image-guided orthognathic surgery," *Oral Surg. Oral Med. Oral Pathol. Oral Radiol.*, vol. 116, no. 4, pp. 402–410, 2013.

Supervisors / Cosupervisors: Prof. dr. ir. Luc Claesen
Prof. dr. ir. Nele Mentens
ing. Wout Swinkels

UHASSELT

KU LEUVEN