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Monocular Pose Estimation Based on Global and Local Features

Marco Antonio Chavarria Fabila

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CHRISTIAN-ALBRECHTS-UNIVERSITÄT

ZU KIEL

Institut für Informatik der
Christian-Albrechts-Universität zu Kiel
Olshausenstr. 40
D – 24098 Kiel

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e-mail: mc@ks.informatik.uni-kiel.de

Dieser Bericht gibt den Inhalt der Dissertation wieder, die der Verfasser im Januar 2007 bei der Technischen Fakultät der Christian-Albrechts-Universität zu Kiel eingereicht hat.
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1. Gutachter	Prof. Gerald Sommer (Kiel)
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ABSTRACT

The presented thesis work deals with several mathematical and practical aspects of the monocular pose estimation problem. Pose estimation means to estimate the position and orientation of a model object with respect to a camera used as a sensor element. Three main aspects of the pose estimation problem are considered. These are the model representations, correspondence search and pose computation. Free-form contours and surfaces are considered for the approaches presented in this work. The pose estimation problem and the global representation of free-form contours and surfaces are defined in the mathematical framework of the conformal geometric algebra (CGA), which allows a compact and linear modeling of the monocular pose estimation scenario. Additionally, a new local representation of these entities is presented which is also defined in CGA. Furthermore, it allows the extraction of local feature information of these models in 3D space and in the image plane. This local information is combined with the global contour information obtained from the global representations in order to improve the pose estimation algorithms. The main contribution of this work is the introduction of new variants of the iterative closest point (ICP) algorithm based on the combination of local and global features. Sets of compatible model and image features are obtained from the proposed local model representation of free-form contours. This allows to translate the correspondence search problem onto the image plane and to use the feature information to develop new correspondence search criteria. The structural ICP algorithm is defined as a variant of the classical ICP algorithm with additional model and image structural constraints. Initially, this new variant is applied to planar 3D free-form contours. Then, the feature extraction process is adapted to the case of free-form surfaces. This allows to define the correlation ICP algorithm for free-form surfaces. In this case, the minimal Euclidean distance criterion is replaced by a feature correlation measure. The addition of structural information in the search process results in better conditioned correspondences and therefore in a better computed pose. Furthermore, global information (position and orientation) is used in combination with the correlation ICP to simplify and improve the pre-alignment approaches for the monocular pose estimation. Finally, all the presented approaches are combined to handle the pose estimation of surfaces when partial occlusions are present in the image. Experiments made on synthetic and real data are presented to demonstrate the robustness and behavior of the new ICP variants in comparison with standard approaches.