SUMMARY OF Ph.D. DISSERTATION

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Title

Research on 3D Surface Reconstruction by Deformable Model-based Methods

Abstract

In this paper, I describe my research work on three-dimensional surface reconstruction by deformable model-based methods.

3D reconstruction technique has been widely used for medical, anthropometry and commercial design. Deformable models offer a good solution for this purpose. By constraining extracted boundaries to be smooth and incorporating other prior information about the object shape, deformable models offer robustness to both image noise and boundary gaps and allow integrating boundary elements into a coherent and consistent description. Since deformable models are complemented on the continuum, the resulting model representation can achieve high accuracy.

There are basically two types of deformable models: free-form deformable models method (FDMM) and parametric deformable models method (PDMM). In this work, the former one is utilized for an application of human skin tissue intersection surface reconstruction from confocal microscope images. FDMM aims to impose smoothness on the prior model and encourage movement towards boundary elements in given images. However, the shape reconstruction of open manifold, such as dermo-epidermal surface in skin tissue, is difficult for this approach. I proposed modifications on initialization of prior model and definition of internal energy functions for processing open manifold. In experiments the 3D models of skin tissue intersection surface are reconstructed by implementing proposed methods in volumetric confocal microscope image data. The availability of proposed methods is validated in comparison with human expert observers.

Moreover, the energy function modified FDMM-based method is also performed in processing foot model reconstruction from multiple camera images. Thus this approach is shown as well as available for coping with closed object surface. However, because the FDMM-based method does not consider the global anatomical structure of object, distinct shape characteristics are removed by the smooth constraint. To address this issue, I proposed a PPDM-based method, in which prior knowledge (e.g., database), including a mount of the same class of object shape instances, is used to offer global shape constraint.

In PDMM the orientation and shape of object are described by a group of parameters, including scale, rotation, translate and weighting parameters of shape mode variations, which are estimated by analyzing the shape instances of prior knowledge. The parameters are optimized by the means of projecting the prior models to given images, so that the prior model approaches the desirable location according to the local image features within the global shape constraint. In foot shape reconstruction experiments, to validate the capability of proposed method, comparisons with aforementioned FDMM-based method and volumetric intersection method are implemented. As the result, the reconstructed 3D model of the PDMM-based method is more similar to object. Furthermore, high performance of the proposed PDMM-based method is also validated quantificationally by estimating the root mean square error between reconstructed model surface and original object.