Xiaoming Jiang

Dr. sc. hum.

Surface reconstruction using a micro-lens array based optical detector (MLA-D) – simulation and initial experimental study

Fach/Einrichtung: DKFZ (Deutsches Krebsforschungszentrum)
Doktorvater: Prof. Dr. Dr. Wolfhard Semmler

Optical imaging (OI) in preclinical research is characterized by several privileges, and is growing to be an indispensable modality *in vivo* molecular imaging. However, detected emitted signals in OI, either in bioluminescence imaging (BLI) or fluorescence imaging (FLI), are surface weighted. Therefore, the surface information of the imaged object plays a significant role in enhancing OI performance. The state-of-the-art methods generally require an additional imaging step (e.g., by means of a secondary structural modality) or additional hardware (e.g., laser-scanning approaches). Recently, a non-contact micro-lens array based optical detector (MLA-D) utilizing a purposely designed micro-lens array has been developed to enhance the performance of OI. The MLA-D possesses a thin construction size, and its imaging performance is optimal for objects positioned close to its optics. A single or multiple MLA-Ds can be arranged circumferentially in close proximity to the imaged object, hence allowing for a confined system assembly. The structure of a micro-lens array resembles the anatomy of an insect compound eye. Thus a single projection of MLA-D image contains three dimensional (3D) information. The placement of MLA-Ds around the imaged object even forms a typical setup of multiview projection system, which might enable the 3D surface retrieval. This thesis explores the feasibility of surface reconstruction using MLA-D from multiview projectional data.

The investigation is preceded with the modeling of MLA-D, and the simulation of MLA-D using a dedicated Monte Carlo based framework. Two proposed designs are assessed from the aspect of geometrical optics. To perform surface reconstruction, a new imaging instrumentation design is proposed with respect to the alignment of MLA-D and light sources. Provided the imaging system design and the obtained simulated dataset, several surface reconstruction methods are presented and evaluated quantitatively. The back-projection method can achieve a reasonable error rate (4.3%) while it cannot resolve concave areas of surface. The artifacts are less severe using MLA-D than those achieved using an orthographic camera model. The adopted feature based method can resolve the concave area while it yields a high error rate (5.1%). The proposed correlation method does have the ability to resolve concave areas and to achieve a high precision (mean accuracy 0.1mm, error rate 1.8%), even when using a low number of projection views without the requirement of any additional hardware. In addition, the initial experimental studies are also conducted for an assembled low resolution MLA-D through the sensor correction and the rotational system calibration. The investigation demonstrated that the surface of the imaged object could be obtained using a lower number of detector projections (40) compared with that using the conventional camera (100 − 300). The optical flow based method can reconstruct the surface of the imaged object from a single view but yielded a coarse result (depth map).