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Combining MEMS-based IMU data and vision-based trajectory estimation

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Abstract. This paper presents an efficient location tracking algorithm that integrates vision-based motion estimation and IMU data. Orientation and translation parameters of the mobile device are estimated from video frames or highly overlapped image sequences acquired with built-in cameras of mobile devices. IMU data are used to maintain continuity of the orientation estimation between sampling of the image homography calculation. The developed algorithm consists of six primary steps: (1) pre-processing; (2) feature points detection and matching; (3) homography calculation; (4) control points detection and registration; (5) motion estimation and filtering; (6) IMU data integration. The pre-processing of the input video frames or images is to control the sampling rate and image resolution in order to increase the computing efficiency. The overlap rate between selected frames is designed to remain above 60 % for matching. After preprocessing, feature points will be extracted and matched between adjacent frames as the conjugate points. A perspective homography is constructed and used to map one image to another if the co-planar feature points between subsequent images are fully matched. The homography matrix can provide the camera orientation and translation parameters according to the conjugate pairs. An area-based image-matching method is employed to recognize landmarks as reference nodes (RNs). In addition, a filtering mechanism is proposed to ensure the rotation angle was correctly recorded and to increase the tracking accuracy. Comparisons of the trajectory results with different combinations among vision-based motion estimation, filtering mechanism and IMU data integration are evaluated thoroughly and the accuracy is validated with on-site measurement data. Experimental results indicate that the develop algorithm can effectively estimate the trajectory of moving mobile devices and can be used as a cost-effective alternative for LBS device both in outdoor and indoor environment.

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