Methods for Feature Point Aggregation of Optical Flow for Orientation Estimation

László Kundra

Estimation of precise orientation using only inertial sensors is a basic problem of the field. Several algorithms have been developed and extensively discussed regarding bias compensation, sensor fusion with complementary and Kalman filters, and so. Although there are impressive results for specific application domains, their restrictions that make them feasible are not generalizable. In this research, inertial measurement unit (IMU) was aided with optical flow based feature displacements from an on-board camera, to calculate a robust and reliable orientation. Such situations when a camera is available is quite frequent. (Mobile phones, unmanned aerial vehicles (UAVs), etc.) However, calculating optical flow on whole images will result a large amount of vectors, representing the addition of physical displacement and rotation. Using algorithms that are beyond the scope of this paper, these vectors can be assigned a reliability value, and physical displacement can also be compensated. Having the orientation change as a set of vectors, an appropriate method can aggregate them into one representative angle. Using these angles and angular velocity in combination with IMU data, a more robust and reliable orientation can be estimated.

The purpose of this paper is to introduce and compare different methods for aggregation on both simulation and real world data. First, the most straightforward ways are examined to aggregate, like mean and median of the vectors. To avoid enormous errors brought into the calculation by outlier points, when calculating the mean these points are rejected. Median by its definition is insensitive for such perturbations, however the central element is not always a good selection. For this, weighted medians has also been considered. Regular weighted median assigns a weight to each item, and by doing so, the central position may point to an item different from the median. An other inspected modification to the median is a method using coefficients to sum the ordered list. In this case the sum of the coefficients should be 1. An other approach to find the most plausible angular rate is to find where the density of these vectors is maximal. In this case, we suppose that there are some vectors that have nearly the same representation of the rotation, thus lying densely to each other, while deceiving vectors are spread in the range. Finding the location of this maximum can be achieved in various way. One method is to count nearby elements (in an ϵ range) for each input point. Where the density is high, this function will have a large output. An other technique is to take the sum of Gaussian functions fit to each point. The density can be calculated the same way as for the previous method. These methods all need some parameters, or parameter vectors, thus these can be calculated based on the nature of the application field.

Measurements were performed on mobile devices (Samsung Galaxy S2 and S4, with different camera resolution and feature point count). Using measurement data, we performed several comparison and tuning of parameters, and for orientation estimation we could produce very low angular rate bias, that led to negligible drift over time.

Acknowledgements

This work was partially supported by the European Union and the European Social Fund through project FuturICT.hu (grant no.: TAMOP-4.2.2.C-11/1/KONV-2012-0013) organized by VIKING Zrt. Balatonfured. This work was partially supported by the Hungarian Government, managed by the National Development Agency, and financed by the Research and Technology Innovation Fund (grant no.: KMR-12-1-2012-0441).