Course Work Cover Sheet - the School of Computing

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Questions

When testing quadratic interpolation on image pairs it is mentioned that Gaussian noise was added up to a sigma of 30 however figure two only shows subpixel disparity estimates up to a sigma value of 20. This is a lot of noise but did the distribution of subpixel disparity continue as suggested by the previous pattern of increasing frequency of peaks around integers in the distribution? At what level of noise did the subpixel disparity estimate become unpractical?

The Kalman filter approach used helps to reduce the effect of noise, but at the cost of assuming movement is restricted to xy directions. Can the system handle objects moving in the z direction? What uncertainty would be expected?

Summary

Kalman Filter

The system uses a Kalman filter approach produce a disparity map. The Kalman filter approach minimizes the effect of noise by looking at several pairs of frames over a period of time instead of just a single pair. It also allows the system to simultaneously find uncertainties in the disparity map while it is created.

Subpixel Interpolation

Problems are identified in using unweighted quadratic interpolation approaches to produce subpixel accurate disparity maps. Due to the asymmetry of the error function e around its minimum. Disparities were found through experimentation to cluster around integer values (as shown in the corresponding graphs) and not be distributed uniformly. This was solved by a weighting scheme that placed importance on points with low error values and the development of a new interpolation scheme that increases the symmetry as the error function decreases to its minimum. This is again shown further down in Fig.2

Estimating Uncertainty

A new measure of uncertainty is suggested which overcomes problems caused by noise. Old uncertainty metrics were tested experimentally. Observations showed that low uncertainty could occur in regions where the disparity values are calculated incorrectly, and uncertainty can decrease in areas where there are high amounts of noise which can again result in improper matching of areas. The new uncertainty metric aims to increase with noise; a larger SSD error should be represented by an increase in the jaggedness of the error function e around the minimum, and the larger the variation in the peaks of the error function the greater value of this uncertainty metric. The three features of an ideal error metric were quantified as coefficients, tested individually and combined into a complete error estimator.

Integrating Stereo and Motion

All disparities and their associated uncertainties are then fed to the Kalman filter which computes the motion in the resulting depth map of each pixel by computing the change in both motion(horizontal) and stereo(vertical) disparities. Both of these calculations are determined by calculating the difference between features of the cameras taking the images. This provides the distance between each pixel along the x axis. The next step is measure the uncertainty increase via exponential age-weighting. The third and final step is to resample and interpolate the depth maps experimenting with linear, non-linear and custom resampling methods.

Testing

Testing took place using a camera on a horizontal rail, with nominal error on the calculated focal length and extrinsic parameters. The complete system was tested on twenty sequences using the system outlined above. Histograms show that the distribution of estimated depths were concentrated around their target value. The results of the depth map of accepted points with a confidence above 90% threshold prove to be very clear for such complex objects with the 3D depth map showing a remarkable amount of information for such a scene. The inclusion of median filtering aids in the reconstruction of fine edge features of the objects while reducing the amount of erroneous holes detected within them.