Multi-Resolution Motion Estimation Using NCC-SAT (MRME-SAT)

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Background

Motion estimation techniques are widely used for video coding applications, the estimation of optical flow, and stereo disparities; however, the real-time motion estimation is not easily achieved due to the enormity of required computations.

One family of fast block motion estimation algorithms relies on the idea of predicting an approximate large-scale motion vector (MV) in a coarse-resolution video and refining the predicted MV in a multi-resolution fashion to obtain the MV in the finer resolution.

Goals

• Develop a fast algorithm for block motion vector estimation based on spatial correlation and a multi-resolution scheme
• Analysis of speed and error of estimated motion vector for different methods of pyramidization (Gaussian, Mean, Sub-sampling) for various test videos

Fundamental Questions/Challenges

• Sum of Absolute Difference (SAD) vs. Normalized Cross Correlation (NCC)
  The NCC measure is more robust than SAD under linear illumination changes, so the NCC measure has been widely used in object recognition and industrial inspection. Although the similarity measure of NCC is more robust than SAD, the computational cost of NCC is very high.
• How to make NCC-based algorithm fast?
  Introduction of summed array tables (SAT) for calculation of NCCs

Speed up factor >9

Which down-sampling method is suitable for pyramidization?

Gaussian Pyramidization is the most efficient method

Algorithm

MV refinement process also includes adaptive successive elimination of motion vector candidates

Test video detail: akiyo, 144 x 176, 300 frames; Template size: 64 x 48; and Pyramidization method : Gaussian

Conclusions

• For Gaussian pyramidization, we got speed up factor >5 without degrading performance for test videos
• Best parameters for Motion estimation
  √ LSR = 2
  √ Level = 2
  √ Pyramidization method = Gaussian
  √ Number of Motion vector candidates = 2

Overall speed up factor > 45

Related Work/Interaction with Other Projects

• Intermodal Freight Train Analysis System, Computer Vision and Robotics Laboratory, UIUC, [http://vision.ai.uiuc.edu/]

Future Work

• Implement adaptive refinement process for motion vector
• Perform theoretical image-model-based study of this algorithm and find motion estimation solution for general case
• Integrate MRME-SAT algorithm with “Railroad Project”