Estimation of Optical Flow for Large Displacements

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Overview

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Introduction

- Disadvantages of actual optical flow estimation methods:
  - computationally expensive
  - use more than 2 frames
  - work well only for small displacements

- Needs for navigation applications:
  - computationally efficiency (real-time processing)
  - estimation of large displacements
Large displacements — why?

- Imagine the following example:
  - camera mounted inside a car
  - sharp turn to the left leads to large optical flow to the right
  - flow of 25 pixels/frame and more

- How can we manage it?
  - multi-resolution estimation
  - prediction of global flow field parameters
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**Adjusting of flow regions**

- A flow region can compute a flow of 2 to 3 pixels per frame accurately.
- In general, flow regions in successive frames have the same position.
- If we adjust the flow region in the second frame to the predicted flow:
  - the remaining flow is smaller
  - we can handle large flows (if we have a good prediction)
Multi-resolution estimation

• Create an image hierarchy
  – downsample image rows and columns by a factor of two
  – apply a low-pass filter (for more accurate derivative computation)

• Estimation of optical flow at different levels of resolution
  – start at top of the hierarchy
  – compute flow at a given level of the hierarchy
  – project it to the next lower level and adjust the flow regions
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**Prediction of global flow field parameters**

- Estimate a linear model of global flow field parameters
  - 4 to 6 previously computed parameter quadruples
  - method of least squares
- Based on this model, extrapolate the 4 parameters for the next frame
- Adjust the flow regions to fit the predicted flow

\[
\begin{align*}
t_x &= \frac{\sum_{a \in A} m_x}{|A|} \\
t_y &= \frac{\sum_{a \in A} m_y}{|A|} \\
\alpha &= \frac{\sum_{a \in A} x m_y + \sum_{a \in A} y m_x}{\sum_{a \in A}(x^2 + y^2)} \\
z &= \frac{\sum_{a \in A} x m_x + \sum_{a \in A} y m_y}{\sum_{a \in A}(x^2 + y^2)}
\end{align*}
\]
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Optical flow visualization

![Optical Flow Visualization](image-url)
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Example flow for the diverging tree sequence (frame 10 and 25)
Comparison (1)

![Graphs showing hierarchical estimation and prediction-based estimation.](image)
Comparison (2)

• Multi-resolution estimation:
  – higher complexity through hierarchy construction
  – wrong flow estimation at high hierarchy level affects all lower levels
  – limited number of hierarchy levels
  + no dependence on a camera motion model

• Prediction-based estimation:
  – dependence on camera motion model
  ± estimation of flow field parameters leads to slightly higher complexity
  + largest range for displacements
Conclusion and Future Work

- Results of the new method are comparable or better than those of multi-resolution estimation methods
- Good performance for small images
- Estimation of global flow field parameters also allows the compensation of optical flow produced by egomotion
- Acceleration of estimation algorithms with SIMD-enhanced microprocessors (AltiVec, 3DNow!, ...)

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