Estimation of Optical Flow for Large Displacements

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Overview

- Introduction
- Adjusting of flow regions
- Multi-resolution estimation
- Prediction of global flow field parameters
- Example flow
- Comparison
- Conclusion and Future Work

Introduction

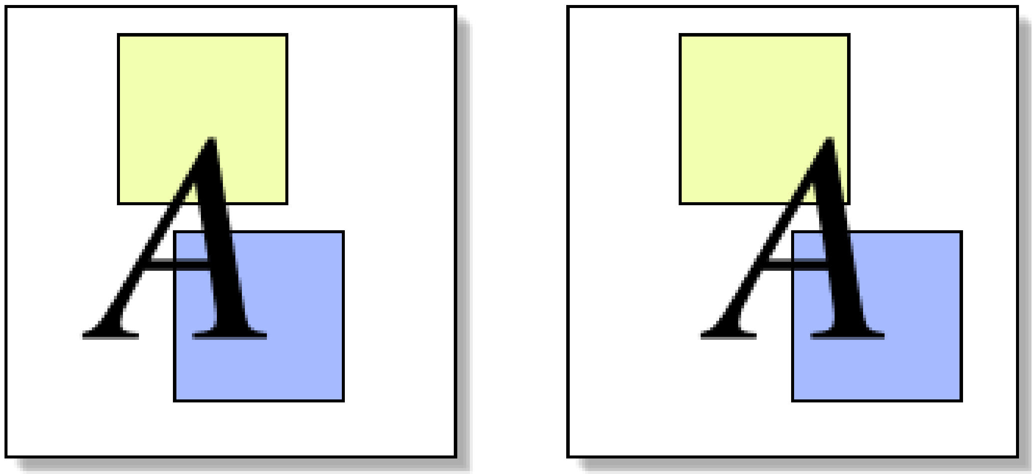
- Disadvantages of actual optical flow estimation methods:
  - computationally expensive
  - use more than 2 frames
  - work well only for small displacements
- Needs for navigation applications:
  - computationally efficiency (real-time processing)
  - estimation of large displacements

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

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

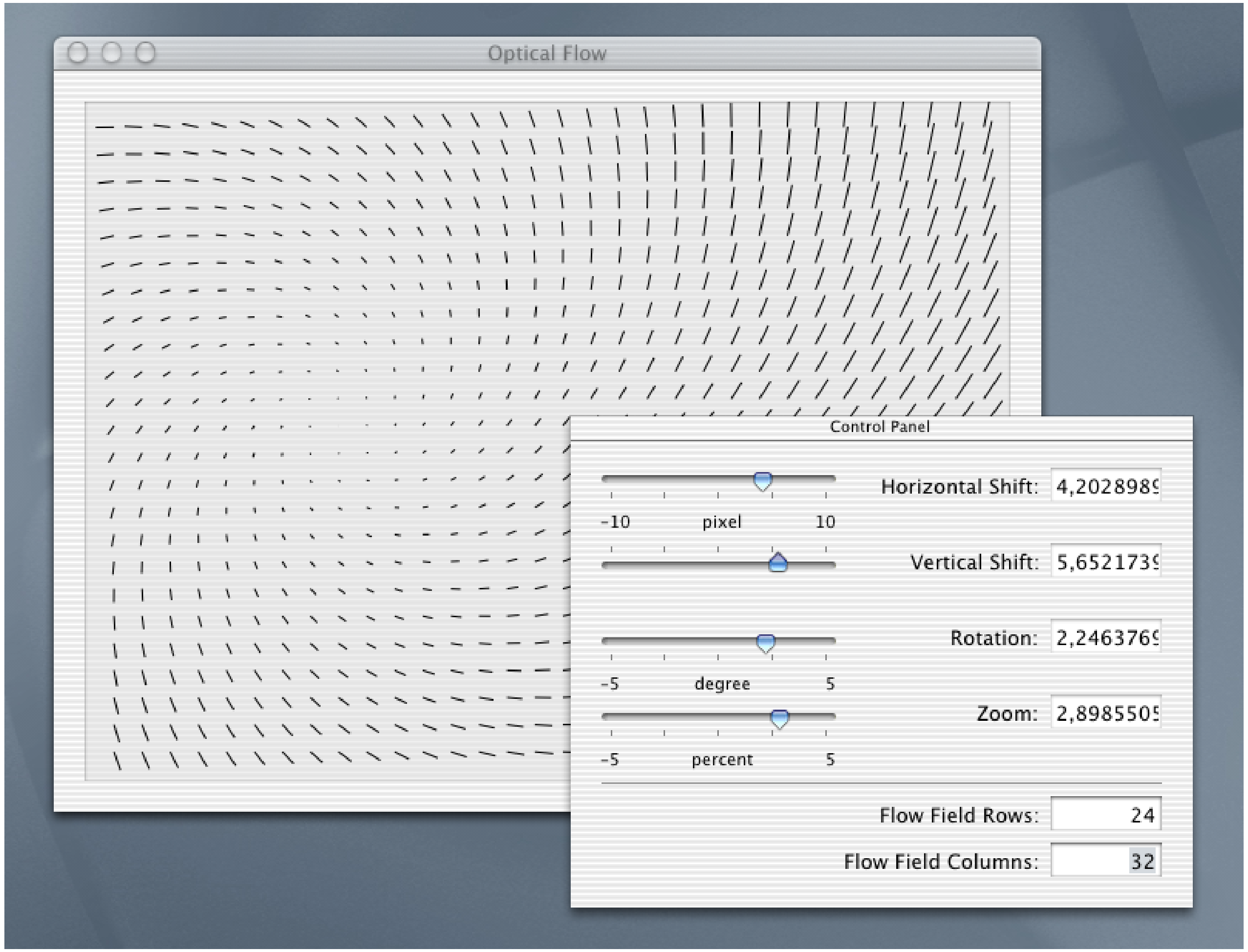
Prediction of global flow field parameters

- 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

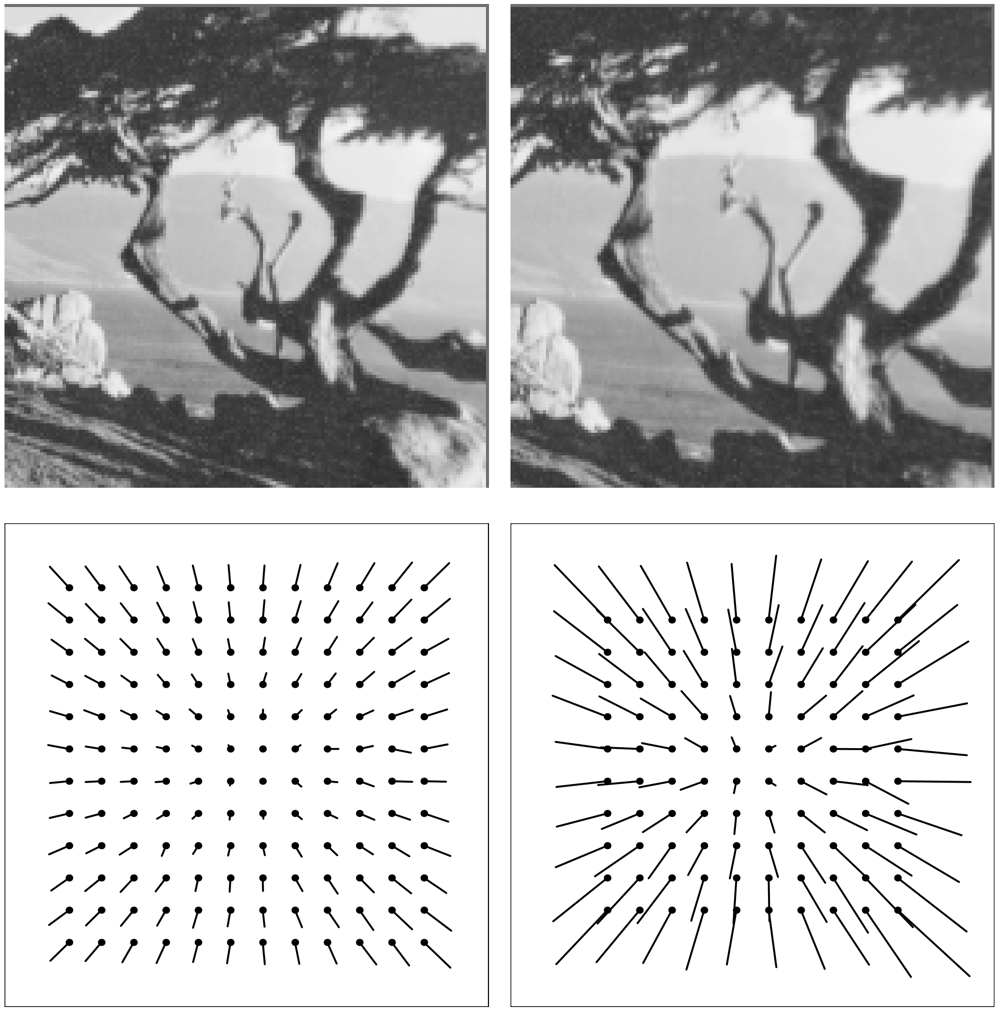
$$t_x = \frac{\sum_{a \in A} m_x}{|A|} \qquad z = \frac{\sum_{a \in A} x m_x + \sum_{a \in A} y m_y}{\sum_{a \in A}(x^2 + y^2)}$$

$$t_y = \frac{\sum_{a \in A} m_y}{|A|} \qquad \alpha = \frac{\sum_{a \in A} x m_y + \sum_{a \in A} y m_x}{\sum_{a \in A}(x^2 + y^2)}$$

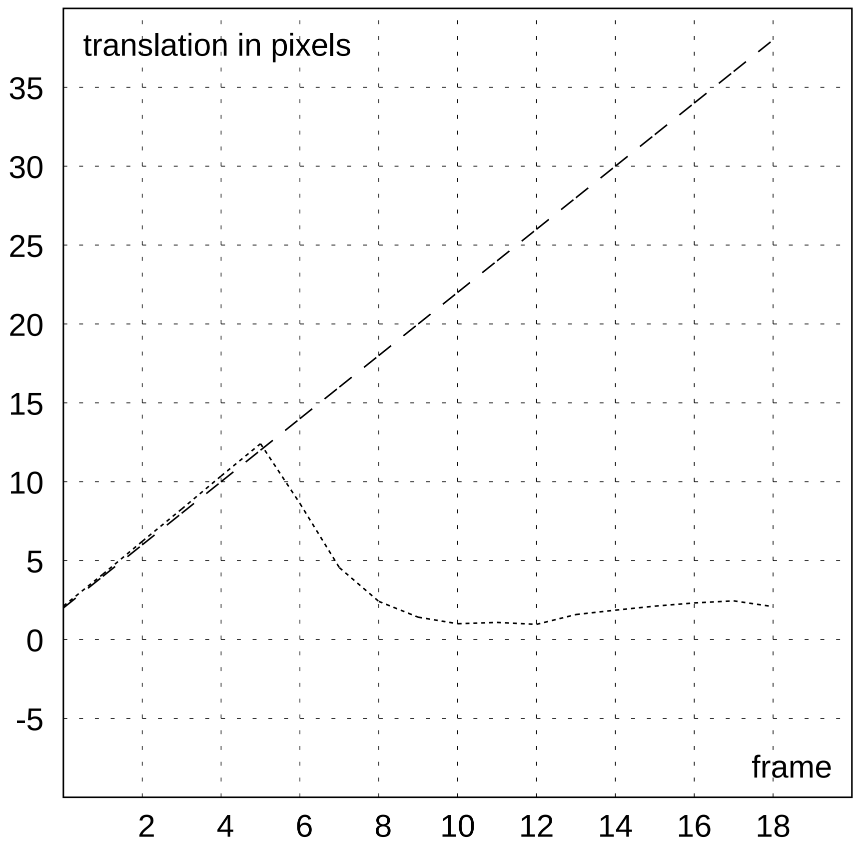
Optical flow visualization



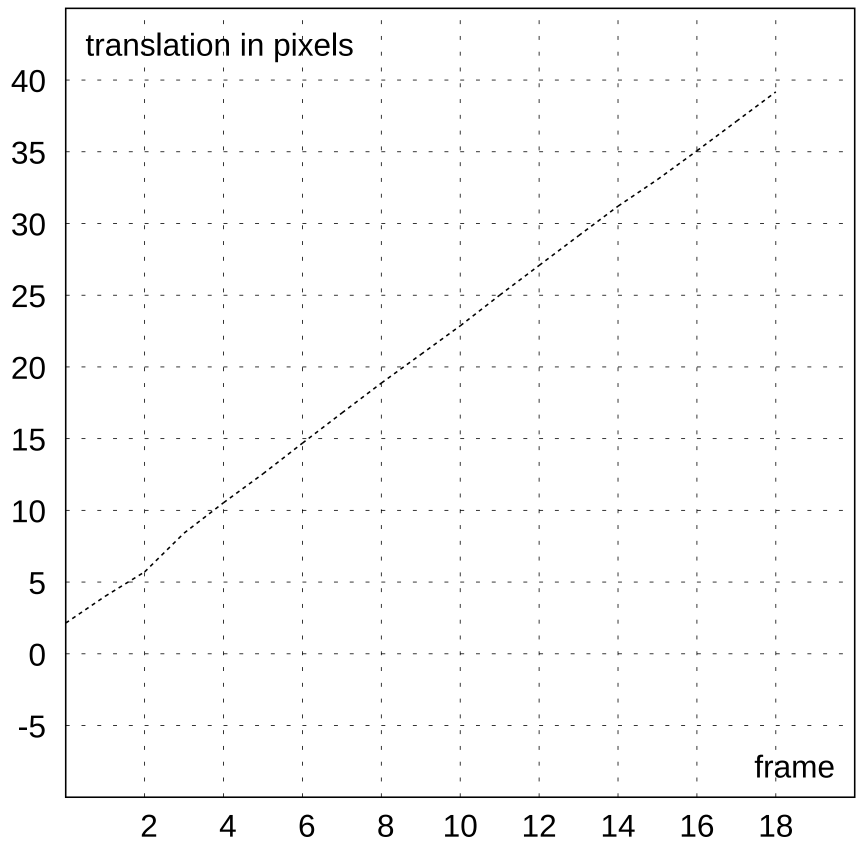
Example flow for the diverging tree sequence (frame 10 and 25)



Comparison (1)



hierarchical estimation



prediction-based estimation

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
  - $\pm$ 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!, . . .)