CS-512 – Assignment 7 (4%)

Motion analysis

Due by: November 27, 2018

Review questions

Answer the following questions. Make sure that your answers are concise. In questions requiring explanations, make sure your explanations are brief.

1. Motion
   (a) Explain the difference between 3D motion vectors, 2D projected motion vectors, and observed 2D motion vectors (optical flow). Is it possible that motion in 3D will not produce optical flow vectors?
   (b) What will be the projected motion field in a video taken by a car driving on a straight road a looking to the side (assume that objects in the scene do not move. Where will projected motion vectors be larger?
   (c) What will be the projected motion field in a video taken by an airplane aiming to land at a fixed point looking forward (assume that objects in the scene do not move. Where will projected motion vectors be larger?
   (d) Write the fundamental motion projection equation relating 3D motion vectors V to 2D projected motion vectors v, the focal length f, and the position of the object point P. Assume the z coordinate of the object point is z, and that the z component of the 3D motion vector is V_z. What is the z component of the projected motion vector v, according to this equation.
   (e) Assuming 3D motion with translational velocity τ and rotational velocity ω, write the equation for the projected translational and rotational motion.
   (f) Explain what the projected motion field looks like in the case of pure translational motion. Make sure to distinguish between the cases where there is or there is no translational component in z.
   (g) Write the equations for the instantaneous epipole.
   (h) Explain when motion parallax is created, and write the relative motion field equations.
2. Optical flow
   (a) Write the optical flow constraint equation (OFCE). What is the basic assumption that is used to derive this equation.
   (b) Explain the aperture problem. What part of the motion can we hope to recover based on a single point?
   (c) Explain how the aperture problem is addressed in block-based optical flow estimation methods.
   (d) Write the objective function of block-based optical flow estimation in a patch. Write the system of equations that has to be solved in order to find the optical flow in the patch. What is the purpose of weighted block methods? How do the weight modify the solution?

(e) Explain the advantage of an affine motion model. Write the objective function for the affine model, then write the solution. How are the motion vectors in a patch recovered once the affine motion parameters are recovered?

(f) Write the objective for global motion estimation (Horn-Schunck). What is the advantage of this solution? What is the difficulty in global motion estimation.

(g) Explain the Horn-Schunck iterative global optical flow estimation algorithm. How can the first iteration be initialized in an informed manner?

Assignment Specifications

In this assignment you need to implement one of several motion analysis algorithms.

- The input image should always be converted to grayscale before processing it. It should either be read from a file or captured from a camera.
- The main parameters of each algorithm should be made available for interactive manipulation through keyboard/mouse/trackbar interaction.
- You may NOT use the OpenCV function which directly implements the algorithm you choose. You may, however, use it for verification purposes. You may use other OpenCV functions as necessary. Use Python and OpenCV for the implementation.
- Your program must include a help key describing its functionality.
- You need to evaluate the performance of the algorithm you choose using test data. The results of your evaluation should be included in your report. Try to determine the strengths and weaknesses of the algorithm.
- For submission instructions and the necessary format of the report refer to assignment 1.
- **The assignment must be submitted by the due date (regardless of any available late days).**

Optical flow estimation

1. In this part you need to estimate the optical flow vectors in a sequence of images. The input to the program should be captured from the camera or read from a video file.
2. The optical flow vectors should be computed and displayed on one of the images in the sequence as colored straight line segments. Pressing 'P' should pause/release the current image.
3. You may choose to implement are the Lucas-Kanade, affine-flow, or Horn-Schunk algorithms.
4. The spatiotemporal derivatives should be computed by extending the spatial gradient estimation technique you used in the previous assignments.
5. If implementing the Lucas-Kanade or affine motion, estimate the reliability of the motion estimation based on the ratio of smallest eigenvalue the system matrix $(A^T A)$, where high value indicates high reliability. The reliability should be displayed by modifying the intensity of the drawn optical flow vectors.
6. Test video sequences are available on the cs512 website.