Assignment 3: Voxel-based Tracking

Deadline: 10/3/2019 at 23.00

Instructions:

I. Overall goal and software

1. You will be making use of the framework of Assignment 2, including your improved background subtraction.
2. You can download four, 4-person, videos. You will use this video to do this assignment, you should be able to reconstruct its 3D data without a problem if you correctly did Assignment 2.
3. The goal of this assignment is to (1) make a color model for each person offline and (2) label the voxels based on this color model in subsequent frames.

II. OFFLINE: make color model for each person

1. You will use a video with 4 persons walking around, which you can download here: http://www.cs.uu.nl/docs/vakken/mcv/download/4persons.zip
2. If your own camera intrinsics from Assignment 2 are below par, I will provide new ones for you upon request (but not until after the deadline of Assignment 2 of course).
3. For the best results make sure that you find a frame in which the persons are largely visible (not occluded) in all 4 camera views, and that the people are as well separated as possible.
4. Cluster the positions of the voxels (ignore the height) using K-means from OpenCV.
   ○ Use K-means in such a way that you don’t get stuck in a local minimum. Running multiple times and then selecting the best configuration?
   This should give you (1) a label for each voxel and (2) a number of cluster centers, each corresponding to the center of the person.
5. Get each voxel’s 2D foreground projection of one or multiple cameras for each person (think about occlusions!). Make color models based on the projected frame pixels, for each person. You can do anything you like, including color histograms (1, 2 or 3 channels, in different color spaces, find a suitable one), Gaussian Mixture Models (using Expectation Maximization (EM) in OpenCV) or a mean color (but this will not grant you the full points for this step). Looking at your data helps to determine which option is wise.
6. You will have to implement the color model yourself. No code from a third party.

III. ONLINE: track the people

1. When you have the color model of each person, you can track them by using the offline histograms as a reference model for clusters of voxels
   a. Given a frame, do initial spatial voxel clustering with K-Means, similar to the offline setting. Again, avoid local minima. You will end up with 4 clusters of
voxels. Typically cluster 1 does not correspond to person 1 so we need to find out which cluster belongs to which person. You can earn bonus points if you come up with a smart way of still getting suitable clusters even if one or more people are outside the voxel space (this occasionally happens).

b. Determine each cluster’s color label by creating a color model from each cluster, and compare it to the OFFLINE-color models based on a color distance measure suitable for your model. This means you need to project all voxels with the same label to your one (or more) selected view(s) and then determine from there which person they correspond to. Do not repeatedly apply this step for a single voxel.

c. Now store the position of the cluster on the floor. That’s it! :)

2. You will get bonus points if you implement smart ways of determining the final position of each person, increasing accuracy. Tracking might be a good idea, but only in addition to the initial labeling based on color. Smoothing is another idea.

3. You will get bonus points if you can clean up the 3D space based on your voxel label assignments. Some voxel can be determined to not belong to any person (spatial outliers, “ghost voxels” or shadow voxels for instance).

4. You will also get bonus points if you find a smart way to deal with occlusions when labeling the voxel clusters.

5. The output should be (1) a movie of the same space with voxels colored according to the clustering, see also the example below, and (2) a colored trajectories image of each person’s path throughout the video. Draw the trajectories on an image that represents the floor of the space. You may also draw this trajectory in the 3D space, but I expect to receive an image (png/jpg) of the floor, showing the complete trajectories of the entire sequence. You may use Excel or other software.

IV. Example output
https://www.youtube.com/watch?v=bh4O2UhJe9o

V. Grading

- Report (clear what you have done and why): 10
- Video (clear what the output of your algorithm is): 10
- Intrinsics/extrinsics (calculated properly): 10
- Offline construction of color models (frame chosen, cameras used, occlusion): 10
- Color model (GMM and histograms vs. mean, selection of channels, smart bins): 10
- Clustering (avoided local minima, ignored Z-axis): 10
- Identification (matching color models to voxel projections, occlusion): 10
- Path (smoothness, taking into account missing people): 10
- Bonus: max 20
  - Finding a way of dealing with people outside the voxel space: 10
  - Tracking: 10
  - Smoothing of trajectories: 5
  - Getting rid of outliers and ghost voxels: 5
VI. Frequently Asked Questions and Notes

1. Check the questions and answers of Assignment 2.
2. **Q:** Are we allowed to use code available on the internet for color models or the tracking?
   **A:** No

Submission:

1. Names and student ID numbers.
2. Submit the code (no libraries!), (1) with link to a movie (YouTube/ Vimeo/ Dropbox/ WeTransfer, etc) with voxels colored according to the clustering (2) the 2D trajectories of the positions of each person on the ground, in an image file. For (1) provide a link to a video source. Submit (2) through the system, together with a detailed report of what you have done and your source code (no libraries, binaries or videos!).
4. **Deadline:** Sunday March 10, 2019, at 23.00
5. If you found that your assignment partner did not work properly, notify Ronald.

Good luck!