Overview

Space carving

Single Object Recognition via SIFT

Histogram of Oriented Gradients (HOG)
Space Carving

Objective:

- Implement the process of space carving.

Lectures:

- Active Stereo & Volumetric Stereo
Visual hull:
an upper bound estimate
Review: Space Carving

Silhouette 1

object

Silhouette 2
Goal of Space Carving

Silhouette 1

Silhouette 2

object?
Review: Space Carving

Silhouette 1

voxels

Silhouette 2
Review: Space Carving

Silhouette 1

voxels

Silhouette 2
Silhouette 1

voxels
Review: Space Carving

Image 1

voxels
Review: Space Carving

Silhouette 1

voxels

object

Silhouette 2
Steps:
- Estimate silhouettes of images (could be based on some heuristics, e.g. color)
- Form the initial voxels as a cuboid
- Iterate over cameras and remove the voxels which project to the dark part of each silhouette
Space carving - (a) (b) (c)

Steps:
- Estimate silhouettes of images (could be based on some heuristics, e.g. color)
- Form the initial voxels as a cuboid
  - You may find these functions useful: np.meshgrid, np.repeat, np.tile
- Iterate over cameras and remove the voxels which project to the dark part of each silhouette
  - Question: What will the voxels look like after the first, second, … iteration?
Space carving - (d)

Steps:
- Estimate silhouettes of images (could be based on some heuristics, e.g. color)
- Form the initial voxels as a cuboid
  - Question: What will the cuboid look like after each iteration?
- Iterate over cameras and remove the voxels which project to the dark part of each silhouette

![Diagram of coarse carving process with iterations and final output]
Steps:
● Estimate silhouettes of images (could be based on some heuristics, e.g. color)
   ○ Problem: The quality of silhouettes is not perfect.
   ○ The silhouette from each camera is not perfect, but the result is ok. Why?
   ○ Experiment: Use only a few of the silhouettes.
● Form the initial voxels as a cuboid
● Iterate over cameras and remove the voxels which project to the dark part of each silhouette
Objective:

● Understand how to use SIFT features for object recognition.
● Implement the RANSAC algorithm.
● Implement the Hough Transform algorithm.
● (Implementation of SIFT is not required.)

Lectures:

● Fitting and Matching
● Detectors and Descriptors
We’ve implemented SIFT descriptor for you, and your task is using it for object recognition.

Read: **Section 7. Application to object recognition** in Lowe’s SIFT paper 

Be sure to understand what does the threshold mean and how to use it.
RANSAC to refine matching

Basic idea: use RANSAC to fit a homography matrix $H$ between two set of key points. Only keep the inliers for matching, remove the outliers.

Question: how many pairs of correspondences do we need in each iteration?
Theoretical properties about RANSAC: see lecture notes / slides

Understand the relations between:

- $N$: number of samples
- $e$: outlier ratio
- $s$: minimum number of data points to fit the model
- $p$: probability guaranteed
Find quantitative relation between two bounding boxes

Input \((u_1, v_1, s_1, \theta_1; u_2, v_2, s_2, \theta_2; x_1, y_1, w_1, h_1)\)  
Output \((x_2, y_2, w_2, h_2, o2)\)

Keypoint1  Keypoint2  Bbx1  Bbx2 & Orientation
Objective:

- Implement HOG features.

Lectures:

- Detectors and Descriptors

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**HoG = Histogram of Oriented Gradients**

Navneet Dalal and Bill Triggs, Histograms of Oriented Gradients for Human Detection, CVPR05

- Like SIFT, but…
  - Sampled on a dense, regular grid around the object
  - Gradients are contrast normalized in overlapping blocks
Histogram of Oriented Gradients (HOG) - Online Reference

https://www.learnopencv.com/histogram-of-oriented-gradients/
Histogram of Oriented Gradients (HOG) - Overview

Steps:

- Preprocessing the image.
- Calculate the gradient image.
- Calculate the gradient histogram of each cell.
- Normalize each block.
- Calculate the HOG feature vector.
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Compute the gradients of image (angles, magnitudes)

The way that the angles and magnitude per pixel are computed as follows:
Given the following pixel grid

\[
\begin{array}{cccc}
P1 & P2 & P3 \\
P4 & P5 & P6 \\
P7 & P8 & P9 \\
\end{array}
\]

We compute the angle on P5 as \(\arctan(dy/dx) = \arctan(P2-P8 / P4-P6)\).

The magnitude is simply \(\sqrt{(P4-P6)^2 + (P2-P8)^2}\)
Steps:

- Preprocessing the image.
- Calculate the gradient image.
- Calculate the gradient histogram of each cell.
  - The output shape is (nbins,).
- Normalize each block.
- Calculate the HOG feature vector.
Histogram of Oriented Gradients (HOG) - (c)

Steps:

- Preprocessing the image.
- Calculate the gradient image.
- Calculate the gradient histogram of each cell.
- Normalize each block.
  - We use a stride of 50% of the block size.
- Calculate the HOG feature vector.
Thank You