Image Feature Descriptors

Course 3, Module 2, Lesson 2

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Image Features: A General Process

Images from CITYSCAPES dataset: https://www.cityscapes-dataset.com/

Learning Objectives

- Learn what characteristics make a good feature descriptor
- Learn different algorithms used to extract feature descriptors from images

Feature Descriptors

- **Feature:** Point of interest in an image defined by its image pixel coordinates $[\boldsymbol{u}, \boldsymbol{v}]$
- **Descriptor**: An **N-dimensional** vector that provides a **summary** of the image information around the detected feature

Position: $[u, v]$

Descriptor: $\{f_1 \ldots \ldots \ldots f_N\}$

Feature Descriptors

- **Feature descriptors** should have the following characteristics:
  - **Repeatability:** manifested as **robustness and invariance** to translation, rotation, scale, and illumination changes

=

Feature Descriptors

- **Feature descriptors** should have the following characteristics:
  - **Repeatability:** manifested as **robustness and invariance** to translation, rotation, scale, and illumination changes
  - **Distinctiveness:** should allow us to distinguish between two close by features, very important for matching later on

$\neq$

Feature Descriptors

- **Feature descriptors** should have the following characteristics:
  - **Repeatability:** manifested as **robustness and invariance** to translation, rotation, scale, and illumination changes
  - **Distinctiveness:** should allow us to distinguish between two close by features, very important for matching later on
  - **Compactness & Efficiency:** reasonable computation time

Designing Invariant Descriptors: SIFT

- **S**cale **I**nvariant **F**eature **T**ransform (**SIFT**) descriptors: [Lowe 1999]
  1. 16 x 16 window around detected feature
  2. Separate into 4 cells, each comprised of 4 x 4 patch of pixels
  3. Compute **edge** orientation of each pixel in the cell
  4. Suppress **weak edges** using a predefined threshold
  5. Construct **32** dimensional **histogram of orientations** for each cell, then concatenate to get **128 dimensional descriptor**

Scale Invariant Feature Transform

- SIFT is an example of a very well human engineered feature descriptor, and is used in many state-of-the-art systems
- The above process is usually compute on rotated and scaled version of the 16 x 16 window, allowing for better scale robustness
- Combined with the DOG feature detector, SIFT descriptors provide a scale, rotation, and illumination invariant detector/descriptor pair

Other Descriptors

- **S**peeded-**U**p **R**obust **F**eatures (**SURF)**
- **G**radient **L**ocation-**O**rientation **H**istogram (**GLOH**)
- **B**inary **R**obust **I**ndependent **E**lementary **F**eatures (**BRIEF**)
- **O**riented Fast and **R**otated **B**rief (**ORB**)
- Many more !

Summary

- Feature descriptors are N-Dimensional vectors characterizing an image's point of interest
- Features descriptors should be **repeatable, distinctive, compact and efficient**

- **Next: Feature Matching**