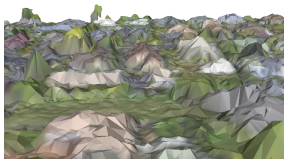
COSC470 Course Overview

COSC470: Special Topic
Computer Vision | 3D Reconstruction
Steven Mills

Processing overview

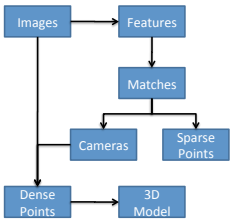
- We are given a set of 2D images

- We want a 3D model



Processing Pipeline

- 'Standard' structure from motion
  - Detect image features
  - Match features between image pairs
  - Estimate relative camera pose and scene structure
  - Dense stereo matching
  - Mesh creation
  - Texture mapping



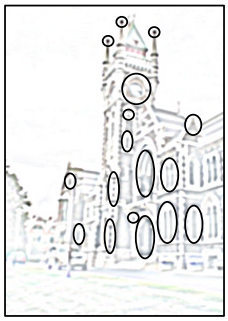
Lecture Plan

1. Introduction
2. Image Processing
3. Feature detection
4. Feature matching
5. Cameras + Transforms
6. Transform estimation
7. Image Warping
8. Stereo Geometry
9. 3D Reconstruction
10. (?)
11. Bundle Adjustment
12. Surface modelling
13. Review

Image Processing

- Input: A set of images
- Representing images
- Working with images
- Image filtering

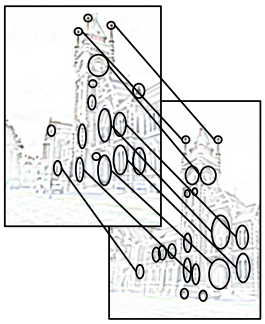
Feature Detection



- Identifying distinctive points in images
- Types of features
- Detecting features
- Describing features

Feature Matching

- Relating pairs of images
- Correspondence issues
- Matching descriptors
- Experiments and evaluation
- Assignment 1



Cameras and Transforms

$$x = PX$$
$$P = K[R\,|\,t]$$
$$= \begin{bmatrix} f_x & s & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \end{bmatrix}$$
$$R = R_x R_y R_z$$
$$R_z = \begin{bmatrix} \cos(\theta) & \sin(\theta) & 0 \\ -\sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$
$$t_x v = t \times v$$
$$t_x = \begin{bmatrix} 0 & t_1 & -t_2 \\ -t_1 & 0 & t_3 \\ t_2 & -t_3 & 0 \end{bmatrix}$$

- Representing problems
- Matrices and vectors
- 2D + 3D transforms
- Cameras and projection

Transform Estimation

- Solving equations
- Types of transform
- Least Squares fitting
- RANSAC methods

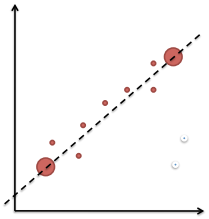
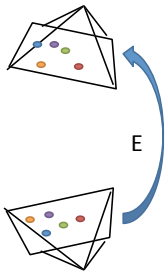


Image Warping

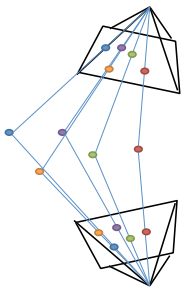
- 2D Mosaicing
- Transforming images
- Image compositing
- Mosaicing is one option for assignment 2

Stereo Geometry

- Combining two views
- Epipolar geometry
- Fundamental and essential matrices
- Estimating F and E



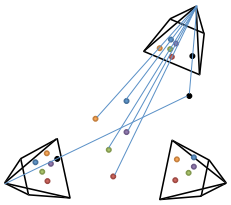
3D Reconstruction



- Building 3D models
- Triangulation
- Reprojection errors
- This is the other option for assignment 2

Multi-View Reconstruction

- Generalising to *n* views
- Multi-view geometry
- Pose estimation
- Bundle adjustment



Surface Modelling

- More scene structure
- Dense stereo
- Surface fitting
- Depth sensing

Practical Work

- Writing CV Code
- C++ language
- OpenCV library
- Eigen matrix library
- Demos in class
- Self-directed work

```
#include <opencv2/opencv.hpp>
#include <iostream>

int main (int arg, char *argv[]) {

  cv::Mat img(cv::Size(200,200),
      CV_8UC3);
  img.setTo(cv::Scalar(0,0,255));

  cv::circle(img,
      cv::Point(100,100), 50,
      cv::Scalar(255,255,255), -1);

  cv::namedWindow("Display");
  cv::imshow("Display", img);
  cv::waitKey();

  return 0;
}
```

Reading for Next Week

- Intro computer vision
  - Szeliski 1.1, 1.2
- Image Filtering
  - Szeliski 3.1, 3.2, 3.3
- homepages.inf.ed.ac.uk/rbf/CVonline
  - Moving to Wikipedia