A screenshot of a cell phone

Description automatically generated

EE5731 Visual Computing

Assignment 1: Panoramic Image Stitching

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Part 1: 2D Convolution

Original image:

A cat sitting on top of a building

Description automatically generated

Sobel horizontal kernel: [-1, -2, -1; 0, 0, 0; 1, 2, 1]

This kernel is for detecting the horizontal edges. See below.

A picture containing building, water, person

Description automatically generated

Sobel vertical kernel: [-1, 0, 1; -2, 0, 2; -1, 0, 1]

This kernel is for detecting the vertical edges. See below.

A picture containing person

Description automatically generated

Combined above sobel vertical and horizontal kernels:

By combining the sobel vertical and horizontal kernels, it is used for edges detecting. See below.

A cat that is looking at the camera

Description automatically generated

Gaussian kernel 1: [1, 2, 1; 2, 4, 2; 1, 2, 1]

This kernel is for blurring the image. See below.

A cat sitting on top of a wooden table

Description automatically generated

Gaussian kernel 2: [1, 4, 7, 4, 1;...

4, 16, 26, 16, 4;...

7, 26, 41, 26, 7;...

4, 16, 26, 16, 4;...

1, 4, 7, 4, 1]

This kernel is also for blurring the image, but more blurring effect than gaussian kernel 1. See below.

A cat sitting on a bench

Description automatically generated

Gaussian kernel 3: [0, 0, 0, 5, 0, 0, 0;...

0, 5, 18, 32, 18, 5, 0;...

0, 18, 64, 100, 64, 18, 0;...

5, 32, 100, 100, 100, 32, 5;...

0, 18, 64, 100, 64, 18, 0;...

0, 5, 18, 32, 18, 5, 0;...

0, 0, 0, 5, 0, 0, 0]

This kernel is also for blurring the image, but more blurring effect than gaussian kernel 1 and gaussian kernel 2. We can conclude that when increasing the size of the gaussian kernel, the blurring effect also is increasing. See below.

A cat sitting on top of a wooden table

Description automatically generated

Haar kernel 1: [-1, 1]

This kernel is for detecting the vertical edges. See below.

A picture containing covered

Description automatically generated

Haar kernel 2: [-1; 1]

This kernel is for detecting the horizontal edges. See below.

A picture containing water, skiing, person, field

Description automatically generated

Haar kernel 3: [1, -1, 1]

This kernel is for detecting vertical line edges that has strong color difference. See below.

A cat sitting on a wooden surface

Description automatically generated

Haar kernel 4: [1; -1; 1]

This kernel is for detecting horizontal line edges that has strong color difference. See below.

A cat that is looking at the camera

Description automatically generated

Haar kernel 5: [-1, 1; 1, -1]

This kernel is for detecting slanted edges. See below.

A close up of a logo

Description automatically generated

Haar kernel 6: [-1, -1, -1, 1, 1, 1;…

-1, -1, -1, 1, 1, 1;…

-1, -1, -1, 1, 1, 1]

This kernel is also for detecting vertical edges comparing to haar kernel 1 [-1, 1] but with larger kernel size. We can see that when increasing the size of haar kernel, it focuses more on the edges and the contrast between the edges and the rest is more obvious. See below for comparing.

Haar kernel 6 Haar kernel 1

A picture containing bird, standing, cat

Description automatically generatedA picture containing covered

Description automatically generated

Part 2: SIFT Features and Descriptors

Original image:

A tall building in a city

Description automatically generated

Key points on the image:

A group of people flying kites in the sky

Description automatically generated

This SIFT code main function takes gray scale image, number of octaves, number of scales per octaves and initial value for sigma as input. And returns key points inside a cell array as output.

Every key point is created and stored in a cell array which is an object. And each key point contains below:

**coordinates**(): [x, y] coordinate of the key point on image.

**direction**(): general direction of the key point.

**magnitude**(): magnitude of general direction vector.

**octave**(): number of the octave which the key point extracted from.

**scale**(): sigma value which the image is convolved with.

**descriptor**(): a vector containing the descriptor.

SIFT keypoint code reference:

<https://github.com/aminzabardast/SIFT-on-MATLAB>

Part 3: Homography

Transform from h1 to h2:

A picture containing object, person

Description automatically generated

Homography matrix:

0.00203167906083710 0.00122619927482271 0.0671747345696785

-0.000791701851303065 0.00110243037291573 0.997725988229764

4.71748268068702e-07 -4.77231045817034e-07 0.00478894737583979

Transform from h2 to h1:

A close up of a logo

Description automatically generated

Homography matrix:

0.00242170779215301 -0.00248424660616874 0.483596840860406

0.00179329663469115 0.00408044437089656 -0.875271597043633

-5.98502355062378e-08 6.51344340126909e-07 0.00135086238428662

Part 4: Manual Homography + Sticthing

Original images im01 and im02:

A tall building in a city

Description automatically generatedA tall building in a city

Description automatically generated

Stitched image:

A view of a city

Description automatically generated

The effect of double edges is due to that the middle part is the overlapping of the two images. The two images were taken from different perspective. So when stitch these two images, the two images cannot be 100% overlapped and there will be double edges shown on the stitched image.

Part 5: Homography + RANSAC

All matches:

A picture containing graphical user interface

Description automatically generated

Inlier matches:

A large building

Description automatically generated

Stitched image:

A view of a city

Description automatically generated

Part 6: Basic Panoramic Image

Inlier matches between im01 and im02:

A large building in the background

Description automatically generated

Inlier matches between im02 and im03:

A picture containing outdoor, building, truck, large

Description automatically generated

Inlier matches between im03 and im04:

A picture containing building, train, highway, track

Description automatically generated

Inlier matches between im04 and im05:

A tall building in a city

Description automatically generated

Final stitched image of im01, im02, im03, im04, im05:

A view of a city

Description automatically generated

Reference:

SIFT keypoint code reference: <https://github.com/aminzabardast/SIFT-on-MATLAB>