Final Project: Stereo Matching

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Language

The main language I select is C++.

The main tool is **opency**.

And the platform is visual studio 2013 on Windows 10, 64-bit.

Basic Task

Evaluate the Quality of My Disparity Maps

I need one "ground truth" disparity map and my disparity map. Since I use **opencv**, the main data structure is **Mat**

I need to traverse every pixel in the standart map and my map, and calculate the **absolute value** between them. If the absolute value is larger than **3**, increase the counter. And divide the counter by the total pixel number, the result is the **percentage of bad pixels**.

Sum of Squared Difference (SSD)

I need to traverse the images in the sub-directories. So I use some **directories operation API** on windows.

The max offset is 79, and the window size is 7*7. First, read two input images and convert them to grey images. Build a vector called **min_ssd** and make some initialization. Build a new Mat called **disp** to load my disparity map.

Second, according to every offset, build a Mat called **tmp** to load the right-eyed image or the lefteyed image after shifting. Build a Mat called **sd** to make some preprocess, which means to calculate the **absolute value** on the pixels between the Mat **tmp** and the other-eyed image and square it.

Third, for every window to every pixel on the Mat **sd**, calculate the sum called **ssd**. If the sum is less than the according value on the **min_ssd**, replace it and change the according value on **disp** to the **current offset * 3**.

The matching cost function is:

$$dist(F_L(x,y),F_R(x-d,y)) = sum((F_L(x,y)-F_R(x-d,y))^2)$$

where F*(x,y) is a feature vector extracted from I* at location (x,y) (e.g. a 5×5 patch centered at

The quality of my disparity maps is:

```
The percentage of bad pixels in my ssd disp1 : 0.217735
The percentage of bad pixels in my ssd disp5 : 0.105747
Babv1:
The percentage of bad pixels in my ssd displ : 0.434559
The percentage of bad pixels in my ssd disp5 : 0.277227
The percentage of bad pixels in my ssd displ : 0.422944
The percentage of bad pixels in my ssd disp5 : 0.304044
The percentage of bad pixels in my ssd disp1 : 0.634789
The percentage of bad pixels in my ssd disp5 : 0.417156
Bowling1:
The percentage of bad pixels in my ssd disp1 : 0.72973
The percentage of bad pixels in my ssd disp5 : 0.696986
The percentage of bad pixels in my ssd disp1 : 0.599091
The percentage of bad pixels in my ssd disp5 : 0.435739
Cloth1:
The percentage of bad pixels in my ssd displ : 0.300039
The percentage of bad pixels in my ssd disp5 : 0.0089442
Cloth2:
The percentage of bad pixels in my ssd disp1 : 0.614718
The percentage of bad pixels in my ssd disp5 : 0.286742
Cloth3:
The percentage of bad pixels in my ssd disp1 : 0.365604
The percentage of bad pixels in my ssd disp5 : 0.066887
Cloth4:
The percentage of bad pixels in my ssd disp1 : 0.460514
The percentage of bad pixels in my ssd disp5 : 0.153811
Flowerpots:
The percentage of bad pixels in my ssd displ : 0.805529
The percentage of bad pixels in my ssd disp5 : 0.66074
Lampshade1:
The percentage of bad pixels in my ssd disp1 : 0.732763
The percentage of bad pixels in my ssd disp5 : 0.622396
Lampshade2:
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🖭 d:\360data\重要数据\我的文档\visual studio 2013\Projects\dip final\Release\di ₁lowerpots: he percentage of bad pixels in my ssd disp1 : 0.805529 he percentage of bad pixels in my ssd disp5 : 0.66074 .ampshade1: The percentage of bad pixels in my ssd disp1 : 0.732763 he percentage of bad pixels in my ssd disp5 : 0.622396 .ampshade2: The percentage of bad pixels in my ssd displ : 0.660695 he percentage of bad pixels in my ssd disp5 : 0.507965 The percentage of bad pixels in my ssd disp1 : 0.688405 The percentage of bad pixels in my ssd disp5 : 0.539843 Nidd2: The percentage of bad pixels in my ssd disp1 : 0.710383 he percentage of bad pixels in my ssd disp5 : 0.668322 √onopoly: The percentage of bad pixels in my ssd disp1 : 0.730718 he percentage of bad pixels in my ssd disp5 : 0.669862 he percentage of bad pixels in my ssd disp1 : 0.799482 he percentage of bad pixels in my ssd disp5 : 0.774909 The percentage of bad pixels in my ssd disp1 : 0.390404 The percentage of bad pixels in my ssd disp5 : 0.162048 The percentage of bad pixels in my ssd displ : 0.387879 he percentage of bad pixels in my ssd disp5 : 0.117755 he percentage of bad pixels in my ssd disp1 : 0.391531 he percentage of bad pixels in my ssd disp5 : 0.208906 he percentage of bad pixels in my ssd disp1 : 0.634035 The percentage of bad pixels in my ssd disp5 : 0.414632 青按任意键继续... 🛓 微软拼音 半:

Normalized Cross Correlation (NCC)

The formula of the NCC matching cost is:

$$N_{cc}(d) = rac{S_{RL} - S_R S_L/m^2}{\sqrt{(S_{RR} - S_R S_R/m^2)(S_{LL} - S_L S_L/m^2)}}$$

where

$$S_{RL} = \sum_{i=1}^m \sum_{j=1}^m I_R I_L$$

$$S_R = \sum_{i=1}^m \sum_{j=1}^m I_R$$

$$S_L = \sum_{i=1}^m \sum_{j=1}^m I_L$$

$$S_{RR}=\sum_{i=1}^m\sum_{j=1}^mI_R^2$$

The max offset is 79, and the window size is 7*7. First, read two input images and convert them to grey images. Build a vector called **max_ncc** and make some initialization. Build a new Mat called **disp** to load my disparity map.

Second, according to every offset, build a Mat called **tmp** to load the right-eyed image or the left-eyed image after shifting.

Third, for every window to every pixel on the Mat, use the formula to calculate the parameters and comes up with a result called **sum_ncc**. If the result is larger than the according value on the **max_ncc**, replace it and change the according value on **disp** to the **current offset** * 3.

The quality of my disparity maps is:

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Aloe:									
The percentage Baby1:	of	bad	pixels	in	щy	ncc	disp1	:	0.211558
The percentage	of	bad	pixels	in	my	ncc	disp1	:	0.281487
Baby2: The percentage	of	bad	pixels	in	щy	ncc	disp1	:	0.32969
Baby3: The percentage	of	bad	pixels	in	ту	ncc	disp1	:	0.504694
Bowling1:									^ 400000
The percentage Bowling2:	οf	bad	pixels	ın	щу	ncc	dıspl	:	U. 483939
The percentage Cloth1:	of	bad	pixels	in	щу	ncc	disp1	:	0.495449
The percentage	of	bad	pixels	in	щу	ncc	disp1	:	0.304375
The percentage	of	bad	pixels	in	щу	ncc	disp1	:	0.446757
Cloth3: The percentage	of	bad	pixels	in	πу	ncc	disp1	:	0.350574
Cloth4: The percentage	of	had	nivole	in	TT/5.7	noc	dien1		0 411525
flowerpots:	OI	bau	biveis	111	щу	ncc	urspi		0. 411000
The percentage Lampshade1:	of	bad	pixels	in	щy	ncc	disp1	:	0.545927
The percentage Lampshade2:	of	bad	pixels	in	πy	ncc	disp1	:	0.553861
The percentage	of	bad	pixels	in	щy	ncc	disp1	:	0.482361
Middl: The percentage	of	bad	pixels	in	ту	ncc	disp1	:	0.615728
Midd2: The percentage	of	had	nivola	in	TT/5.7	noo	dien 1		0 61/091
The percentage Monopoly:	UI	Dau	biveis	111	щу	ncc	urspi		0.014521
The percentage Plastic:	of	bad	pixels	in	щy	ncc	disp1	:	0.605643
The percentage	of	bad	pixels	in	my	ncc	disp1	:	0.50092
Rocks1: The percentage	of	bad	pixels	in	πу	ncc	disp1	:	0.332922
Rocks2: 微软拼音 半 :									

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The percentage of bad pixels in my ncc disp1 : 0.483939
Bowling2:
The percentage of bad pixels in my ncc displ : 0.495449
Cloth1:
The percentage of bad pixels in my ncc disp1 : 0.304375
Cloth2:
The percentage of bad pixels in my ncc disp1 : 0.446757
Cloth3:
The percentage of bad pixels in my ncc disp1 : 0.350574
Cloth4:
The percentage of bad pixels in my ncc disp1 : 0.411535
flowerpots:
The percentage of bad pixels in my ncc disp1 : 0.545927
.ampshade1:
The percentage of bad pixels in my ncc disp1 : 0.553861
.ampshade2:
The percentage of bad pixels in my ncc disp1 : 0.482361
Widd1:
The percentage of bad pixels in my ncc disp1 : 0.615728
Widd2:
The percentage of bad pixels in my ncc disp1 : 0.614921
Monopoly:
The percentage of bad pixels in my ncc disp1 : 0.605643
Plastic:
The percentage of bad pixels in my ncc displ : 0.50092
Rocks1:
The percentage of bad pixels in my ncc disp1 : 0.332922
Rocks2:
The percentage of bad pixels in my ncc disp1 : 0.370709
√ood1:
The percentage of bad pixels in my ncc disp1 : 0.272104
√ood2:
The percentage of bad pixels in my ncc disp1 : 0.441417
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Add a Constant Amount of Intensity to Right Eye Images

The constant amount of intensity I added is 10. Here are the results:

Cloth4:

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Cloth4:
The percentage of bad pixels in my right eyed ssd disp1 : 0.635597
The percentage of bad pixels in my right eyed ssd disp5 : 0.365321
The percentage of bad pixels in my right eyed ncc displ : 0.446389
?lowerpots:
The percentage of bad pixels in my right eyed ssd disp1 : 0.926798
The percentage of bad pixels in my right eyed ssd disp5 : 0.920014
The percentage of bad pixels in my right eyed ncc displ : 0.545927
.ampshade1:
The percentage of bad pixels in my right eyed ssd disp1 : 0.815867
The percentage of bad pixels in my right eyed ssd disp5 : 0.825105
The percentage of bad pixels in my right eyed ncc disp1 : 0.553861
.ampshade2:
The percentage of bad pixels in my right eyed ssd disp1 : 0.868654
The percentage of bad pixels in my right eyed ssd disp5 : 0.886742
The percentage of bad pixels in my right eyed ncc disp1 : 0.482417
Widd1:
The percentage of bad pixels in my right eyed ssd disp1 : 0.769677
The percentage of bad pixels in my right eyed ssd disp5 : 0.712119
The percentage of bad pixels in my right eyed ncc disp1 : 0.615728
Widd2:
The percentage of bad pixels in my right eyed ssd disp1 : 0.782198
The percentage of bad pixels in my right eyed ssd disp5 : 0.743855
The percentage of bad pixels in my right eyed ncc displ : 0.614921
∜onopoly:
The percentage of bad pixels in my right eyed ssd disp1 : 0.591556
The percentage of bad pixels in my right eyed ssd disp5 : 0.410134
The percentage of bad pixels in my right eyed ncc disp1 : 0.605643
Plastic:
The percentage of bad pixels in my right eyed ssd disp1 : 0.831723
The percentage of bad pixels in my right eyed ssd disp5 : 0.776174
The percentage of bad pixels in my right eyed ncc disp1 : 0.50092
Rocks1:
The percentage of bad pixels in my right eyed ssd disp1 : 0.411351
The percentage of bad pixels in my right eyed ssd disp5 : 0.227828
The percentage of bad pixels in my right eyed ncc disp1 : 0.332922
Rocks2:
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■ d:\360data\重要数据\我的文档\visual studio 2013\Projects\dip_final\Release\dip_final.exe
The percentage of bad pixels in my right eyed ncc disp1 : 0.482417
Midd1:
The percentage of bad pixels in my right eyed ssd disp1 : 0.769677
The percentage of bad pixels in my right eyed ssd disp5 : 0.712119
The percentage of bad pixels in my right eyed ncc disp1 : 0.615728
Midd2:
The percentage of bad pixels in my right eyed ssd disp1 : 0.782198
The percentage of bad pixels in my right eyed ssd disp5 : 0.743855
The percentage of bad pixels in my right eyed ncc disp1 : 0.614921
Monopoly:
The percentage of bad pixels in my right eyed ssd displ : 0.591556
The percentage of bad pixels in my right eyed ssd disp5:0.410134
The percentage of bad pixels in my right eyed ncc disp1 : 0.605643
Plastic:
The percentage of bad pixels in my right eyed ssd disp1 : 0.831723
The percentage of bad pixels in my right eyed ssd disp5 : 0.776174
The percentage of bad pixels in my right eyed ncc disp1 : 0.50092
Rocks1:
The percentage of bad pixels in my right eyed ssd displ : 0.411351
The percentage of bad pixels in my right eyed ssd disp5 : 0.227828
The percentage of bad pixels in my right eyed ncc disp1 : 0.332922
Rocks2:
The percentage of bad pixels in my right eyed ssd displ : 0.428553
The percentage of bad pixels in my right eyed ssd disp5 : 0.212127
The percentage of bad pixels in my right eyed ncc disp1 : 0.370709
₩ood1:
The percentage of bad pixels in my right eyed ssd displ : 0.795221
The percentage of bad pixels in my right eyed ssd disp5 : 0.763386
The percentage of bad pixels in my right eyed ncc disp1 : 0.272104
₩ood2:
The percentage of bad pixels in my right eyed ssd displ : 0.874166
The percentage of bad pixels in my right eyed ssd disp5 : 0.836123
The percentage of bad pixels in my right eyed ncc disp1 : 0.441417
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As for the **SSD**, the absolute value between the pixels on two images are increased, then the sum of squared difference are also increased, which might results in confusion while matching.

As for the **NCC**, the averages are also increase but the standard differences on self image stay the same.

With larger patches, NCC can occasionally outperform SSD. Additionally, when there are smaller/less areas where the shade is near flat, accuracy grows as the patch size increases. This makes sense since correspondences between patches are more likely to be unique. But we see that when handling images with more/larger areas with flat shading, larger patches could mean less accuracy.

Adaptive Support Weight (ASW)

Here are the results:

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Aloe:									
The percentage Baby1:	of	bad	pixels	in	πy	asw	disp1	:	0. 222812
The percentage	of	bad	pixe1s	in	щу	asw	disp1	:	0.466756
Baby2: The percentage	of	had	nivels	in	mv	acw	dien1		0 591912
Baby3:	01	Naca	PINOID		my	abn	arbyr	١	0.001012
The percentage Bowling1:	of	bad	pixels	in	щy	asw	disp1	:	0.696765
The percentage	of	bad	pixels	in	my	asw	disp1	:	0.768929
Bowling2:									^ ^ ^ ^ ^ ^ ^ ^ ^
The percentage Cloth1:	οf	bad	pixels	ın	щy	asw	dıspl	:	0.682112
The percentage Cloth2:	of	bad	pixels	in	πу	asw	disp1	:	0.347988
The percentage Cloth3:	of	bad	pixels	in	πy	asw	disp1	:	0.684377
The percentage	of	bad	pixels	in	πy	asw	disp1	:	0.383998
Cloth4: The percentage	of	bad	pixels	in	πy	asw	displ	:	0.469971
Flowerpots:									
The percentage Lampshade1:	ΟĬ	bad	pixels	ın	щу	asw	dıspl	:	0.835593
The percentage Lampshade2:	of	bad	pixels	in	πy	asw	disp1	:	0.784789
The percentage Middl:	of	bad	pixels	in	πy	asw	disp1	:	0.694701
The percentage	of	bad	pixels	in	πy	asw	disp1	:	0.708056
Midd2: The percentage	of	bad	pixels	in	πy	asw	disp1	:	0.725625
Monopoly: The percentage	of	bad	pixels	in	mν	asw	disp1	:	0. 8831
Plastic:									
The percentage Rocks1:	of	bad	pixels	in	πy	asw	disp1	:	0.866379
The percentage Rocks2: 微软拼音 半 :	of	bad	pixels	in	щу	asw	disp1	:	0. 433259
MINWIH I									

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The percentage of bad pixels in my asw disp1 : 0.768929
Bowling2:
The percentage of bad pixels in my asw disp1 : 0.682112
Cloth1:
The percentage of bad pixels in my asw disp1 : 0.347988
Cloth2:
The percentage of bad pixels in my asw disp1 : 0.684377
Cloth3:
The percentage of bad pixels in my asw disp1 : 0.383998
Cloth4:
The percentage of bad pixels in my asw disp1 : 0.469971
Flowerpots:
The percentage of bad pixels in my asw disp1 : 0.835593
Lampshade1:
The percentage of bad pixels in my asw disp1 : 0.784789
Lampshade2:
The percentage of bad pixels in my asw disp1 : 0.694701
Midd1:
The percentage of bad pixels in my asw disp1 : 0.708056
Midd2:
The percentage of bad pixels in my asw displ: 0.725625
Monopoly:
The percentage of bad pixels in my asw disp1 : 0.8831
Plastic:
The percentage of bad pixels in my asw displ : 0.866379
Rocks1:
The percentage of bad pixels in my asw disp1 : 0.433259
Rocks2:
The percentage of bad pixels in my asw disp1 : 0.490645
₩ood1:
The percentage of bad pixels in my asw disp1 : 0.478006
₩ood2:
The percentage of bad pixels in my asw disp1 : 0.64589
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The max offset is 79, and the window size is 7*7. First, read two input images and convert them to CIELab color space. Build a vector called **min_asw** and make some initialization. Build a new Mat called **disp** to load my disparity map.

Second, according to every offset, build a Mat called **tmp** to load the right-eyed image or the left-eyed image after shifting and build a Mat called **rgb5** to convert **tmp** to RGB color space.

Third, for every window to every pixel on the Mat, use the formula to calculate the parameters and comes up with a result called **sum_asw**. If the result is less than the according value on the **min_asw**, replace it and change the according value on **disp** to the **current offset * 3**.

The idea of the ASW paper is how to implement ASW stereo matching. Similarity and proximity are

the two main grouping concepts in the classic gestalt theory: similarity refers to what items look like and how that affects grouping, and proximity refers to where items are and how that affects grouping. The gestalt principles of similarity and proximity are also used to compute support-weights. The more similar the color of a pixel, the larger the support-weight of the pixel. In addition, the closer the pixel is, the larger the supportweight. The former is related to the grouping by similarity, and the latter is related to the grouping by proximity.

With larger patches, ASW can occasionally outperform NCC since the accurancy has been improved a lot.