A Framework for Content-Adaptive Photo Manipulation Macros: Application to Face, Landscape, and Global Manipulations

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Thank you for your time and effort.

## **Tilt-Shift Manipulation**

We demonstrate the tilt-shift manipulation on 10 images, and our framework successfully learns to blur the regions above and below the car.

### Demonstration Manipulations:



Target Images







Macro Results

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## **Car Recoloring Manipulation**

We demonstrate recoloring of 5 red cars and 5 green cars to blue. Our content-adaptive macro correctly recolors new target cars, without recoloring red/green elements (e.g. red flowers) that fall outside the car bounding box. But, it fails when red/green background elements, like grass, fall within the bounding box.

Macro Results

**Demonstration Manipulations:** 



Target Images



### Limitations:

The macro can only recolor cars that are within a certain range of red and greens. Because this car is pink and therefore contains some red, the selection mask indicates that this region has a small but non-zero probability to be selected. For this reason, our content-adaptive macro only tints the car and does not fully select and recolors it.



The macro only changes the roof color of the car, because this is the only region the car is red or green. It also changes the color of the red shirt of the man in the background.



The macro recolors the red car as well as the grass, because the green grass is within the bounding box of the car and we trained our macro for green and red cars.





### Eye Makeup / Bag Removal

To test the influence of landmark points on our framework for face manipulations, we learned the eye makeup and bag removal manipulations by replacing the 83 landmark points for faces with the 4 corner points of the axis-aligned bounding box for each labeled face region (e.g. eye, mouth, lip). We applied the resulting macros to 20 new target images and observed that 17 of the bag removal transfers were successful, but only 4 of the eye makeup transfers were successful. The eye makeup manipulation requires more precise brush strokes than the bag removal manipulation. Using only the bounding box vertices as landmarks reduces the precision of our brush stroke transfers and leads to less successful results for the eye makeup macro.

#### Eye Makeup



Bag Removal



# **Amazon Mechanical Turk Task**

We used the task template shown below to solicit user feedback on the quality of our results as compared to ground-truth and average images.



# **Mechanical Turk Average Difference Ratings**

This page shows average difference ratings from the Amazon Mechanical Turk studies.

			# of tr	aining d	emonst	rations		
	1		10		20		30	
Bag Removal	ave	std div	ave	std div	ave	std div	ave	std div
ground truth	1.99	1.04	2.03	1.03	2.03	1.08	1.49	0.76
ours automatic	2.48	1.15	2.51	1.20	2.42	1.19	1.79	1.09
ours corrected	2.40	1.11	2.45	1.17	2.29	1.11	1.64	0.94
average	3.01	1.35	3.05	1.34	2.96	1.37	2.94	1.58
Contrast								
ground truth	1.60	0.69	1.70	0.68	1.70	0.73	1.82	0.85
ours automatic	3.89	1.47	3.18	1.37	2.05	0.88	2.02	0.92
ours corrected	3.91	1.47	3.13	1.36	2.05	0.89	2.07	0.96
average	3.89	1.45	3.21	1.33	3.77	1.46	3.58	1.36
Dark Sky								
ground truth					1.50	0.73		
ours automatic					2.01	1.00		
ours corrected					1.82	1.13		
average					4.66	0.84		
Eye Makeup								
ground truth	1.65	1.00	1.59	0.95	1.63	0.98	1.71	1.03
ours automatic	2.87	1.33	2.63	1.43	2.57	1.35	2.60	1.40
ours corrected	2.43	1.27	1.90	1.09	2.04	1.19	2.13	1.13
average	4.16	1.11	4.16	1.06	4.07	1.14	4.26	1.06
Film Noir								
ground truth	1.66	0.88	1.64	0.79	1.81	0.91	1.81	0.90
ours automatic	3.23	1.28	2.75	1.16	2.00	0.98	1.95	0.92
ours corrected	3.22	1.28	2.63	1.09	1.93	0.94	1.87	0.89
average	3.24	1.30	3.40	1.33	3.52	1.35	3.34	1.37
Lomo								
ground truth					1.45	0.70		
ours automatic					1.83	0.88		
ours corrected					1.83	0.89		
average					3.87	1.31		
Sunset								
ground truth	1.88	0.94	1.94	0.93	1.92	0.94	1.81	0.83
ours automatic	2.29	0.98	2.18	0.98	2.23	0.99	2.11	0.97
ours corrected	2.05	0.96	2.04	0.99	2.04	0.96	1.95	0.98
average	3.71	1.48	2.97	1.43	2.93	1.46	2.95	1.48

# **Mechanical Turk Rating Consistency and Outliers**

The table below shows the number of automatic and corrected images that were rated as better than or equal to ground truth by at least 3 of the 5 workers and the number of automatic and corrected images that were rated no better or worse than the average images by at least 3 of the 5 workers. Column f shows the percentage of automatic and corrected results that were rated lower or the same as ground truth across all training examples and the percentage of automatic and corrected results that were rated as no better or worse than the average across all training examples (i.e. (column e)/340). Column g shows the same calculation but only includes images that were computed from 20 training demonstrations.

	а	b	с	d	e	f	g
						Total as % of	
Contrast	1	10	20	30	Total	all tasks (340)	20 as %
automatic <= ground truth	0	5	48	41	94	0.28	0.60
average <= automatic	85	64	2	0	151	0.44	0.03
corrected <= ground truth	0	5	49	42	96	0.28	0.61
average <= corrected	69	49	1	0	119	0.35	0.01
Film Noir							
automatic <= ground truth	7	10	49	46	112	0.33	0.61
average <= automatic	75	21	1	2	99	0.29	0.01
corrected <= ground truth	7	11	51	48	117	0.34	0.64
average <= corrected	74	18	1	1	94	0.28	0.01
Sunset							
automatic <= ground truth	40	32	27	25	124	0.36	0.34
average <= automatic	2	4	2	3	11	0.03	0.03
corrected <= ground truth	55	41	34	36	166	0.49	0.43
average <= corred	1	0	2	0	3	0.01	0.03
Eye Makeup							
automatic <= ground truth	22	36	28	28	114	0.34	0.35
average <= automatic	16	17	18	15	66	0.19	0.23
corrected <= around truth	34	62	52	35	183	0.54	0.65
average <= corrected	6	0	1	2	9	0.03	0.01
Bag Removal							
automatic <= ground truth	29	30	32	35	126	0.37	0.40
average <= automatic	5	6	6	6	23	0.07	0.08
corrected <= ground truth	24	27	38	36	125	0.37	0.48
average <= corrected	5	7	5	5	22	0.06	0.06

training demonstration	e)
ound truth 21	0.60
omatic 0	0.00
ound truth 24	0.69
ected 0	
ning demonstrations)	
ound truth 17	0.49
omatic 0	0.00
	ound truth 21 omatic 0 ound truth 24 ected 0 ning demonstrations) round truth 17 omatic 0

For the dark sky and lomo manipulations we performed experiments with 20 training demonstrations. The table on the left shows our results.

## **Mechanical Turk Rating Distributions**

We show difference rating distributions for all tested manipulations. Despite the fact that we did not remove outliers and the data includes noise, the affect of the learning techniques is clear in the distributions. As the number of training demonstrations increases, difference ratings for our automatic and corrected images become close and in some cases match exactly to the difference ratings for the ground truth.



#### **Absolute Parameter Difference**

We compare the parameter values for the automatic, average and corrected conditions to the ground truth parameters. We do this comparison separately for each parameter. Only the values for the mustache manipulation were computed for 10 training demonstrations. We compute the values for all other manipulations for the case of 20 training demonstrations.

Manipulations	Conditions									
Bag Removal		Healing Brush Source Point	Healing Brush Source	Bruch Size	Onacity					
bag nemoval	automatic	15.73	11.48	4.56	9.42					
	average	108.53	245.76	3.97	10.03					
	corrected	5.71	6.94	3.91	9.42					
Black & White	automatic	Levels Tool 15.83	Levels Tool 14.79	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point			
	average	16.38	13.46	17.86	14.71	14.53	11.74			
Contrast	automatic	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point					
	average	15.78	18.21	25.47	12.49					
	corrected	8.76	7.98	10.64	4.19					
Dark Sky		grow selection	feather amount	transform param 1	transform param 2	brightness	opacity			
	automatic	0	0	571	52	17	23			
	corrected	0	0	98	47	14	8			
Eye Makeup		Brush Size	Brush Size	Brush Size	Brush Size	Brush Size	Brush Size			
	automatic	2.63	2.82	1.85	2.63	2.82	1.85			
	corrected	2.45	2.44	1.25	2.45	2.44	1.25			
Film Noir		Levels Tool	Levels Tool	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Color Balance	Color Balance	
	automatic	14.6	8.93	7.61	10.04	6.93	6.71	2.01	4.57	
	corrected	15.39	8.93	7.61	10.04	6.93	6.71	2.01	4.85	
Film Noir (Continuation)		Color Balance	Color Balance	Color Balance	Color Balance	Color Balance	Color Balance	Color Balance	Color	
	automatic	2.63	1.74	3.52	2.54	5.26	4.62	1.25	14.52	
	average	3.74	2.06	3.15	2.67	5.55	4.98	1.79	17.83	
	concetted	2.05	2.74	5.52	2.54	5.20		1.25	14.52	
Film Noir (Continuation)		Color	Color	Onacity	Curve Control Point	Curve Control Point	Brush Size	Brush Opacity		
(continuation)	automatic	14.52	14.52	15.6	16.2	14.59	5.67	9.46		
	average	17.83	17.83	20.31	11.27	29.78	5.84	10.54		
	corrected	14.52	14.52	15.0	10.2	14.55	5.07	5.40		
Lin Close		Hue	Saturation	Lightnoss	Cursus Control Point	Cursue Control Point				
Lip Gloss	automatic	12.89	6.52	6.42	8.44	4.37				
	average	5.4	3.5	12.53	15.17	9.56				
	corrected	5.65	4.41	3.52	0.15	4.11				
Lomo	automatic	Vignetting midpoint	Vignetting amount	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Opacity
	average	15	17	8	9	17	23	12	11	16
	corrected	8	11	6	9	14	19	8	13	5
		Unsharp Amount	Unsharp Radius							
		37	11							
		21	7							
Mustache		Brush Size								
	average	5.13								
	corrected	4.68								
Skin Tone		Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point			
	automatic	2.17	8.63	4.12	1.34	3.15	21.45			
	corrected	2.22	6.47	1.14	1.25	3.09	11.63			
Sunset Enhancement		Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	Curve Control Point	
	corrected	12.45	9.11	8.74	9.6	9.55	13.01	20.15	16.58	
	corrected	9.63	8.74	8.27	7.32	8.21	11.52	17.82	15.79	
Sunset Enhancement										
(Continuation)	corrected	channel mixer tool	channel mixer tool	channel mixer tool	channel mixer tool	channel mixer tool	channel mixer tool	channel mixer tool	channel mixer tool	channel mixer tool
	average	5.36	3.11	3.26	4.36	6.14	1.25	9.74	4.17	4.93
	corrected	2.15	3.04	2.21	2.99	4.31	2.47	6.01	1.79	3.1

## **MSE** Data

This page includes the data from our MSE analysis, which compares our automatic and corrected results to the average. MSEs are computed with respect to the manually generated ground truth images.

			# of trainin	ig demonst	rations				
	1		10		20		30		
Bag Removal	ave	std dev	ave	std dev	ave	std dev	ave	std dev	
ours automatic	2.71	5.802628	0.78	0.89656	0.70	3.09912	0.60	1.40647	
ours corrected	2.63	6.00734	0.59	0.71009	0.32	0.48943	0.21	0.61187	
average	2.89	2.139916	2.67	2.2086	2.58	2.07845	2.47	2.14307	
Contrast									
ours automatic	606.19	240.46	515.59	34.11	166.14	73.93	121.89	25.47	
ours corrected	606.19	347.08	515.59	266.60	158.20	326.62	95.79	186.00	
average	606.19	355.85	515.59	264.00	585.46	469.00	484.80	376.75	
Dark Sky									
ours automatic					228.23	187.95			
ours corrected					207.15	164.46			
average					966.04	357.14			
Eye Makeup									
ours automatic	4.63	3.79	4.47	5.59	4.19	4.94	4.15	5.62	
ours corrected	3.28	2.83	1.34	1.64	1.86	2.48	1.65	3.17	
average	8.54	4.13	8.89	4.13	8.81	4.00	8.85	4.39	
Film Noir									
ours automatic	887.94	228.10	496.16	978.41	224.71	287.20	205.83	226.69	
ours corrected	847.94	978.41	446.16	450.86	183.72	228.10	161.38	141.37	
average	1067.94	730.11	1611.02	978.41	1454.97	969.73	1675.96	1076.24	
Lomo									
ours automatic					177.65	97.1163			
ours corrected					177.65	97.1163			
average					675.94	343.72			
Sunset									
ours automatic	282.19	148.94	160.30	243.20	151.44	219.87	137.27	205.83	
ours corrected	91.92	101.38	53.37	255.43	48.53	65.53	33.93	42.71	
average	474.32	248.56	355.55	267.76	323.75	249.44	310.42	244.12	
									7

### LARS versus Least Squares

As an alternative to LARS, we tested using a basic least squares regression algorithm to adapt adjustment parameters for two manipulations, contrast and skin tone. We used 20 training images and computed the absolute parameter difference between the parameters generated using least squares, LARS and the ground truth parameters. We also computed the MSE for the results generated using these two regression techniques and the ground truth.

Absolute Parameter Difference

Manipulations	Conditions						
		Curve Control	Curve Control	Curve Control	Curve Control		
Contrast		Point	Point	Point	Point		
	automatic	9.41	8.32	12.17	4.75		
	average	15.78	18.21	25.47	12.49		
	corrected	8.76	7.98	10.64	4.19		
	Least Squares (automatic)	13.27	17.21	24.77	15.22		
		Curve Control					
Skin Tone		Point	Point	Point	Point	Point	Point
	automatic	2.17	8.63	1.01	1.34	3.15	11.89
	average	3.32	17.54	4.12	2.07	5.58	21.45
	corrected	2.22	6.47	1.14	1.25	3.09	11.63
	Least Squares (automatic)	3.01	15.83	3.85	1.96	4.98	18.53

MSE

Manipulations	Conditions	
Contrast	automatic	166
	average	585
	corrected	158
	Least Squares (automatic)	394
Skin Tone	automatic	126
	average	351
	corrected	104
	Least Squares (automatic)	259