

# Detecting Fakes



Bernadette by Stephen Molyneaux



<http://www.flickr.com/photos/kjmeow/2320759046/>

Computational Photography  
Derek Hoiem, University of Illinois

# Reminder of upcoming deadlines + logistics

- Deadlines
  - Wed: project 5 due
  - Mon (11/16): final project proposal due
  - Next Thurs (11/19): midterm
    - Review next Tues in class
- Derek out of town wed to fri

# Detecting Fakes

1. Detecting photorealistic graphics
2. Detecting manipulated images

# CG vs. Real: Can you do it?

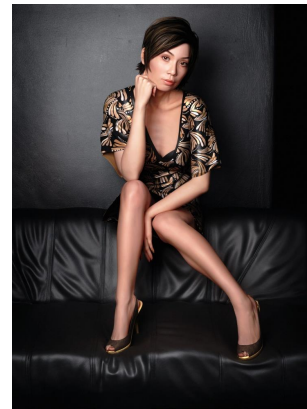
- <http://area.autodesk.com/fakeorfoto/>
- I got 7 out of 12 right

# CG vs. Real -- Why It Matters: Crime

- 1996 Child Pornography Prevent Act made certain types of “virtual porn” illegal
- Supreme court over-ruled in 2002
- To prosecute, state needs to prove that child porn is not computer-generated images



Real Photo



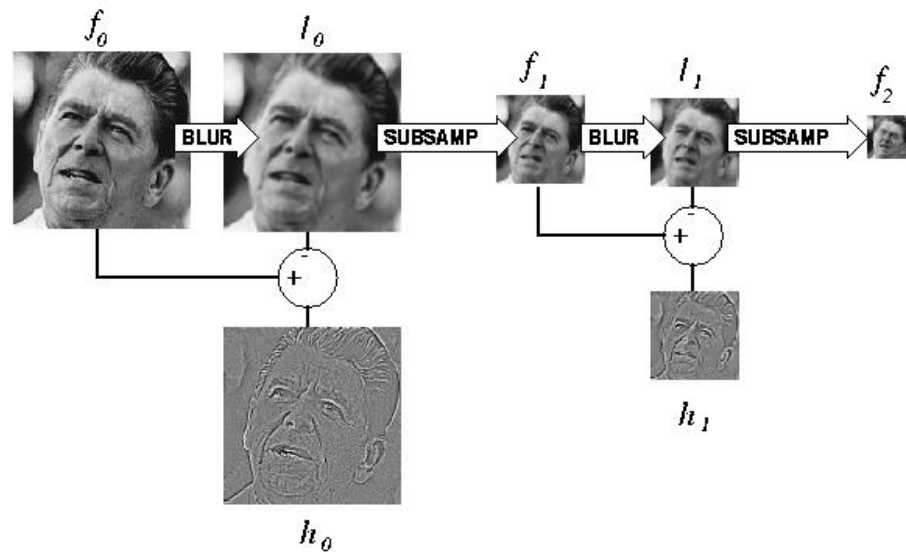
CG

# Automatically Detecting CG

- Sketch of approach
  - Intuition: natural images have predictable statistics (e.g., power law for frequency); CG images may have different statistics due to difficulty in creating detail
  - Decompose the image into wavelet coefficients and compute statistics of these coefficients

# 2D Wavelets

Kind of like the Laplacian pyramid, except broken down into horizontal, vertical, and diagonal frequency



Laplacian Pyramid

L1 LL	L1 HL	Level 2 HL	Level 3 HL
L1 LH	L1 HH		
Level 2 LH		Level 2 HH	
Level 3 LH			Level 3 HH

Wavelet Pyramid

# 2D Wavelet Transform

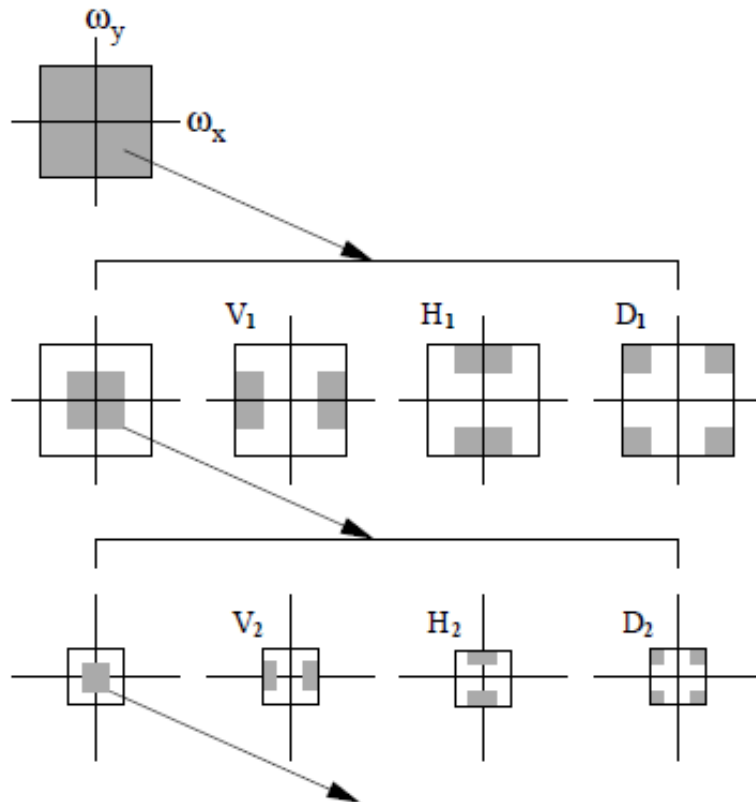
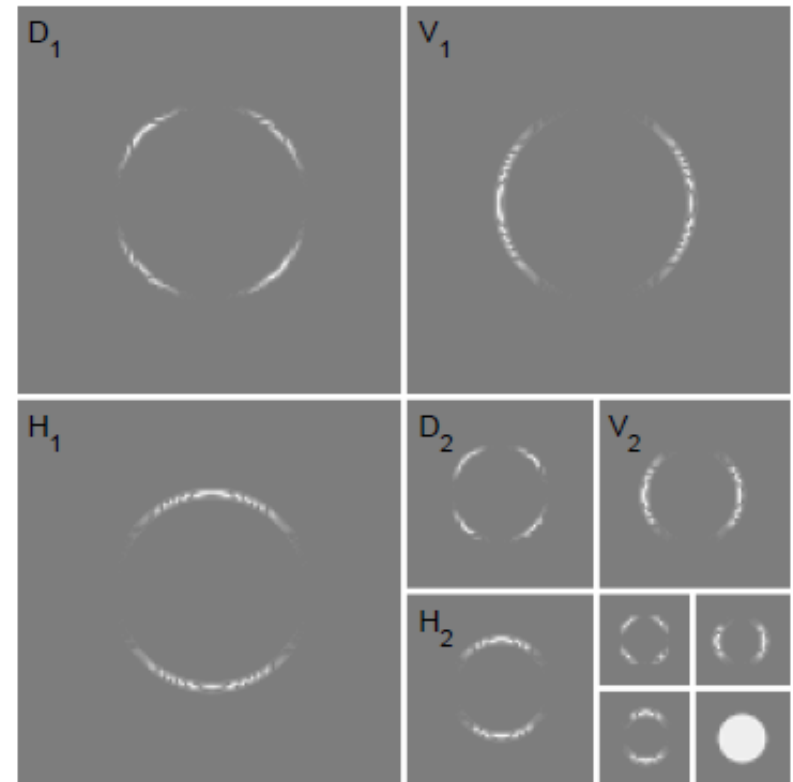


Illustration of procedure



Wavelet decomposition of disc image



# Automatically Detecting CG

- Sketch of approach
  - Intuition: natural images have predictable statistics (e.g., power law for frequency); CG images may have different statistics due to difficulty in creating detail
  - Decompose the image into wavelet coefficients and compute statistics of these coefficients
  - Train a classifier to distinguish between CG and Real based on these features
    - Train RBF SVM with 32,000 real images and 4,800 fake images
    - Real images from <http://www.freefoto.com>
    - Fake images from <http://www.raph.com> and <http://www.irtc.org/irtc/>

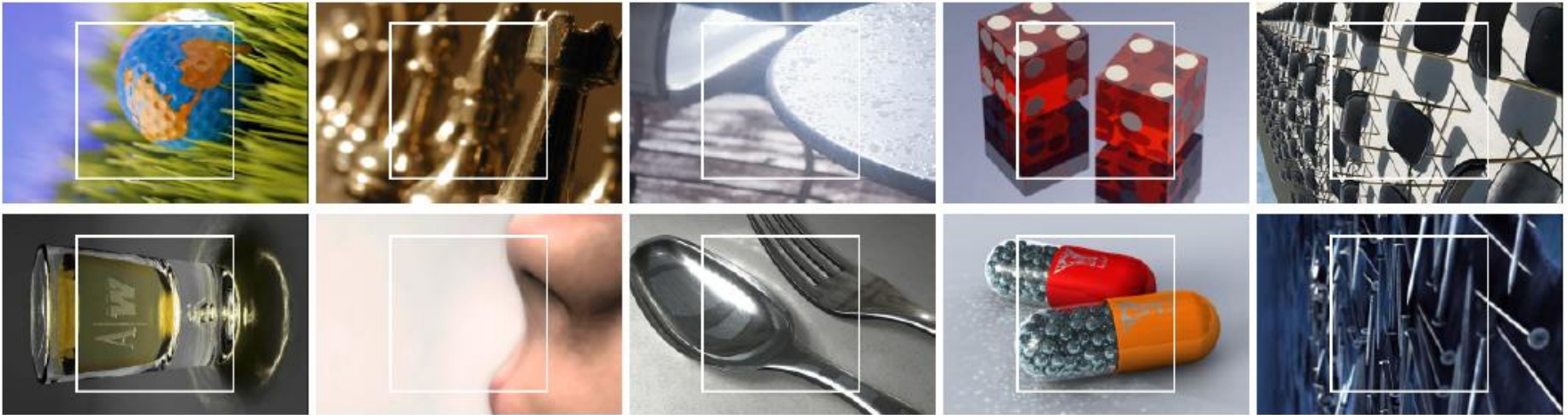
# Results

- 98.8% test accuracy on real images
- 66.8% test accuracy on fake images
- 10/14 on fakeorfoto.com

# Results

- Fake-or-photo.com: Correct

Real Photos

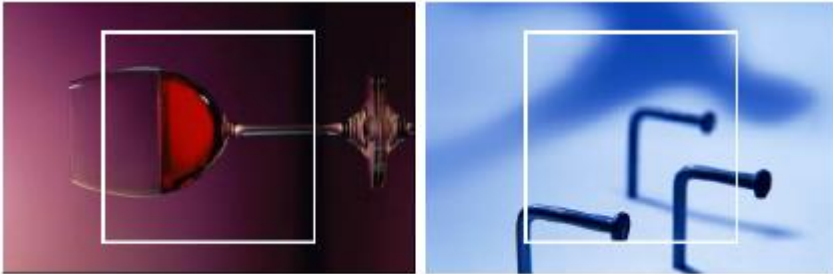


CG

# Results

- Fake-or-photo.com: Wrong

Real photos misclassified as CG



CG misclassified as real photos

# Results

- Fakes, confidently labeled as fake





# Results

- Fake images thought to be real



# Results

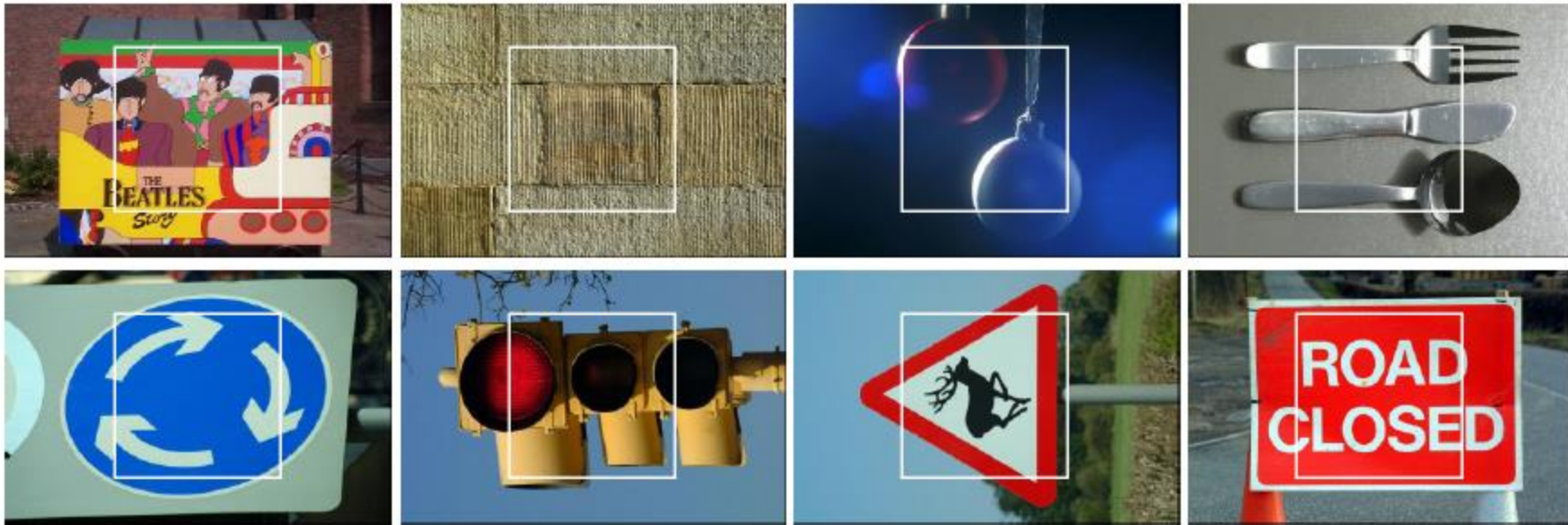
- Real photographs, confidently labeled as real





# Results

- Real photos, incorrectly thought to be fake





# Detecting Forgery -- Why It Matters: Trust

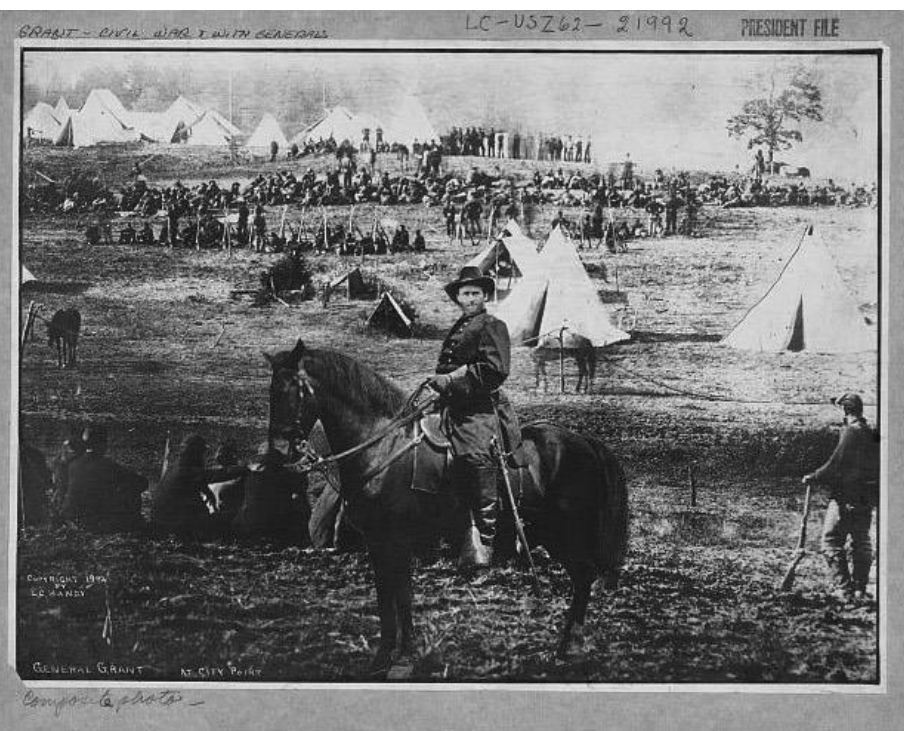
Examples collected by Hany Farid: <http://www.fourandsix.com/photo-tampering-history/>



Iconic Portrait of Lincoln (1860)

“While photographs may not lie, liars may photograph.”

Lewis Hine (1909)



General Grant in front of Troops (1864)



Mussolini in a Heroic Pose (1942)



1950: Doctored photo of Senator Tydings talking with Browder, the leader of the communist party, contributed to Tydings' electoral defeat



Pulitzer Prize winning photograph of Kent State killing (1970)



Gang of Four are removed (1976)



1989 composite of Oprah and Ann-Margret (without either's permission)





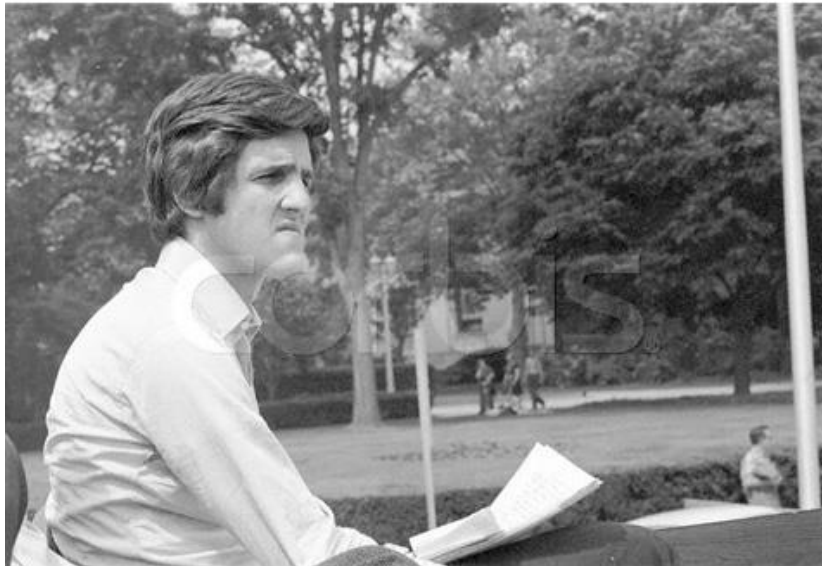
Photo from terrorist attack in 1997 in Hatshepsut, Egypt

## Fonda Speaks To Vietnam Veterans At Anti-War Rally



Actress And Anti-War Activist Jane Fonda Speaks to a crowd of Vietnam Veterans as Activist and former Vietnam Vet John Kerry (LEFT) listens and prepares to speak next concerning the war in Vietnam (AP Photo)

Caption: “Actress and Anti-war activist Jane Fonda speaks to a crowd of Vietnam veterans, as activist and former Vietnam vet John Kerry listens and prepares to speak next concerning the war in Vietnam.” (AP Photo)



Kerry at Rally for Peace 1971



Fonda at rally in 1972



2005: Pres Bush scribbles a note to C. Rice during UN Security Council Meeting

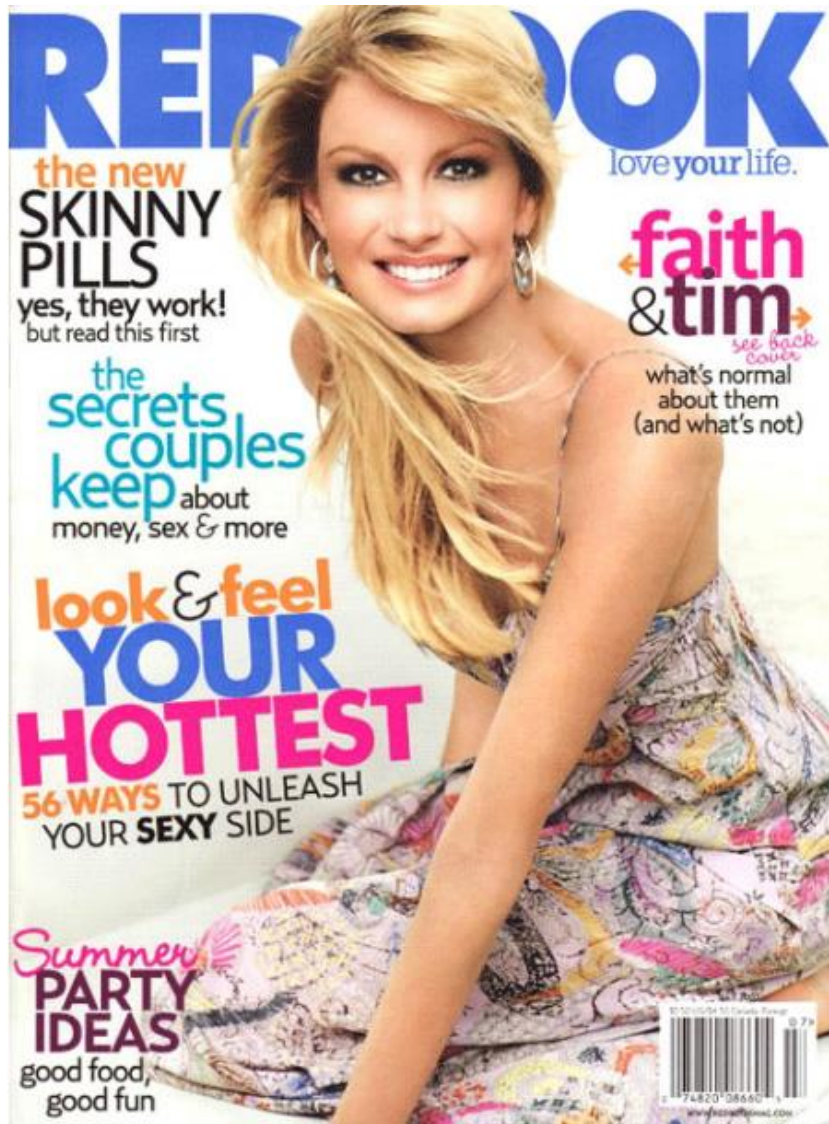


2005: USA Today SNAFU



2006: Photo by Adnan Hajj of strikes on Lebanon (original on right)  
Later, all of Hajj's photos were removed from AP and a photo editor was fired.





2007 Retouching is “completely in line with industry standards”



2013: Fake fattening



The French Magazine Paris Match altered a photograph of French President Nicolas Sarkozy by removing some body fat. (2007)





Claimed Photo



Poster



Overlay

2007: Zhou Zhenglong claimed to take 71 photos of the nearly extinct South China tiger



Similar scandal in 2011 from Terje Helleso who won Swedish Env. Prot. award



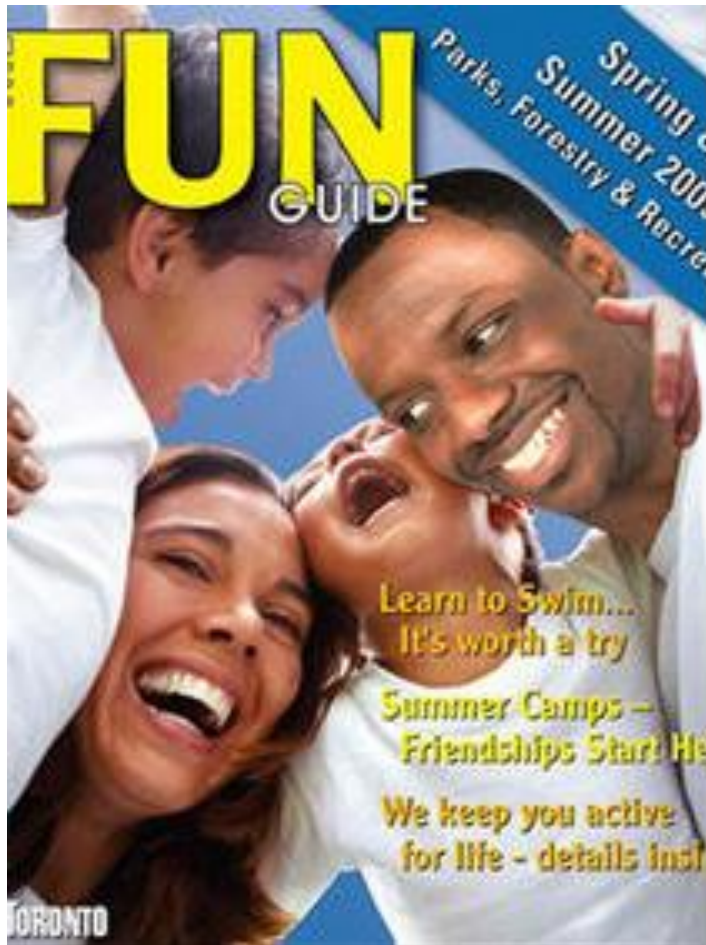


(2012) A Russian newspaper distributed by a pro-Kremlin group printed a photograph showing blogger/activist Aleksei Navalny standing beside Boris A. Berezovsky, an exiled financier being sought by Russian police.



2008





2009: Digital diversity



“Evidence” that Malaysian politician Jeffrey Wong Su En was knighted by the Queen (2010)



Cloning sand to remove shadow. Miguel Tovar – banned from AP, all his photos removed (2011)





Photo from Korean Central News Agency, determined to be composite (people don't appear wet) – was attempt to get sympathy for North Korea to get more international aid





2013: fake floors, counter, appliances digitally added for listing in Luis Ortiz's show "Million Dollar Listing New York"



A farmer from Hunan province, China was sentenced to 12 years in prison and fined 500,000 yuan after receiving 453,00 yuan (US\$73,000) in blackmail payments out of an attempted 9.47 million yuan. He had mailed to more than 200 officials pornographic photos into which he had inserted them using photo editing software. He threatened to publicize the photos unless he was paid. One of the victims claimed that he made the demanded payment before he “sensed later on that the man inside the photo was actually not me.”



Nov 2014: Russian state media ran a story with “proof” that a Ukrainian jet shot down the Malaysian airlines plane. Photo is composed of Google Earth imagery, Yandex maps, and a stock photo of a Boeing jet.



# Detecting forgeries

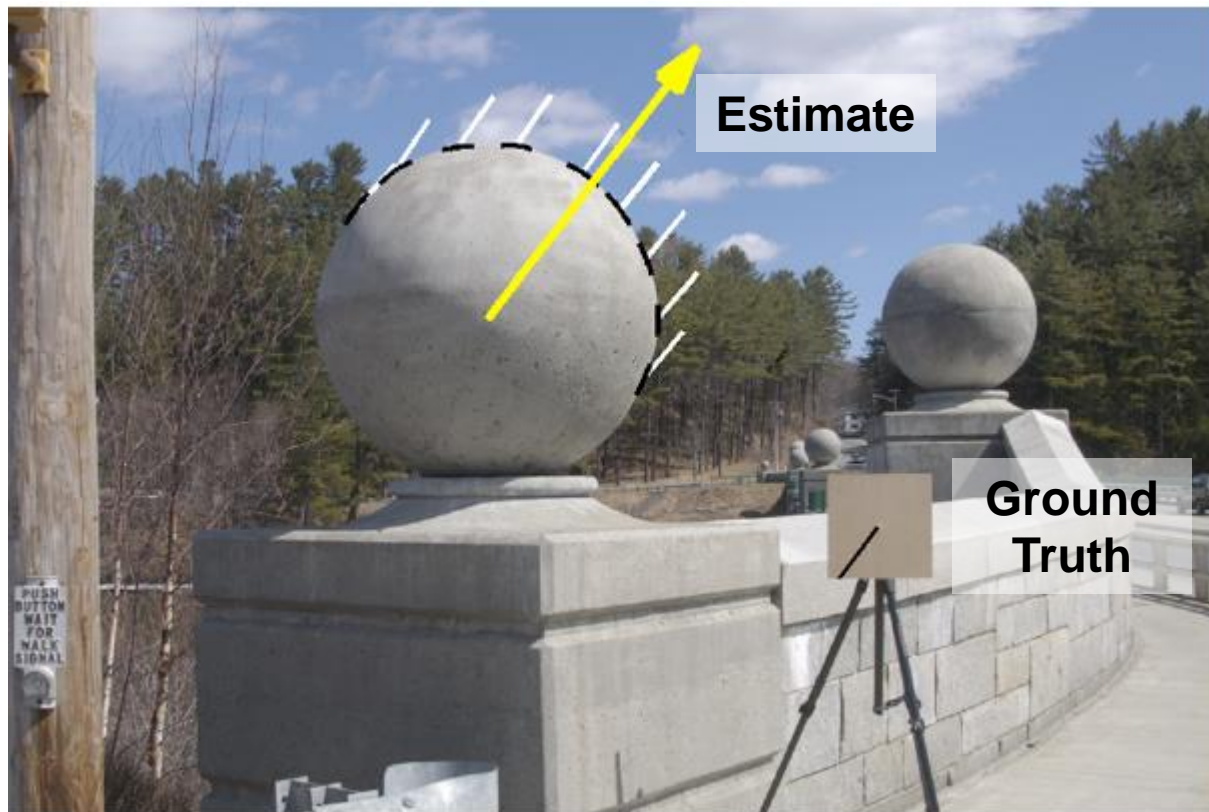
- Work by Hany Farid and colleagues
- Method 1: 2D light from occluding contours



# Estimating lighting direction

## Method 1: 2D direction from occluding contour

- Provide at least 3 points on occluding contour (surface has 0 angle in Z direction)
- Estimate light direction from brightness



# Estimating lighting direction



# Estimating lighting direction

- Average error: 4.8 degrees





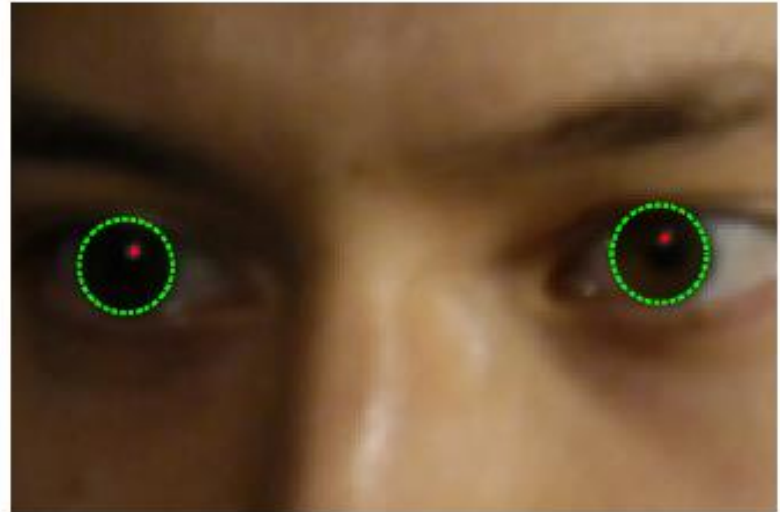
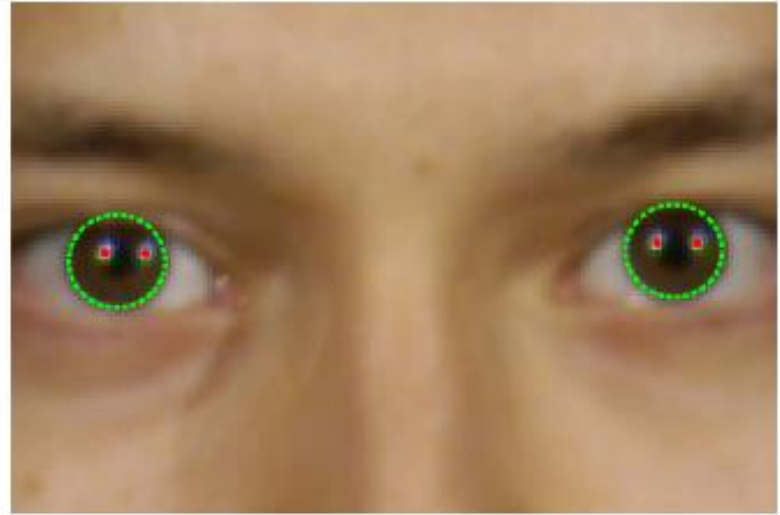
# Method 2: Light from Eyes



Farid – “Seeing is not believing”, IEEE Spectrum 2009

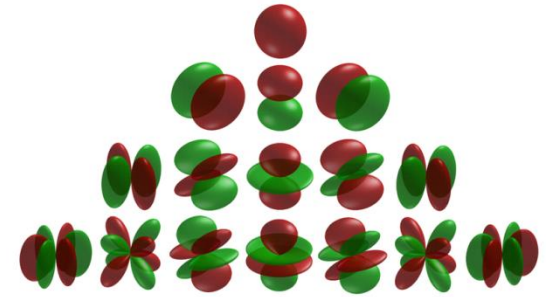


# Estimating Lighting from Eyes

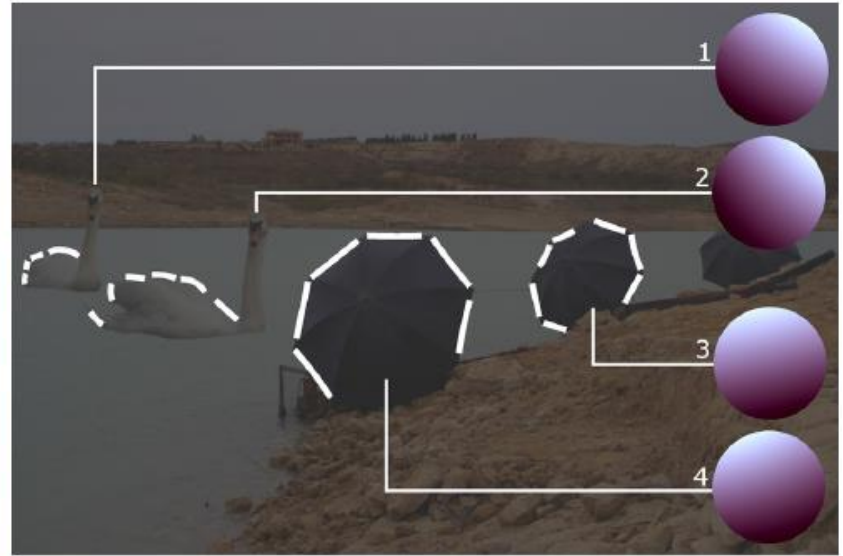


# Method 3: Complex light with spherical harmonics

- Spherical harmonics parameterize complex lighting environment
- Same method as occluding contours, but need 9 points



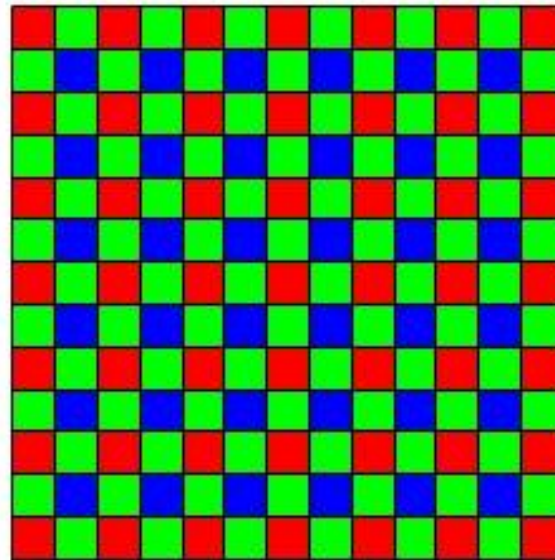
# Method 3: Complex light with spherical harmonics





# Method 4: Demosaicking Prediction

- In demosaicking, RGB values are filled in based on surrounding measured values
- Filled in values will be correlated in a particular way for each camera
- Local tampering will destroy these correlations



**Bayer filter**

# Demosaicking prediction

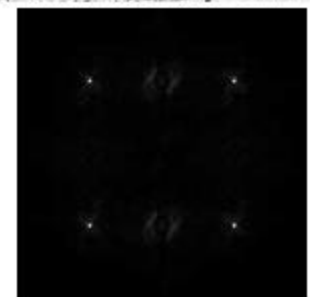
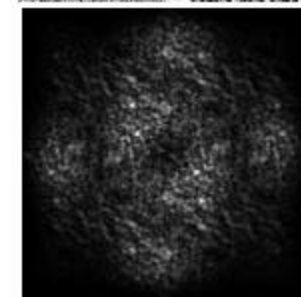
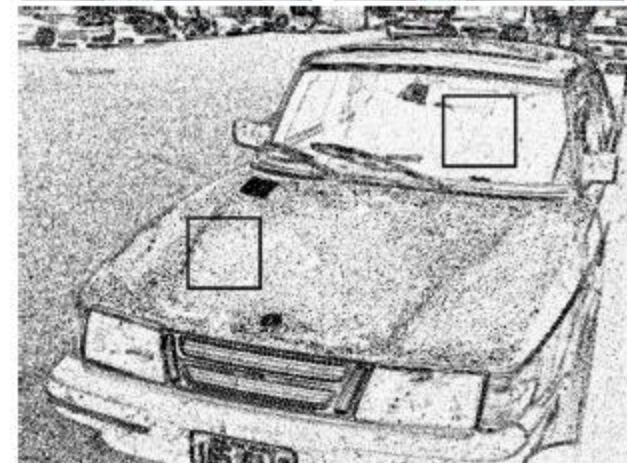
- Upside: can detect many kinds of forgery
- Downside: need original resolution, uncompressed image

Error in pixel prediction from a linear interpolation

Original



Tampered



FFT of error in each window  
(periodic for untampered case)

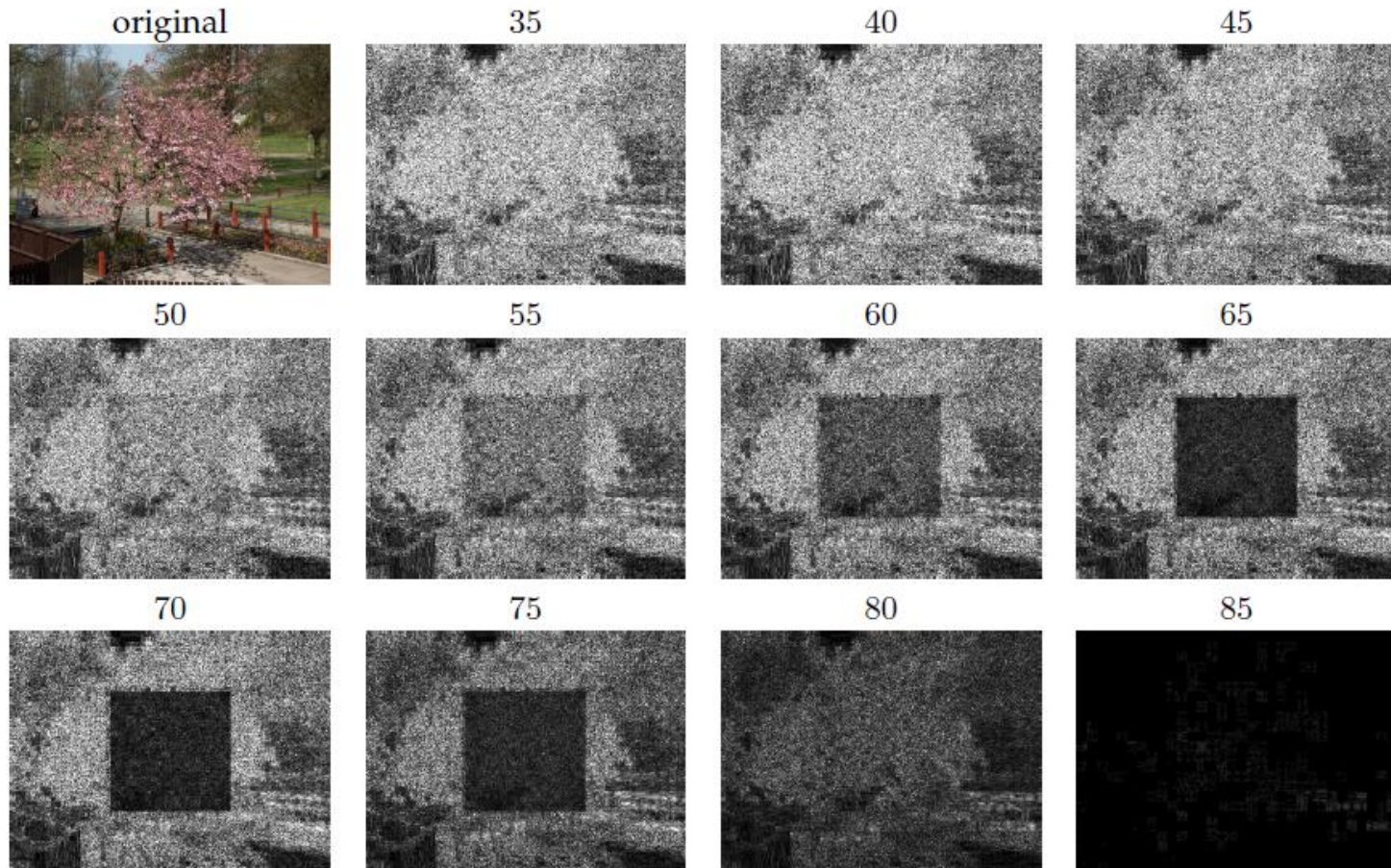
# Method 5: JPEG Ghosts

- JPEG compresses 8x8 blocks by quantizing DCT coefficients to some level
  - E.g., coefficient value is 23, quantization = 7, quantized value = 3, error =  $23 - 21 = 2$
- Resaving a JPEG at the same quantization will not cause error, but resaving at a lower *or higher* quantization generally will
  - Value = 21; quantization = 13; error = 5
  - Value = 21; quantization = 4; error = 1



# JPEG Ghosts

- Original is saved at 85 quality, center square is cut out and compressed at 65 quality; then image is resaved at given qualities



Pixel error for image saved at various JPEG qualities

# JPEG Ghosts

- If there is enough difference between the quality of the pasted region and the final saved quality, the pasted region can be detected with high accuracy

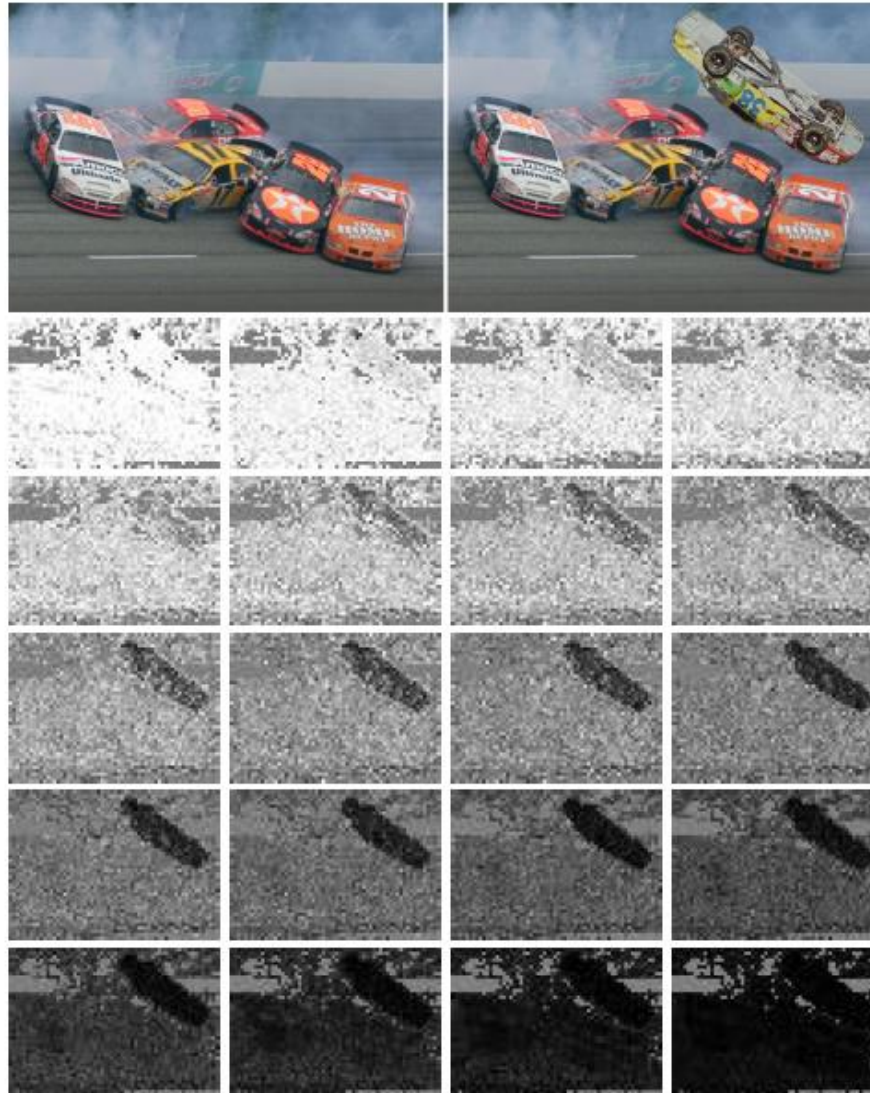
Table 2: JPEG ghost detection accuracy (%)

size	$Q_1 - Q_0$					
	0	5	10	15	20	25
$200 \times 200$	99.2	14.8	52.6	88.1	93.8	99.9
$150 \times 150$	99.2	14.1	48.5	83.9	91.9	99.8
$100 \times 100$	99.1	12.6	44.1	79.5	91.1	99.8
$50 \times 50$	99.3	5.4	27.9	58.8	77.8	97.7

# JPEG Ghosts

original

manipulated

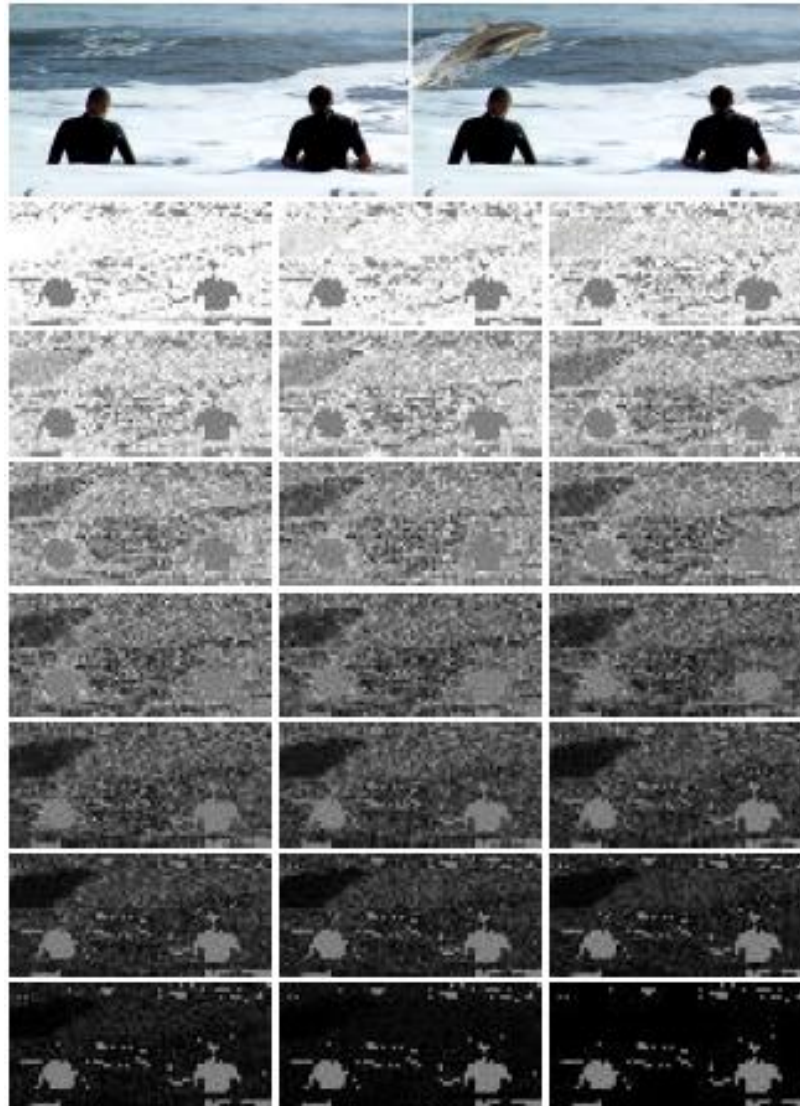


Pixel error for manipulated image saved at various JPEG qualities

# JPEG Ghosts

original

manipulated



Pixel error for manipulated image saved at various JPEG qualities



# Summary

- Digital forgeries are an increasingly major problem as it becomes easier to fake images
- A variety of automatic and semi-automatic methods are available for detection of well-done forgeries
  - Checking lighting consistency
  - Checking demosaicking consistency (for high quality images)
  - Checking JPEG compression level consistency (for low quality images)

# Upcoming

- Thursday: Computational approaches to cameras