

Digital Image Processing

CS390S

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2018 Spring



METROPOLITAN STATE UNIVERSITYSM
OF DENVER

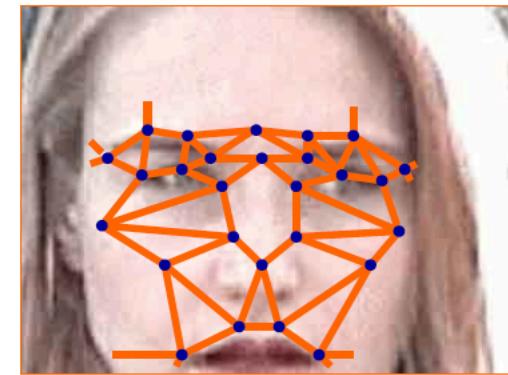
Project 1 Due April 2nd

- Report (include plots, figures, analysis, discussion of results) 10/25
- Performance (able to run the program, correctness of algorithm) 10/25
- Presentation (**Due March 27th 11:59pm**) 5/25
 - Name on slide! peer review score (1-5)
 - 3 minutes
 - Design + special approaches + performance analysis and applications

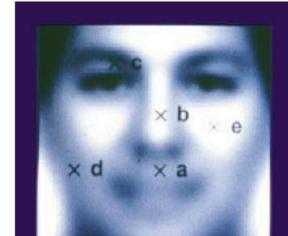
Face Recognition

Feature-based (structural) matching methods

- The Structure of the face



- The skin of the face



Face Recognition

- Holistic matching methods
- Feature-based (structural) matching methods
- Hybrid methods
- Other methods

Face Recognition

- Infrared Face



Infrared imagery:
Immune to lighting



Easy

3D face images ...



Day 17

Human visual system & visual saliency

Human visual perception

- ✓ Computer vision produces images for computer use or analysis whereas image processing produces images for human consumption
- ✓ Image processing is the process of taking an image and getting a better image out
Better in what sense?
Enhanced, restored or compressed

Human visual perception

- ✓ Image enhancement and restoration both involve techniques to make a better image
- ✓ Image compression involves development of techniques to make smaller files, while still retaining high quality images
- ✓ Metrics to measure image quality must be defined to compare improvement methods
- ✓ The human visual system must be understood to help determine what makes a better image

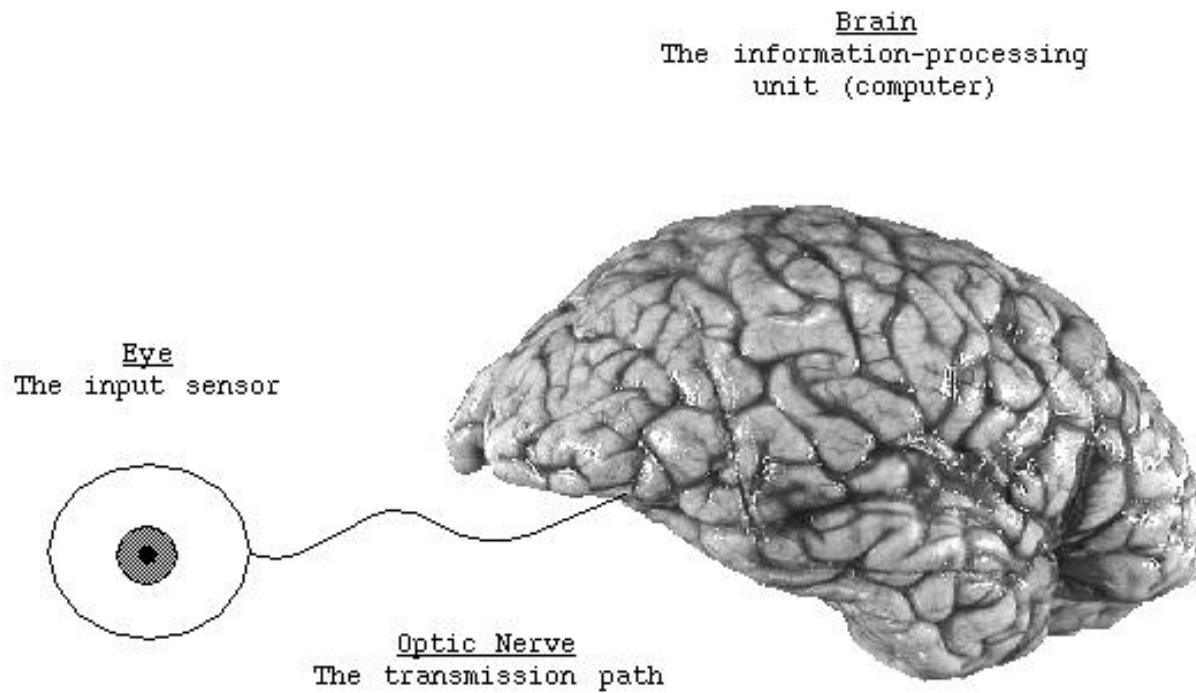
Human visual perception

- ✓ Human visual perception encompasses both physiological and psychological components
- ✓ Why study visual perception?
In order to design compression, enhancement and restoration algorithms

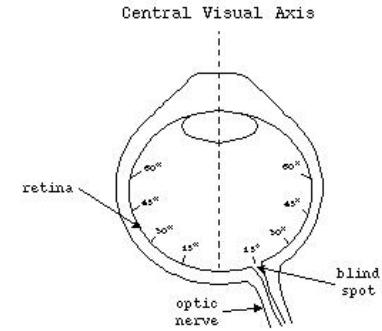
Human visual system (HVS)

- Vision is our most powerful sense
- Enables us to gather information and learn through observation
- Allows to interact with the environment without any physical contact
- HVS consists of two primary components:
 - ❖ The eye (receiving sensor)
 - ❖ The brain (processor)Both are connected by the optic nerve

Human visual system



Human visual system



- **The HVS works in the following way:**
 1. Light energy is focused by the lens onto the sensors of the retina at the back of the eye
 2. Sensors respond to the light energy by an electro-chemical reaction that sends an electrical signal down the optic nerve to the brain
 3. Brain uses nerve signals to create neurological patterns that we perceive as images

Human visual system

Brightness adaptation

- The HVS responds to a wide range of brightness levels
- The response varies based on the average brightness observed , and is limited by the *dark threshold* and *glare limit*

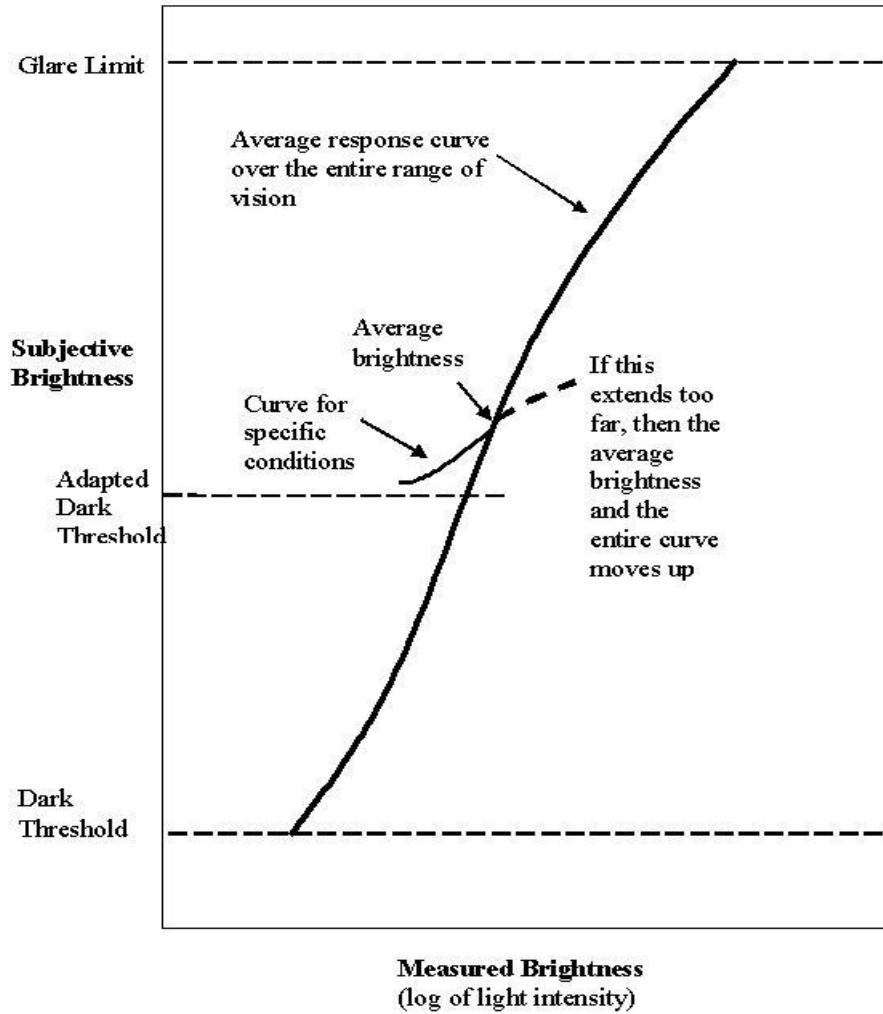
Dark threshold: Below this brightness level all appears black to the HVS

Glare limit : Above this brightness level is blinding, all we see is white

Human visual system

- The HVS adapts to existing lighting conditions, which allows us to see over a small part of the overall range at any one time
- The adaptation is due to the pupil which acts as a diaphragm on the lens by controlling the amount of light that can enter
- Subjective brightness is a logarithmic function of the incident light energy on the eye
-

Human visual system



Human visual system

- It has been experimentally determined that we can only detect about 20 changes in brightness in a small area within a complex image
- It has also been determined that about 100 different gray levels are necessary to create a realistic image (7 bits per pixel)
- False contours may be observed if fewer gray levels are used
-

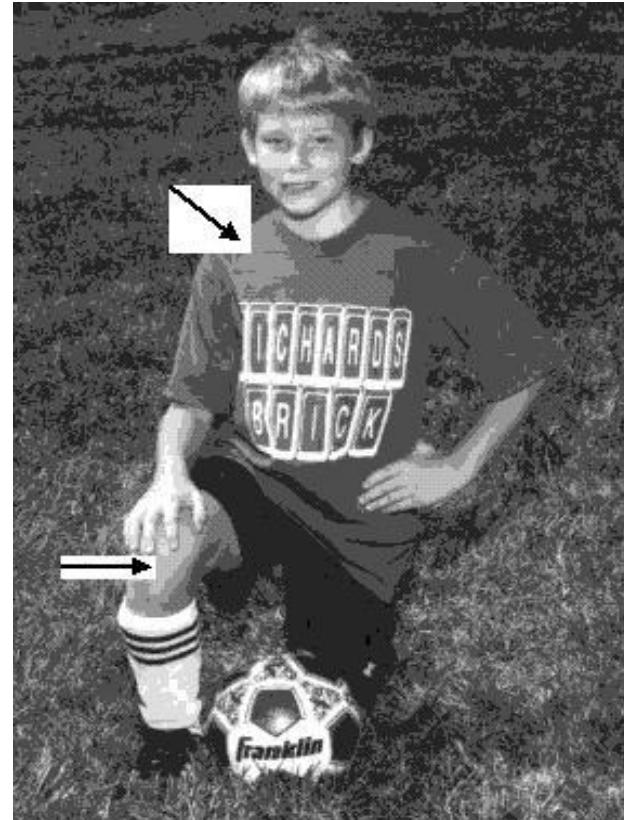
Human visual system

False contouring

-



Original image at 8 bits /pixel
for 256 gray levels



Original image at 3 bits /pixel
for 8 gray levels



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Human visual system

Perception and Illusion

- To fully understand our ability to perceive visually, the current biological system model is limited
- Spatial frequency resolution and brightness adaptation phenomena are caused by physical limitations of the visual system
- Perception involves the brain, which is not fully understood
- Perception is relative, not absolute, and depends on context
-

Human visual system

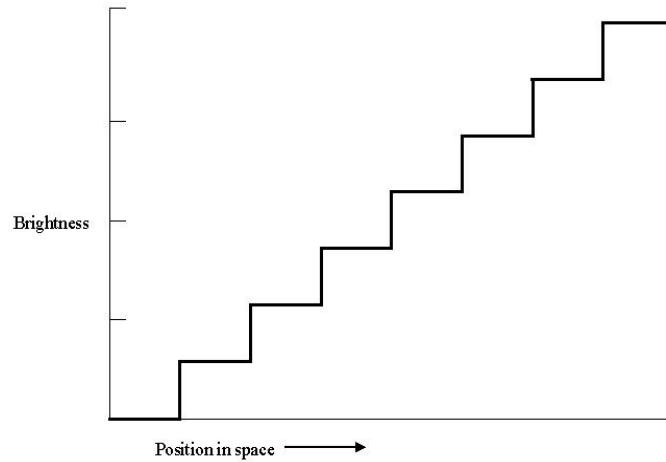
- **Mach band effect:**

- ❖ An effect caused by the lateral inhibition process inherent in the visual neural system which emphasizes edges in images
- ❖ Creates an optical illusion
- ❖ Accentuates the edges, and helps to distinguish and separate objects within an image
- ❖ Combined with brightness adaptation response, allows us to see outlines even in dimly lit areas

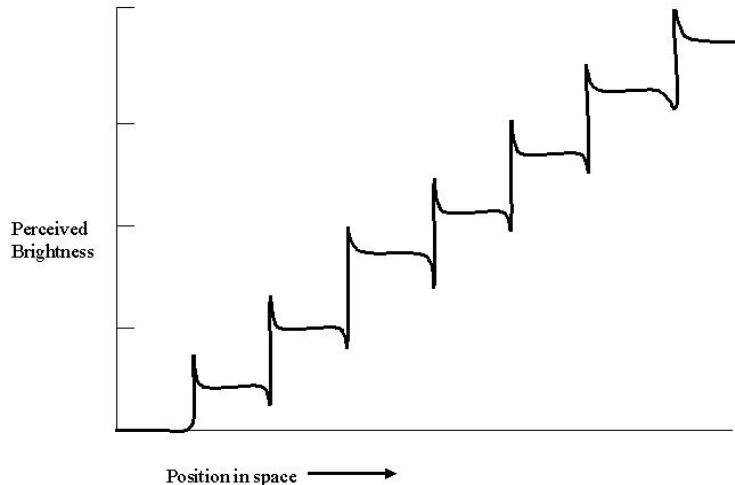
Human visual system



Image with uniformly distributed gray levels



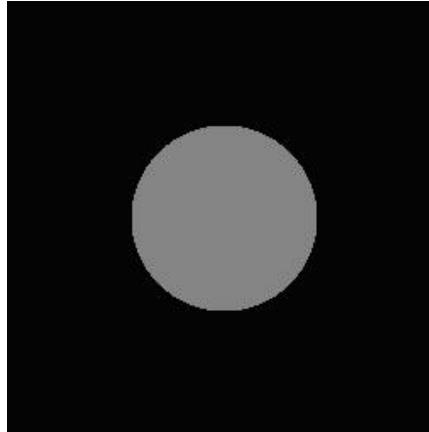
Actual brightness values



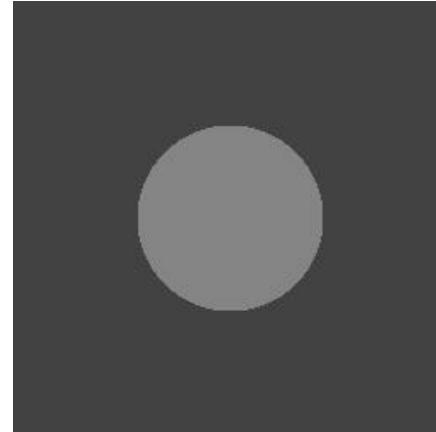
Perceived brightness values due to the Mach band effect, creating a scalloped effect

Human visual system

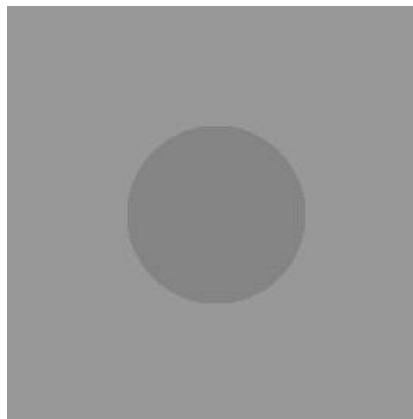
Simultaneous contrast



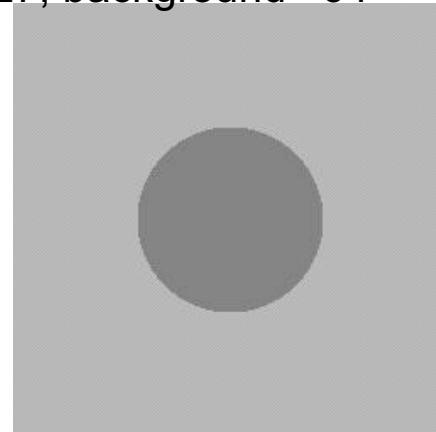
Circle = 127, background =0



Circle = 127, background =64



Circle = 127, background =150



Circle = 127, background =180

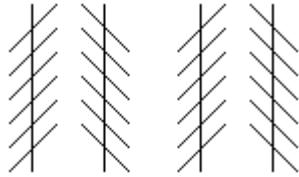
Human visual system

- A phenomenon of the HVS that causes perceived brightness to be dependent not only on the brightness levels, but also on brightness levels of the adjacent areas

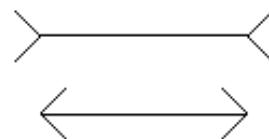
Human visual system

- **Optical illusion:**
 - ❖ A phenomenon created when the brain completes missing spatial information or misinterprets objects' attributes
 - ❖ Emphasizes the concept that visual perception depends not simply on individual objects, but also on the background and on how the objects are arranged in the image

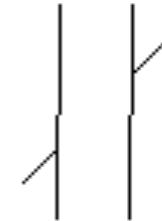
Human visual system



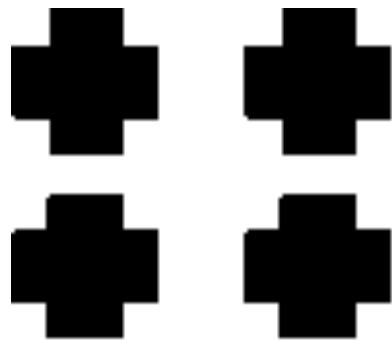
Vertical lines appearing tilted



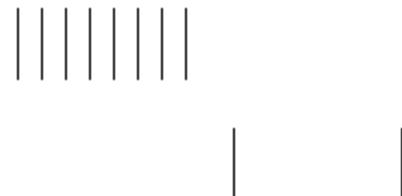
Top line appears longer than bottom line



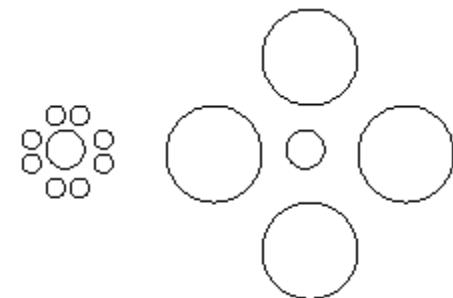
Two diagonal line segments appear not to be collinear



Is this four black crosses, or connected white rectangles?



Outer two lines in the upper group appear to be farther apart



Two center circles are of same size, but the one surrounded by larger circles appears smaller

Human visual system

Image quality

- ✓ Determines exactly what information is important and enables the measurement of image quality
- ✓ Information required is application specific
- ✓ They can be divided into two classes:
 - **Objective fidelity criteria**
 - **Subjective fidelity criteria**

Human visual system & visual saliency

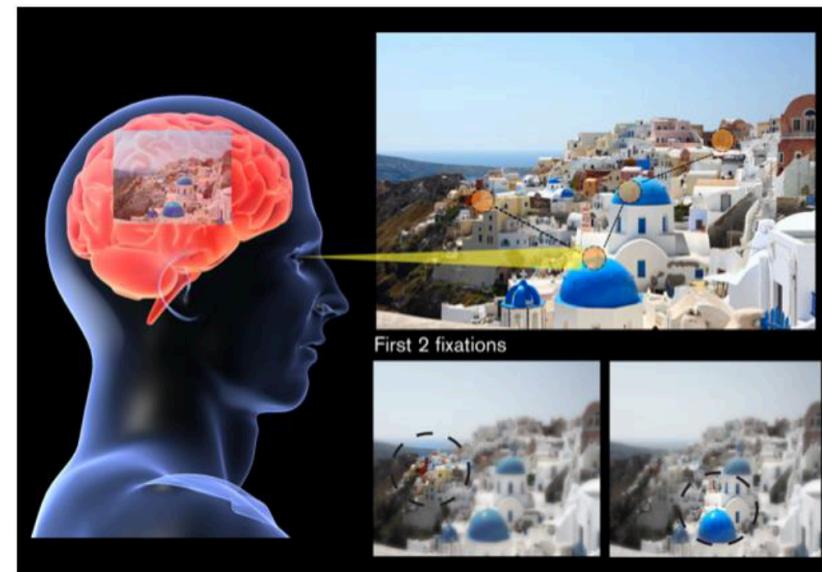
- Visual Attention
- Visual Saliency

Human visual system & visual saliency

Visual attention



Visual attention is a built-in mechanism of the human visual system for scene understanding.



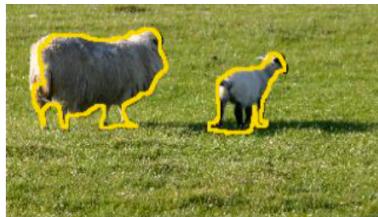
<http://www.tobii.com/eye-tracking-research/global/library/white-papers/tobii-eye-tracking-white-paper/>

Human visual system & visual saliency

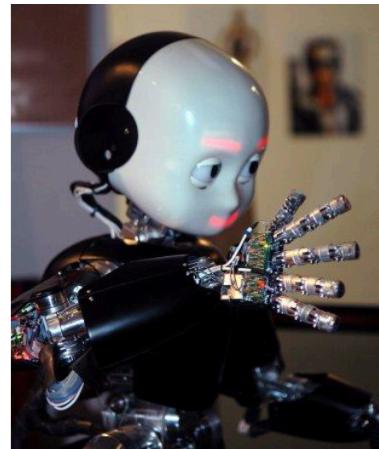
Simulating visual attention is essential



Such a pre-selection mechanism would be essential in enabling computers to undertake



[Donoser *et al.* 09]



[<http://www.icub.org>]



[<https://www.google.com/glass>]

Object detection

HCI

Visual assistance

Human visual system & visual saliency

Saliency as a measure of attention



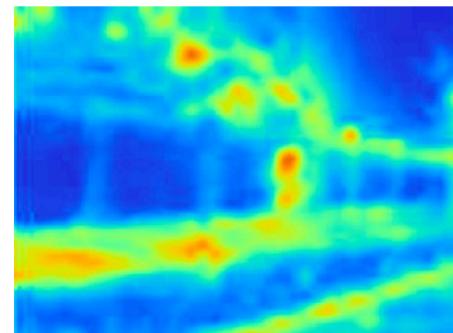
Saliency = attractiveness of visual attention

- Simple, easy to implement, reasonable outputs

Estimating human visual focus of attention



Input image



Saliency map [Itti et al. 98]



Human visual system & visual saliency

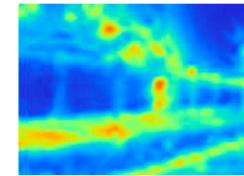
Related work

Visual saliency

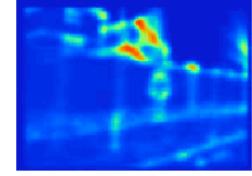
- Saliency map model [Itti 1998]
- Shannon self-information [Bruce 2005]
- Incorporating temporal dynamics [Itti 2009]



Input image



[Itti *et al.* 98]



[Bruce *et al.* 05]

Visual saliency

- Required paper reading (GBVS): “Graph-Based Visual Saliency” by Jonathan Harel, Christof Koch , Pietro Perona
- Papers for reading
- Two papers in Blackboard: saliency1 saliency2
- Code (GBVS)

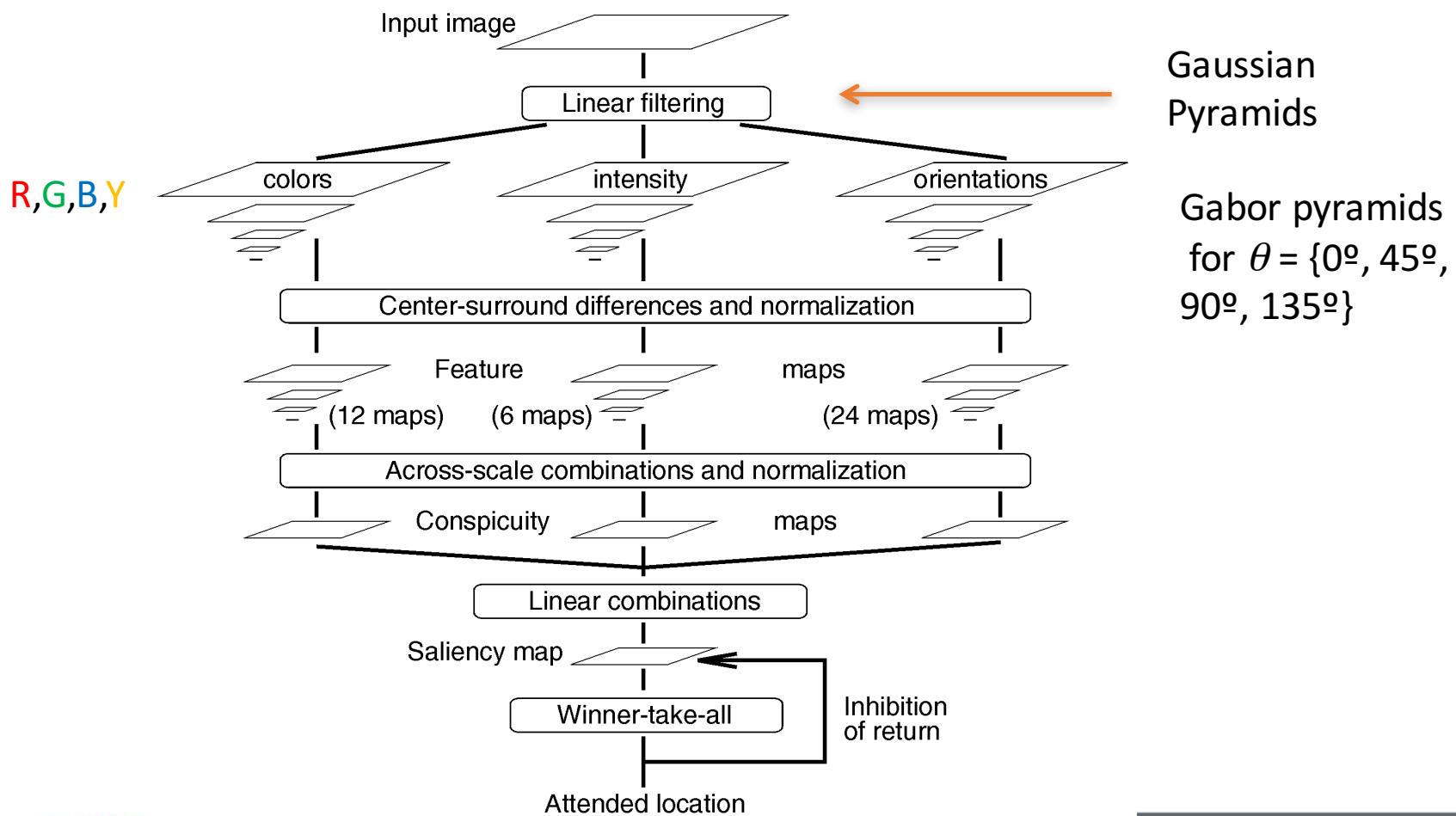
Visual saliency

- Applications “SalApplications.pdf”

Visual saliency

- <http://www.vision.caltech.edu/~harel/share/gbvs.php>
- Code install
- Download GBVS from blackboard
- Install GBVS:
- <http://www.vision.caltech.edu/~harel/share/gbvs/readme.txt>

L. Itti's approach



Question



Fig. 1. Reference Image I18.

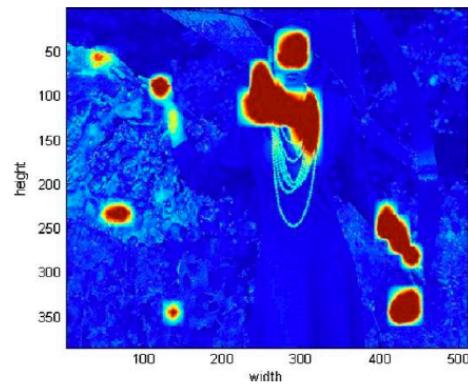


Fig. 2. Saliency map of I18
with face detection.

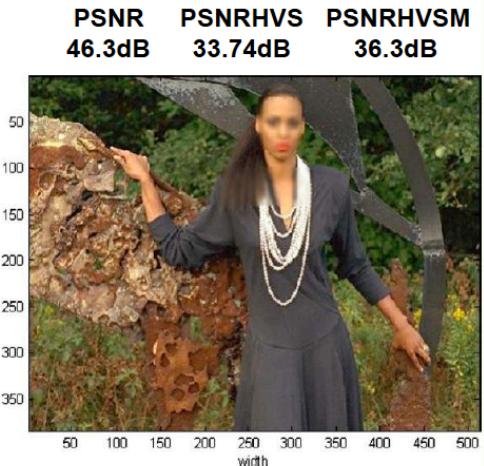


Fig. 3. I18 with noise in one
salient region

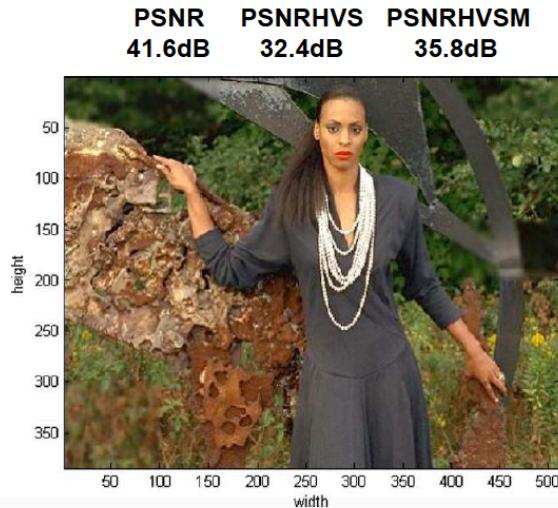


Fig. 4. I18 with noise in nonsalient region



Fig. 5. I18 with distortion in four nonsalient region

