Exposure metering (AE)

CS 178, Spring 2014

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Outline: metering

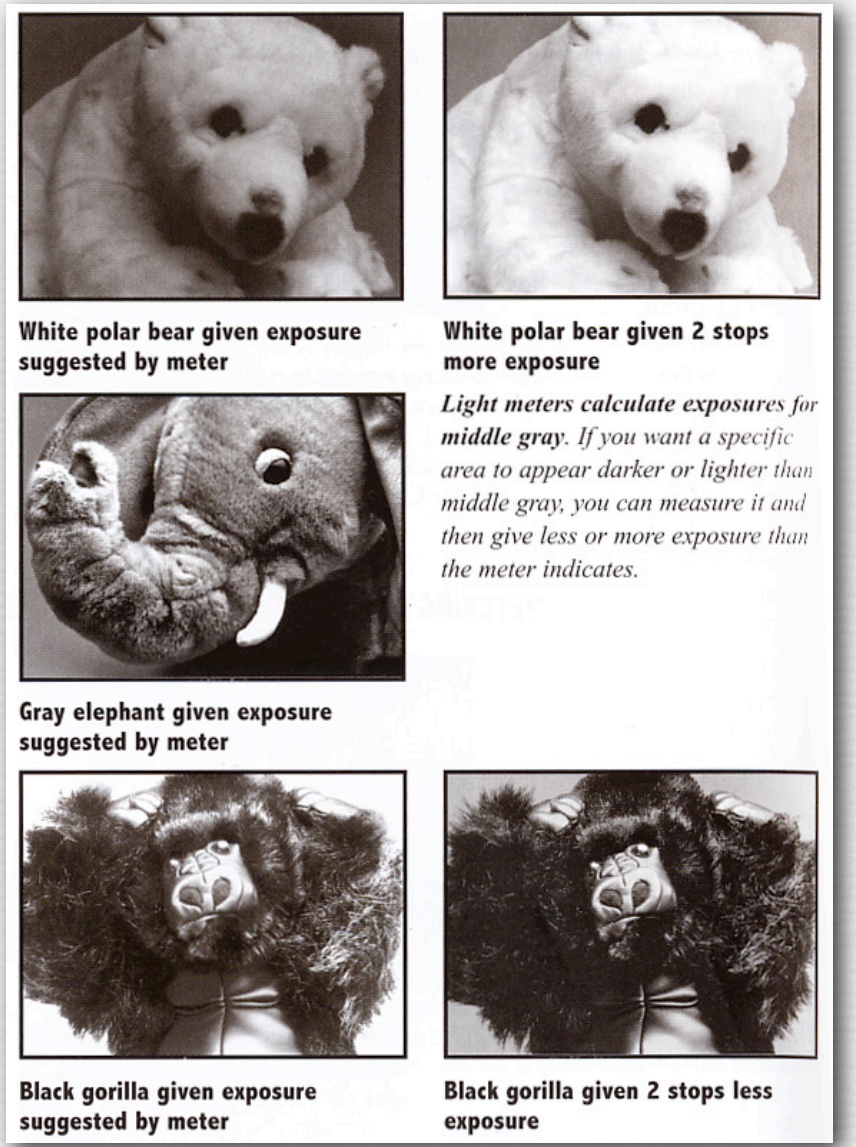
- What makes metering hard?
  - the meter doesn't know what you're looking at
  - the dynamic range problem
- background topics
  - Ansel Adams' zone system
  - gamma and gamma correction
- metering technologies
- metering modes (center, evaluative,...)
- shooting modes (Av, Tv, P, M)
- exposure compensation, etc.

What makes metering hard?

- light meters don't know what you're looking at
  - so they assume the scene is mid-gray (18% reflective)

- the world is full of hard metering problems...

(London)



White polar bear given exposure suggested by meter

White polar bear given 2 stops more exposure

Light meters calculate exposures for middle gray. *If you want a specific area to appear darker or lighter than middle gray, you can measure it and then give less or more exposure than the meter indicates.*

Gray elephant given exposure suggested by meter

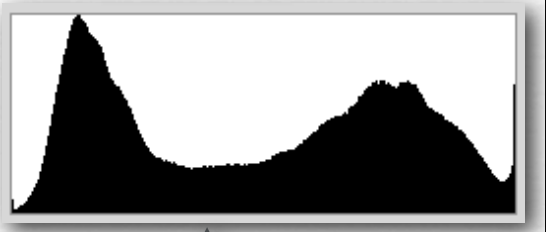
Black gorilla given exposure suggested by meter

Black gorilla given 2 stops less exposure

(http://fotocommunity.de)

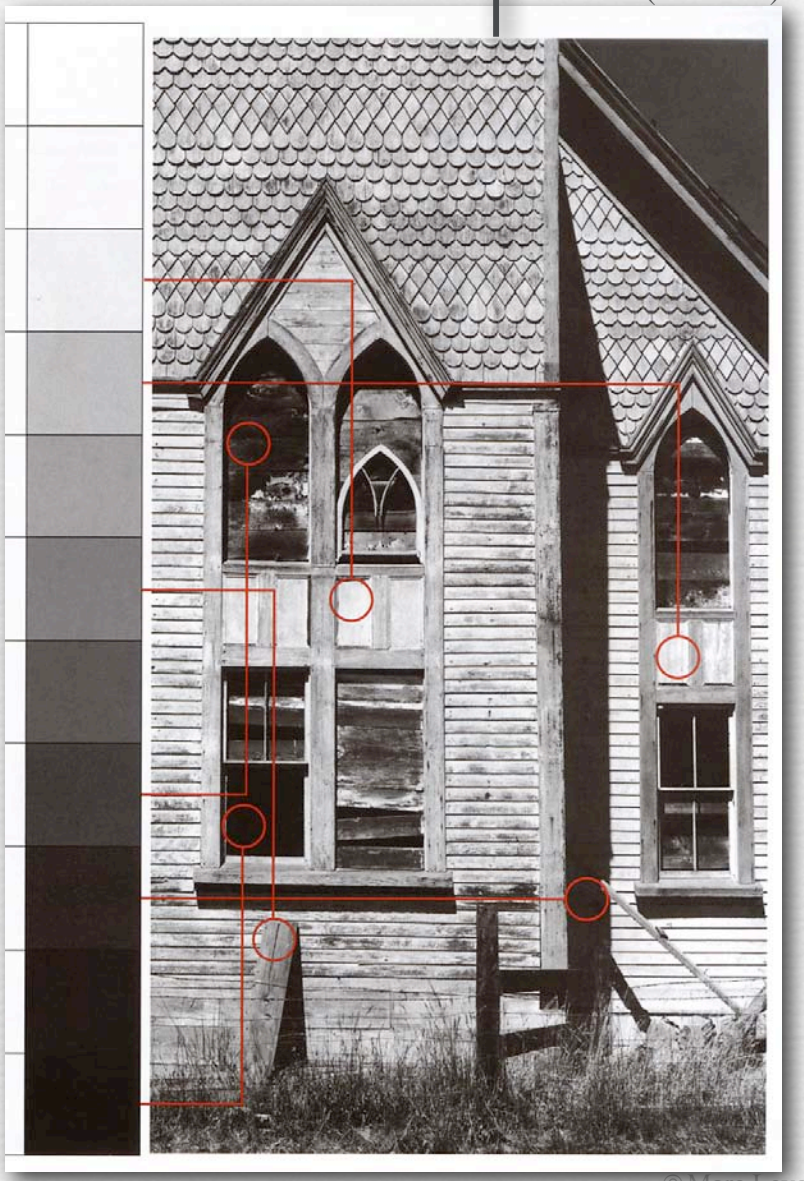
Ansel Adams's zone system

histogram



(London)

- roughly 1 f/stop per zone
  - X = "maximum white of the paper base"
  - IX = "slight tonality, but no texture: flat snow in sunlight"
  - VIII = "textured snow, lightest wood at right"
  - .....
  - V = 18% gray card
  - .....
  - 0 = "maximum black that photographic paper can produce"
- lesson for the digital age
  - plan the tones you want in your image for each part of the scene



The dynamic range problem

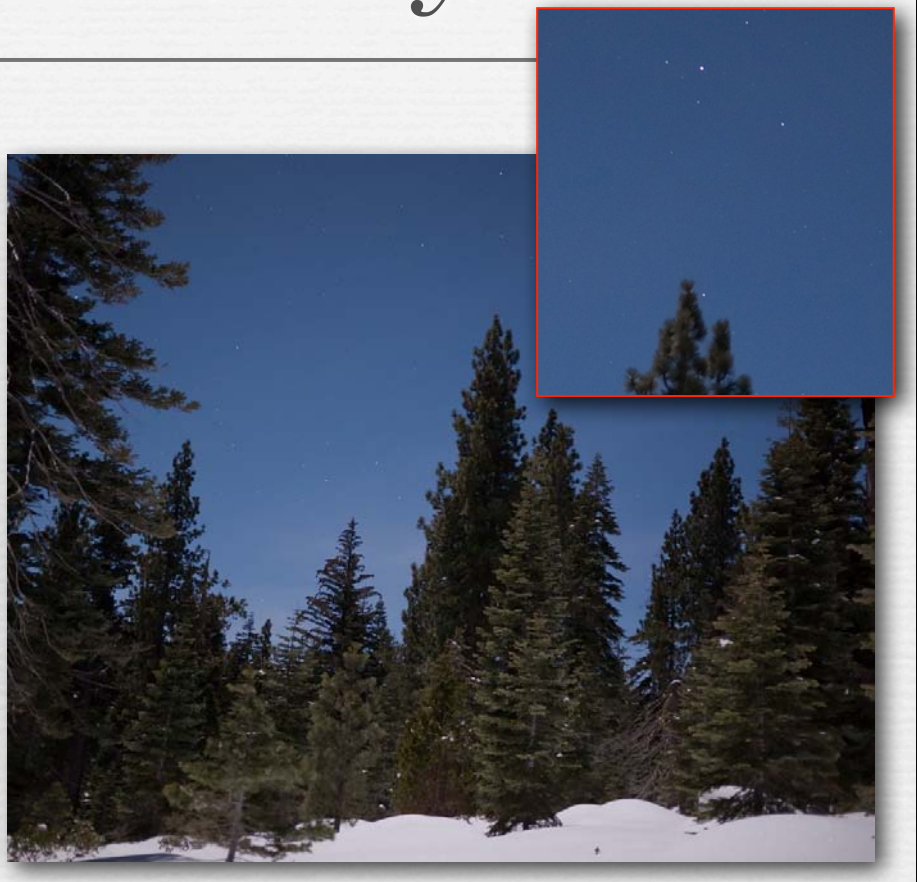
- even if meters were omniscient, the dynamic range of the world is higher than the dynamic range of a camera

- the real world

800,000:1	surface illuminated by sun vrs by moon, (20 f/stops, or 1/1000 sec vrs 13 minutes)
100:1	diffuse white surface versus black surface
80,000,000:1	**total dynamic range**

Illuminated by sun versus by moon

1/500s, f/6.3, ISO 100



8s, f/1.7, ISO 400

- total difference in shooting settings = 256,000:1
- luminance of snow pixels (in RAW file) differ by another ~2×

Illuminated by sun versus by moon

RAW file

1/500s, f/6.3, ISO 100

RAW file

8s, f/1.7, ISO 400

- total difference in shooting settings = 256,000:1
- luminance of snow pixels (in RAW file) differ by another ~2×
- JPEG value = (RAW value / 65536)$^{1/\gamma}$ × 255, where γ = 2.2

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- human vision

100:1	photoreceptors (including bleaching)
10:1	variation in pupil size
100,000:1	neural adaptation
100,000,000:1	**total dynamic range**

The dynamic range problem

- media (approximate and debatable)
  - 40:1 photographic print (more if glossy paper)
  - 50:1 artist's paints
  - 500:1 negative film
  - 1000:1 LCD display
  - 4000:1 digital SLR sensor (~12 bits)

To clarify my in-class narration of this slide, the dynamic range of the world could be as high as 80,000,000:1 (or even higher, if you include unusually bright lights or dark closets!), but most scenes have a much lower dynamic range. For an SLR, if the scene is more than 4000:1, then metering must decide what to leave in shadow (i.e. black), or what to blow out (to white). If the scene is less than 4000:1, then metering still faces the hard problem of deciding where to place the dynamic range of the camera relative to the brightnesses present in the scene. Should that polar bear be gray or white?

A student asked whether there is a higher-bitdepth standard than JPEG, which limits images to 8 bits per pixel per color component (R,G,B). 12-bit pixels have been defined within the JPEG standard for a while, but are not widely supported. Earlier this year a new version of the widely used libjpeg library was released, implementing compression and decompression with 12 bits per pixel. It will presumably be a while until JPEG viewers in popular programs and browsers incorporate this support.

- challenges
  - choosing which 4000:1 of the 80M:1 world to record on your sensor
  - metering the world to help you make this decision, since the world has more dynamic range than the sensor can see at once
  - compressing 12 bits into 5 bits for print, or 8 for JPEG
    - this is the *tone mapping* problem

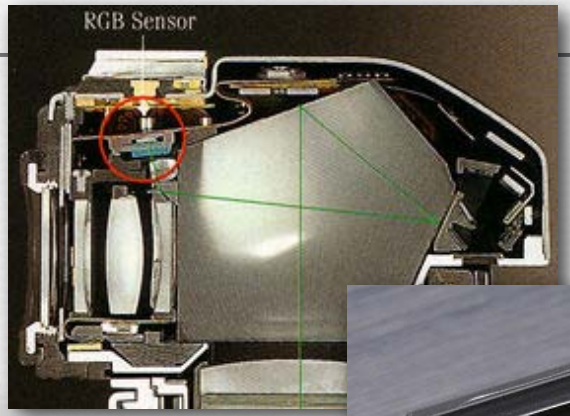
Recap

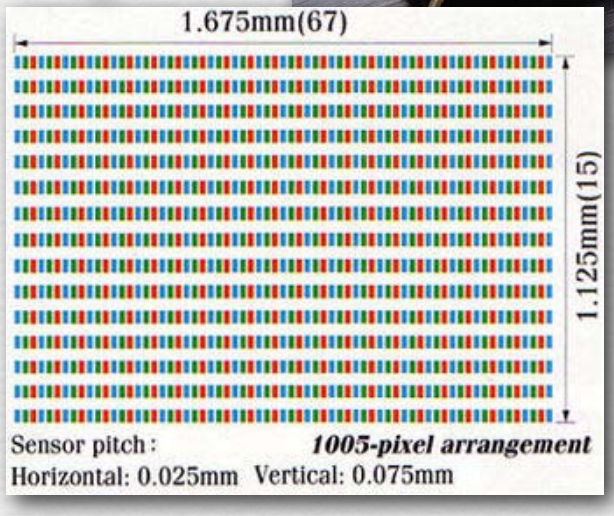
- automatic metering is hard
  - the camera doesn't know how bright objects really are, hence where in the image intensity range to place them
  - the camera's main sensor can't see the world's dynamic range at once
- the dynamic range problem
  - the dynamic range of the real world is large (80M:1)
  - the dynamic range humans can see is also large (100M:1)
  - the dynamic range of reproduction media is small (100's:1)
  - the range of cameras is somewhere in the middle (1000's:1)
  - so cameras can't see the whole world's range at once, and they must compress the range they do see for reproduction on most media
- you can use image intensities to compare scene brightnesses, but only before the non-linear RAW → JPEG gamma mapping

Questions?

Metering technologies

- SLRs use a low-res sensor looking at the focusing screen
  - Nikon: 1005-pixel RGB sensor
  - Canon: silicon photocell (SPC) with 35 B&W zones **NOW 63-ZONE !**
  - big pixels, so low res, but wide dynamic range (Canon=20 bits)
- point-and-shoots use the main image sensor
  - small pixels, so easily saturated
  - if saturated, reduce exposure time and try again
- both are through the lens (TTL)

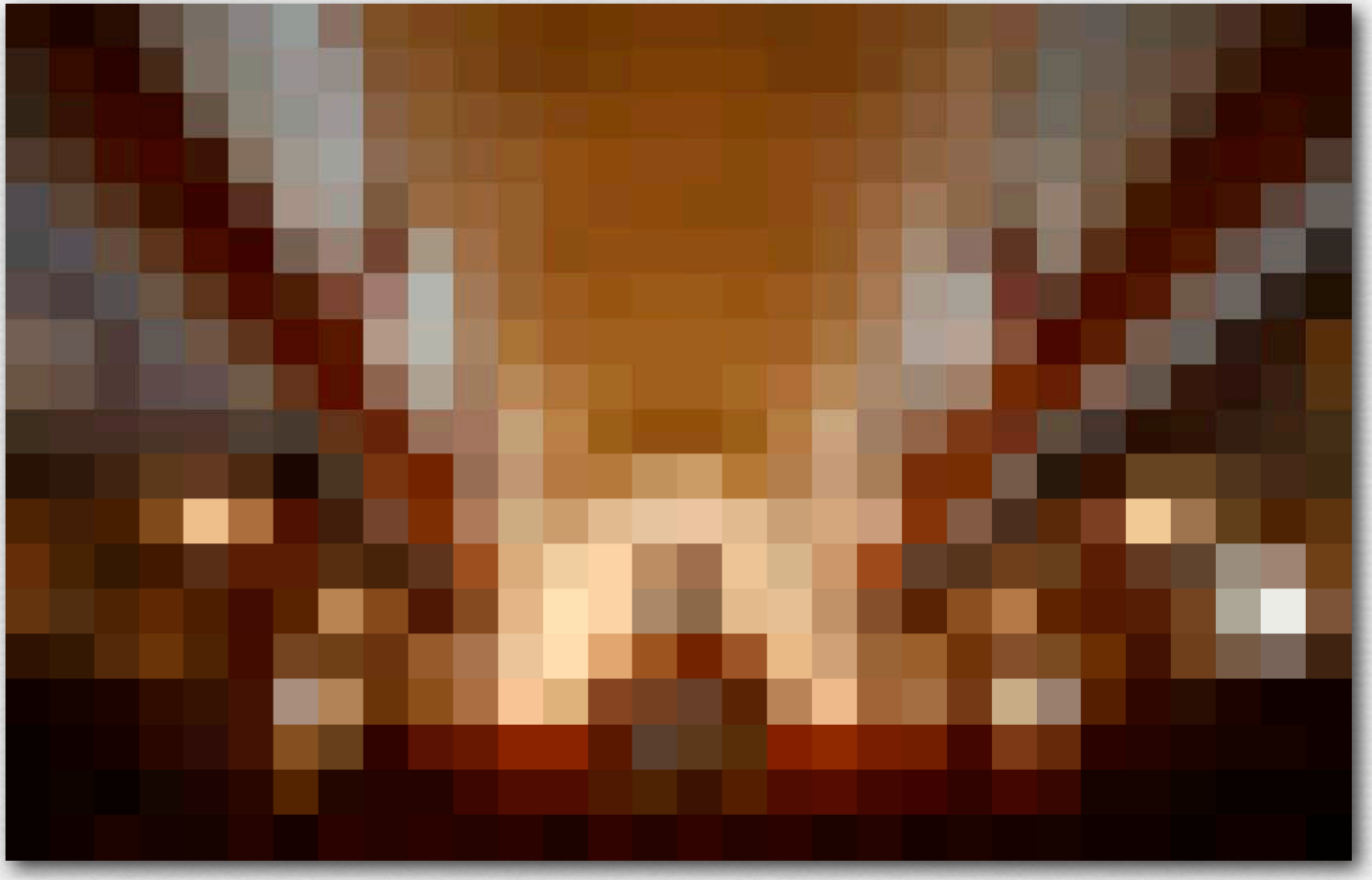




(http://steves-digicams.com & http://mir.com.my)

Low resolution makes metering hard

- What's this scene? What should the exposure be?



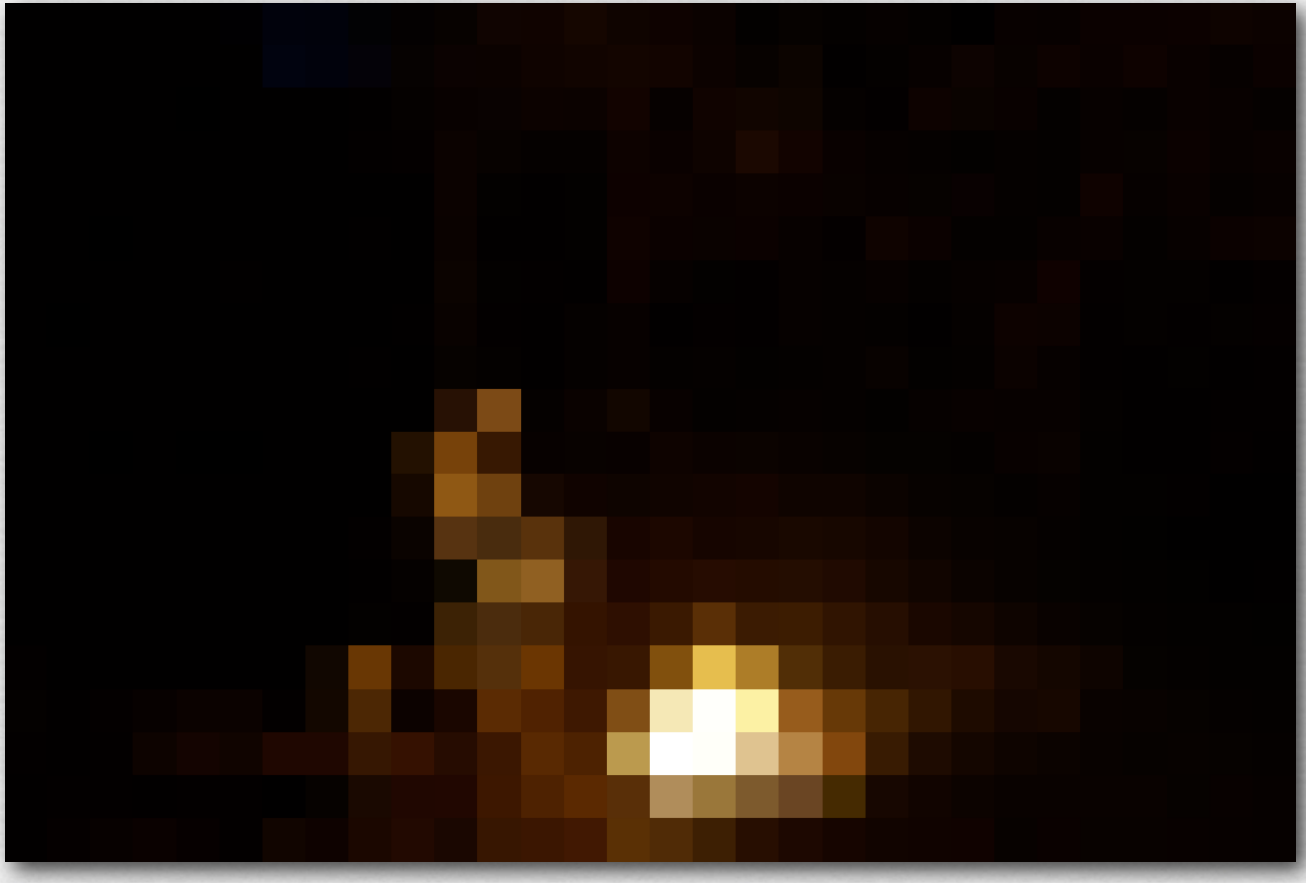
Low resolution makes metering hard

- What's this scene? What should the exposure be?

(Marc Levoy)

Low resolution makes metering hard

- How about this scene?
  Should the bright pixels be allowed to saturate?



Nikon: 1005 color pixels

Low resolution makes metering hard

- How about this scene?
  Should the bright pixels be allowed to saturate?

Canon: 35
B&W zones

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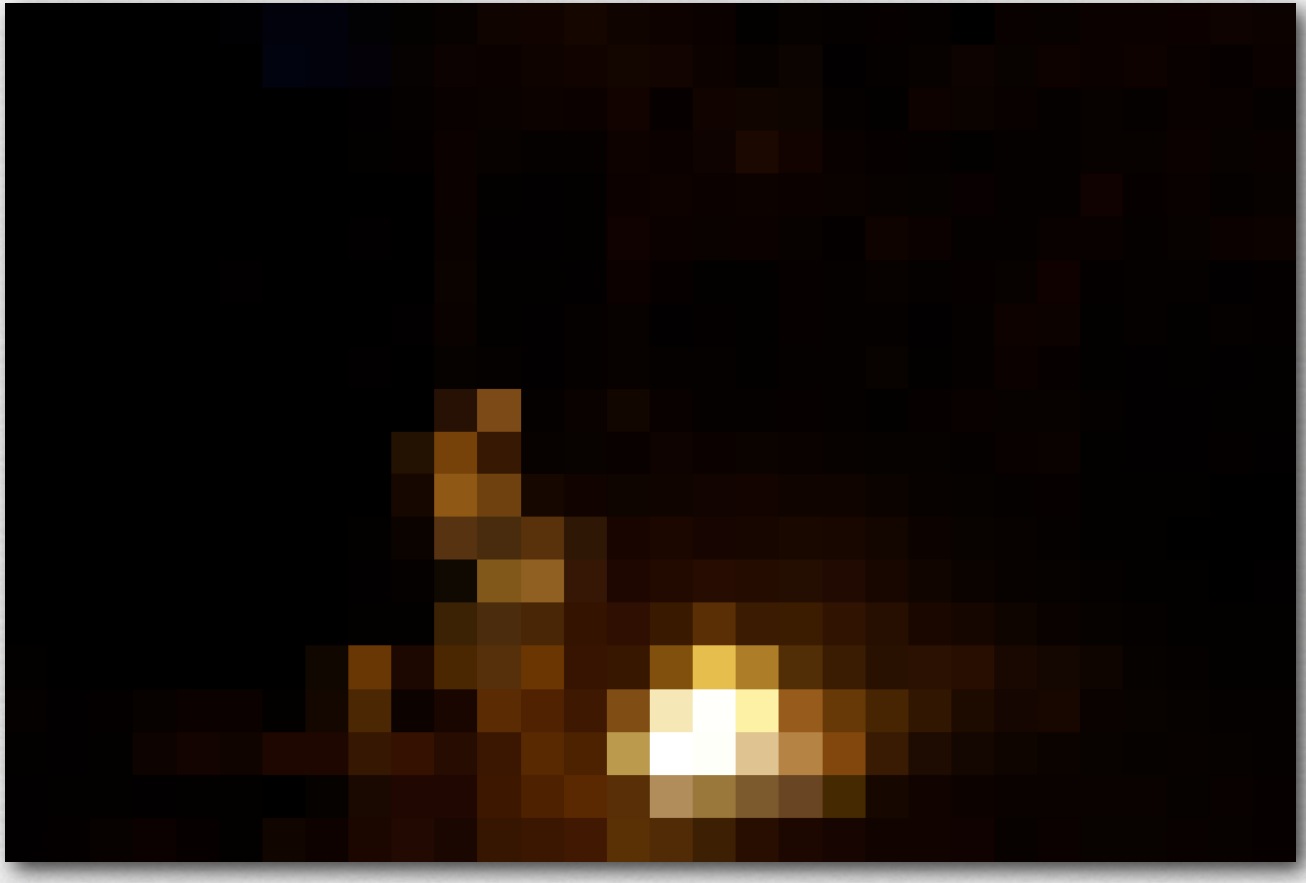

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Low resolution makes metering hard

- How about this scene?
  Should the bright pixels be allowed to saturate?

(Andrew Adams)

Low resolution makes metering hard

- What about the bright pixel in this scene?

Nikon: 1005 color pixels

Low resolution makes metering hard

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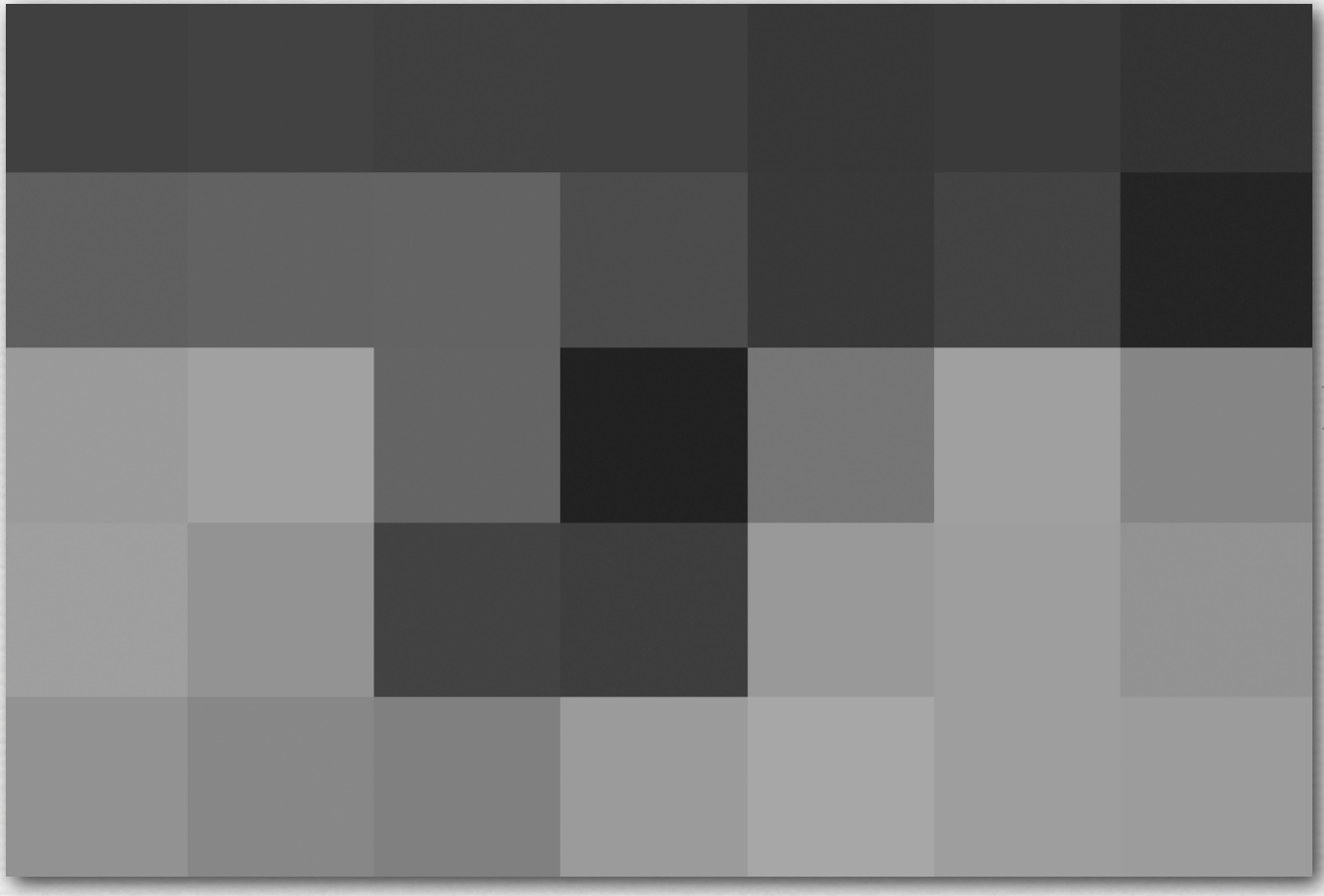

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Low resolution makes metering hard

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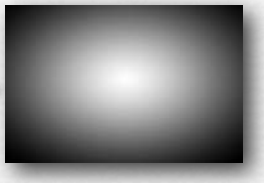
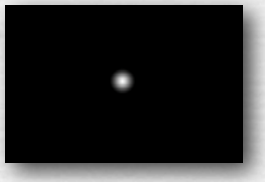
Metering modes

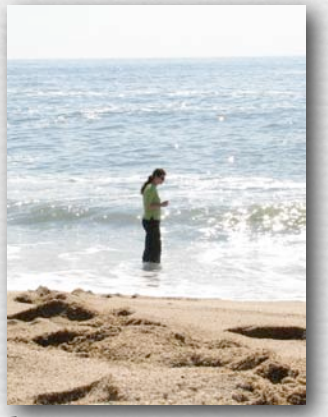
- center-weighted average



- spot (3.5% of area on Canon)



- evaluative
  - learn from database of images
  - decision may depend on brightness from each zone, color, local contrast, spatial arrangement of zones, focus distance
  - decision affected by camera mode (Portrait, Landscape,...)

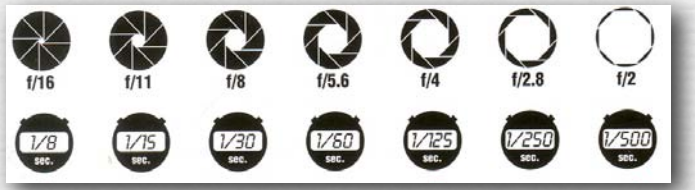


- face detection
- future?
  - object recognition, personalization based on my shooting history or online image collections, collaborative metering

Shooting modes

- Aperture priority (Av)
  - photographer sets aperture (hence depth of field)
  - camera sets shutter speed
- Shutter priority (Tv)
  - photographer sets shutter speed (hence motion blur)
  - camera sets aperture

- Manual (M)
  - photographer decides both (with feedback from meter or viewfinder)



- Program (P)
  - camera decides both
  - photographer can trade off aperture against shutter speed with a dial
- Auto
  - camera decides both
  - photographer can't make stupid mistakes

Other modes

- exposure compensation
  - tells camera to under/over-expose by specified # of f/stops
  - use to ensure correct appearance of dark or light subjects
  - don't forget to reset it to zero when you're done!
- exposure lock (a.k.a. AE lock)
  - freezes exposure
  - pressing shutter button halfway only focuses
- exposure bracketing
  - takes several pictures a specified number of f/stops apart

Recap

- metering in SLRs is done by a special sensor with big pixels
  - big pixels provide high dynamic range, to allow a one-shot decision
- metering in point-and-shoots is done by the main sensor
  - if the scene is too bright, it must reduce exposure and try again
- metering systems try to "understand" the scene
  - including analyzing focus, placement of objects, camera mode, etc.
  - but their low resolution makes this hard
- cameras offer a range of automatic to manual shooting modes
  - they also allow you to compensate if your object of interest is unusually light (polar bear) or dark (gorilla)

Questions?

Slide credits

- Andrew Adams
- Fredo Durand

- London, Stone, and Upton, *Photography* (ninth edition), Prentice Hall, 2008.
- Canon, *EF Lens Work III: The Eyes of EOS*, Canon Inc., 2004.