

# LEBANON CAMERA CLUB

## Autofocus

9/1/2020

See last slide for Fair  
Use Notice & Disclaimer

# Autofocus

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## History

- 1977 – Konica C35 AF
  - First mass-produced autofocus camera (point & shoot)
- 1978 – Polaroid SX-70 Sonar OneStep
  - First autofocus single lens reflex (SLR) camera
- 1981 – Pentax ME-F
  - 1<sup>st</sup> Pentax AF camera → AF motor in lens
- 1985 – Minolta 7000
  - 1<sup>st</sup> Minolta AF camera → AF motor in body, auto winder
- 1986 – Nikon F-501
  - 2<sup>nd</sup> Nikon AF camera → AF motor in body (motor in lens on 1<sup>st</sup> AF camera in 1983)
- 1987 – Canon EOS 650
  - 1<sup>st</sup> Canon AF camera → AF motor in lens
- 1992 – Nikon
  - Nikon introduces AF-I lenses with AF motor



Polaroid SX-70



Canon EOS 650

# Autofocus

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## Types

- Active
  - ◆ Camera emits a ranging signal
    - Polaroid SX-70 → ultrasonic sonar

sonar element

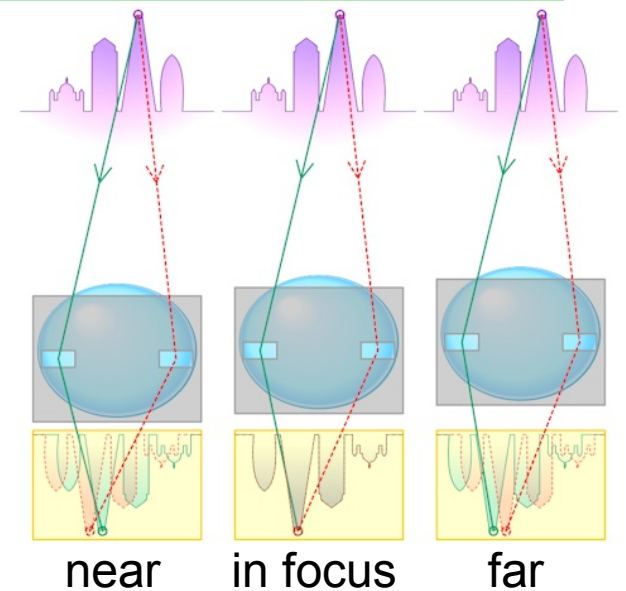


Polaroid SX-70

# Autofocus

## Types

- **Active**
  - ◆ Camera emits a ranging signal
    - Polaroid SX-70 → ultrasonic sonar
- **Passive**
  - ◆ Image analysis determines focus
  - ◆ Phase → sensor compares light from opposite sides of lens
    - DSLR camera when mirror is down (separate sensor gets light from mirror)
    - Fast → phase value immediately gives focus offset and near/far info
    - Modern mirrorless cameras have phase AF points on imaging sensor



Note: The use of a separate sensor for phase AF requires the AF sensor and the imaging sensor to be calibrated. If the calibration is off, there will be focusing errors. Some cameras allow the user to compensate for miscalibration, but only at a specific focus distance.

# Autofocus

## Types

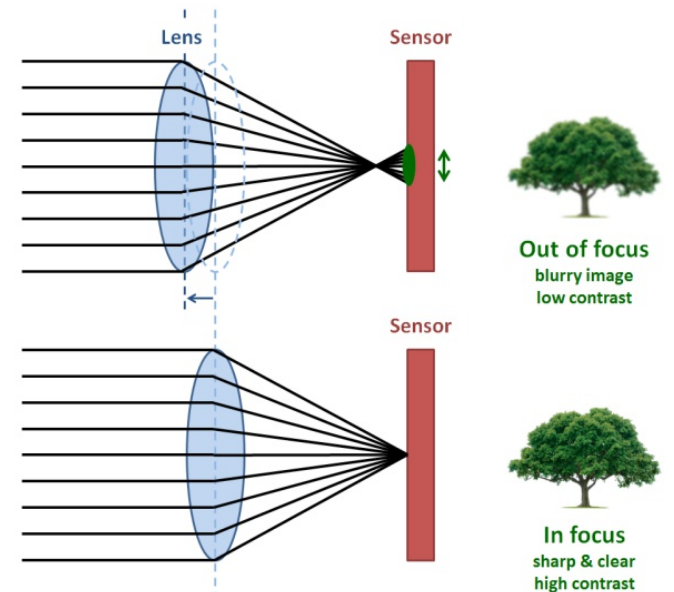
- Active

- ◆ Camera emits a ranging signal
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- Passive

- ◆ Image analysis determines focus
- ◆ Phase → sensor compares light from opposite sides of lens
  - DSLR camera when mirror is down (separate sensor gets light from mirror)
  - Fast → phase value immediately gives focus distance
  - Modern mirrorless cameras have phase AF points on main sensor
- ◆ Contrast → maximizes contrast in small part of image
  - Originally used in mirrorless cameras
  - Slow → maximizing contrast takes several steps
  - Mirrorless w/ phase sensors: phase for coarse AF, refine with contrast
  - Used in DSLR cameras in Live View mode (mirror is up)

Note: Both types of passive AF require image features in the sensor area → cannot focus on featureless area



# Autofocus

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## Modes

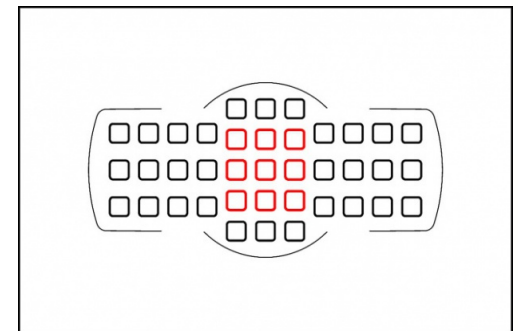
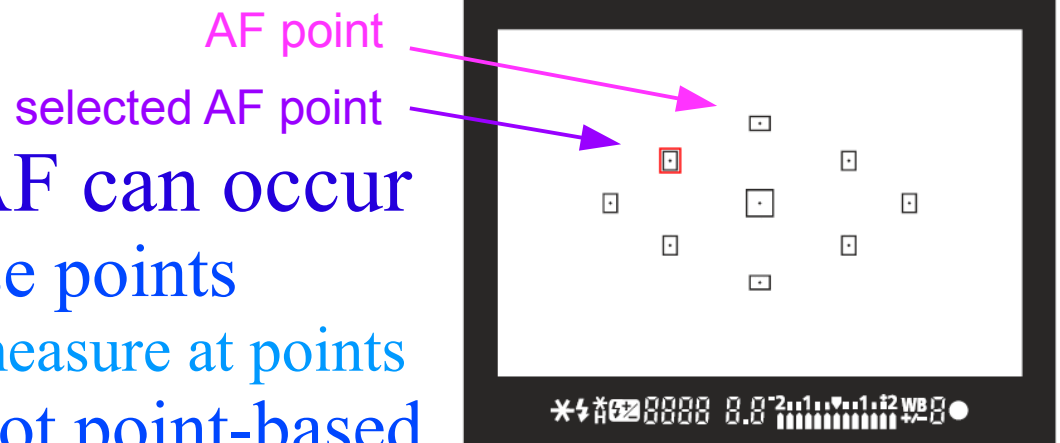
Note: In AF-S and AF-C modes some cameras will not take the shot if focus is not achieved. Also, some cameras indicate when focus is achieved with a light or a sound.

- **AF-M (or MF) → manual focus**
  - ◆ **Disables AF system**
    - Manual focus on AF lens is not as smooth or accurate as a MF lens
- **AF-S (or One-Shot AF) → single autofocus**
  - ◆ **AF system enabled once, when shutter button half-pressed**
    - Focus held as long as shutter button remains half-pressed
    - Useful for focusing and recomposing the shot
- **AF-C (or AI Servo) → continuous autofocus**
  - ◆ **AF system continuously refocuses while half-pressed**
    - Useful for objects moving nearer/farther from camera
    - Most cameras can track moving objects → some better than others
- **AF-A → camera chooses between AF-S and AF-C**
  - ◆ **On some Nikon cameras, possibly on other brands as well**

# Autofocus

## Points

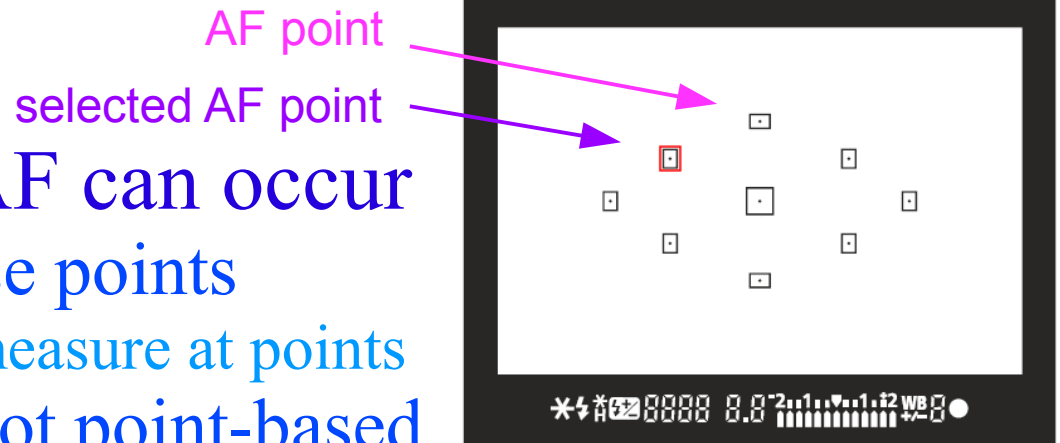
- Discrete areas where AF can occur
  - ◆ DSLR phase AF must use points
    - Separate sensor can only measure at points
  - ◆ Mirrorless contrast AF not point-based
    - Contrast can be measured anywhere on the image sensor
- Selection
  - ◆ Active point usually selected with joystick
    - May be able to tap on LCD touchscreen
  - ◆ DSLR (phase AF)
    - May be able to select groups of points for wider coverage
    - Camera will choose which point to use in group



# Autofocus

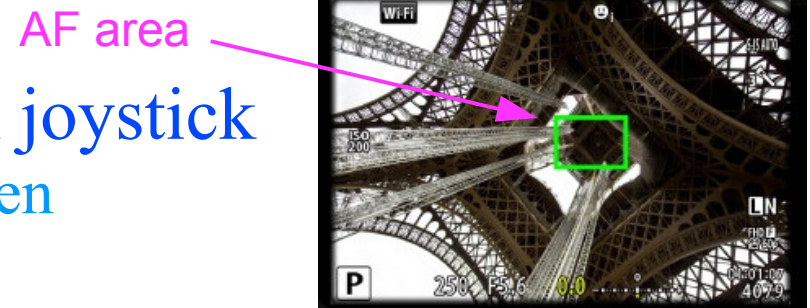
## Points

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## Selection

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- ◆ DSLR (phase AF)
  - May be able to select groups of points for wider coverage
  - Camera will choose which point to use in group
- ◆ Mirrorless camera (or DSLR in Live View)
  - AF area can be moved anywhere (contrast AF, maybe not for hybrid AF)
  - AF area size can be controlled (contrast AF, maybe not for hybrid AF)

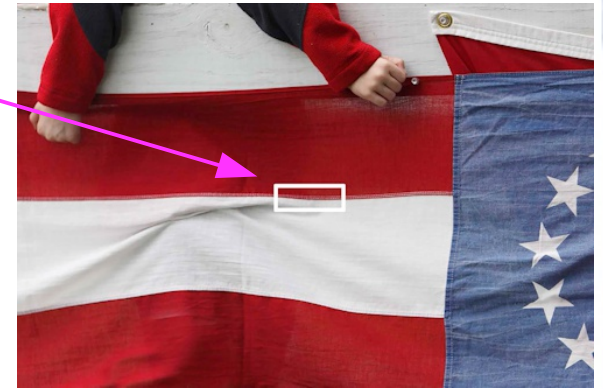




# Autofocus

## Points

horizontal AF point cannot detect any feature changes along horizontal axis



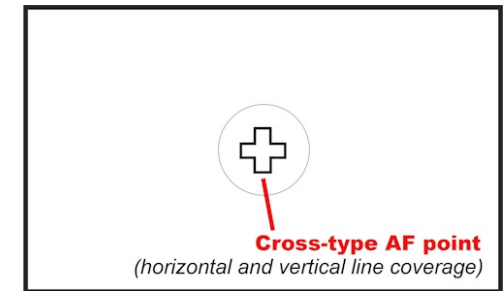
### • Phase AF types

#### ◆ Normal → one dimension only

- Point usually on horizontal axis
- If no features exist in axis, AF may fail

#### ◆ Cross → two dimensions

- Phase detection in horizontal and vertical axes
- Much more likely AF will succeed
- May only be one cross sensor → center point
- More expensive cameras have more cross sensors
- **May only be cross for some apertures** →  $f/2.8$  and faster ( $f/2$ ,  $f/1.4$ )



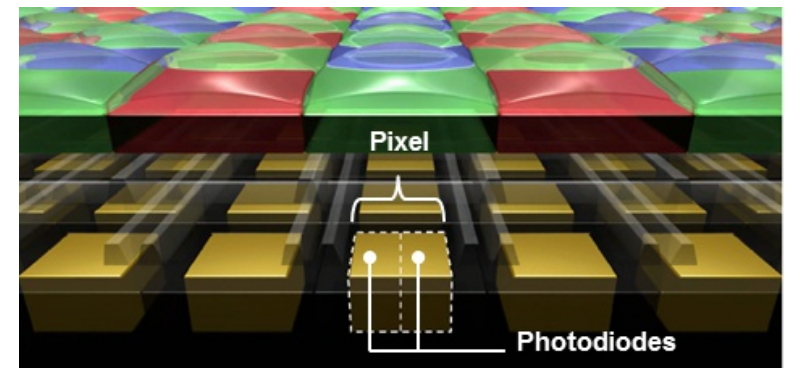
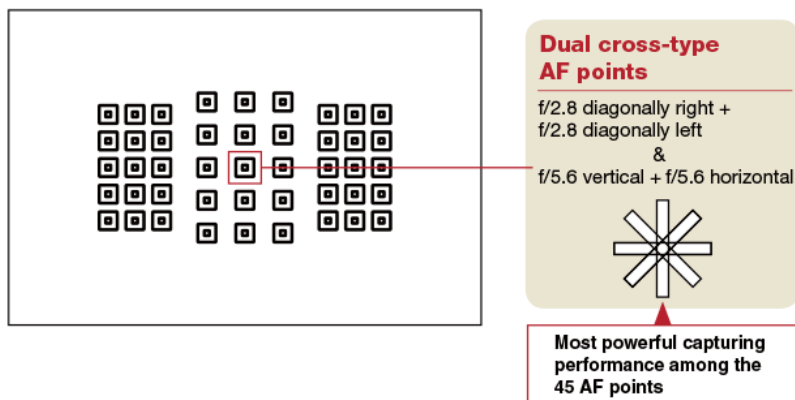
Note: Lens minimum aperture is the  $f$ -number wide open (zoom lens may have a range of values, like  $f/3.5-5.6$  → 3.5 wide, 5.6 telephoto). This determines the maximum amount of light that can pass through the lens, and the amount of light that gets to the AF sensor (DSLR mirror down). Sensing elements may not function if given too little light. Example: H =  $f/5.6$ , V =  $f/2.8$

# Autofocus

## Points

- Phase AF types

- ◆ Dual cross → adds 45° angle sensing
  - Even greater likelihood of successful AF (with appropriate lens)
  - May not exist on lower-end models
- ◆ Dual pixel → phase detection by imaging pixels
  - Analyzes pixel halves separately for focus information
  - A majority of imaging pixels can be used for autofocus (~80%)
  - Each pixel is only a single-axis sensor, but no calibration issues
  - Only available on some Canon models



Dual Pixel CMOS AF structure

# Autofocus

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## Points

- Automated point selection
  - ◆ Eye-controlled
    - Camera senses where the photographer is looking in viewfinder → picks closest AF point (must be calibrated to the user's eye)
    - Introduced by Canon in 1992 (EOS 5), refined in 1998 (EOS 3)
    - Not continued in later cameras
    - Rumored to be coming in new Canon mirrorless cameras

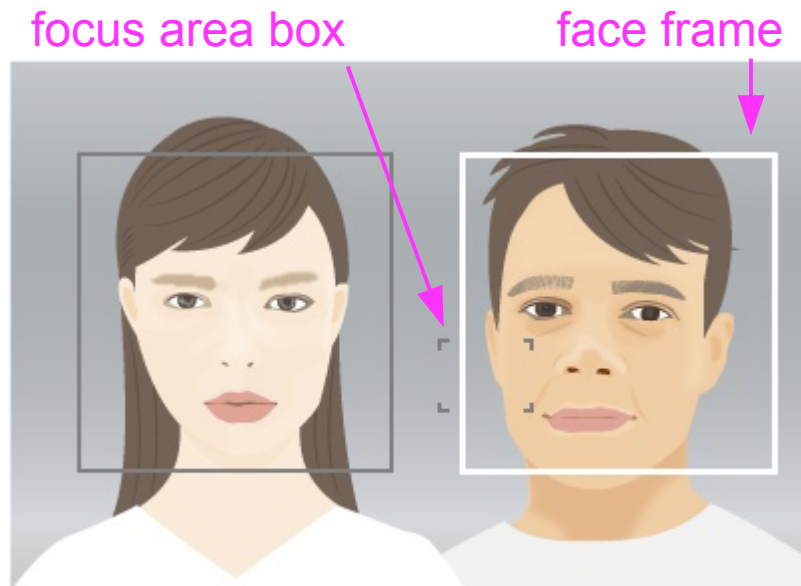


# Autofocus

## Points

Note: A DSLR can focus on and possibly track a subject's eye if the focus point is manually placed on the eye initially

- Automated point selection
  - ◆ Image analysis → image analyzed for features
    - Mirrorless cameras (possibly DSLR in Live View mode)
    - Face AF → detected faces have frames (can register faces for priority)
    - Eye AF → can select left or right eye, can track eye (on newer cameras)
    - Animal eye AF



Sony example



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