

U3A Hillingdon Digital Photo Group

**“Autofocus & How It Works”
(*& why it sometimes doesn't!* 😞)**

28th October 2019

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“AUTOFOCUS” – WHAT IS IT?

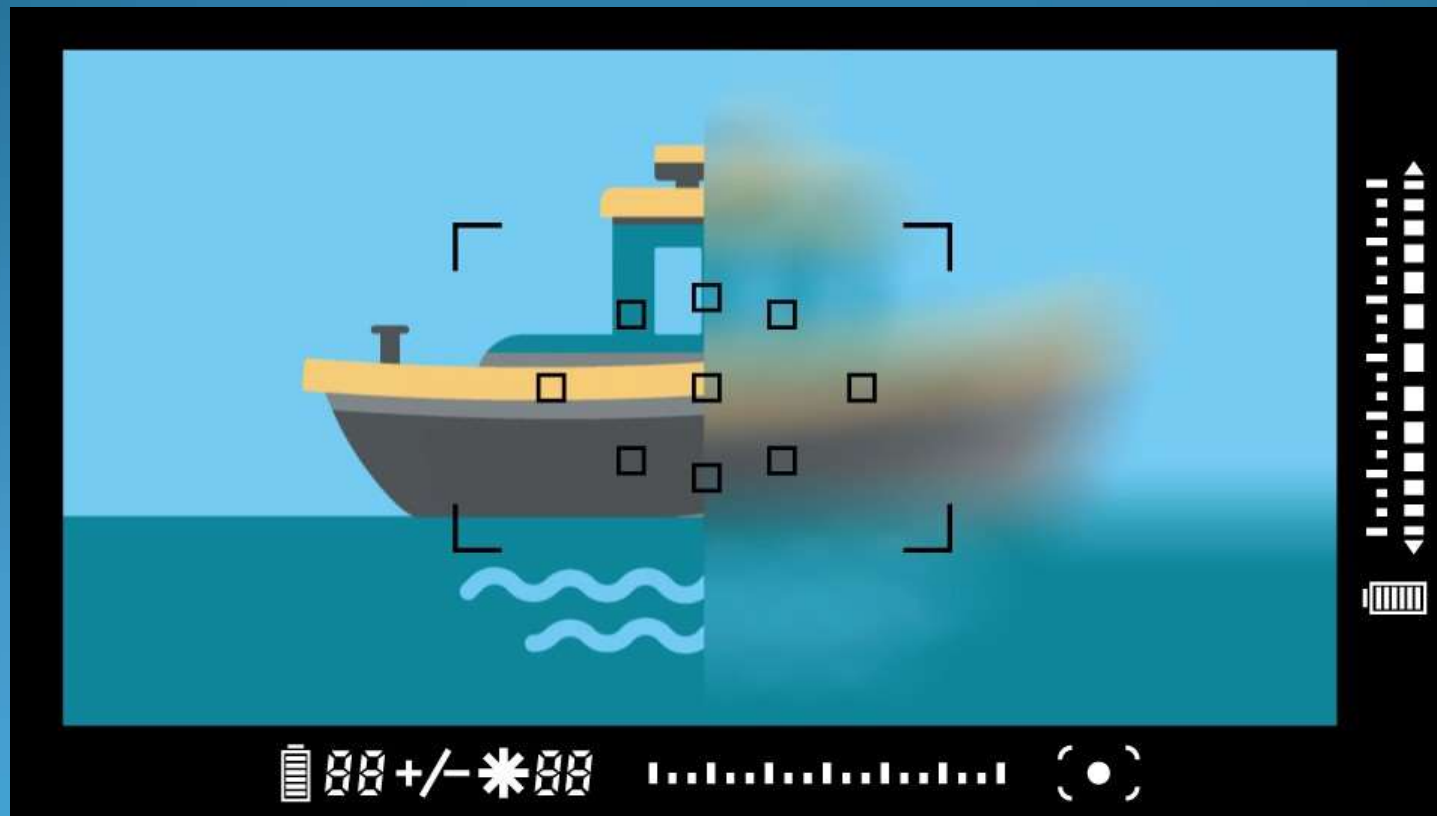
- Camera autofocus (AF) systems intelligently adjust the lenses to obtain focus on the subject s => difference between sharp photos & missed opportunities.
- The two basic AF design techniques are:
 - Passive AF - using **contrast sensors** within the camera.
 - This is the most common method nowadays, and uses the **contrast detection or/& phase detection** techniques
 - Active AF - emitting sound or light signals to illuminate or estimate the distance to the subject.

Very common in early AF cameras & lenses, but now only used as an “AF Assist Light” when lighting levels are low
- Both techniques rely on contrast detection to achieve focus

CONCEPT: AUTOFOCUS SENSORS - 1

- A camera's AF sensor(s) focus points are the real engine behind achieving focus lock – these are laid out in various arrays across the image's field of view, thus:

○ .



CONCEPT: AUTOFOCUS SENSORS - 2

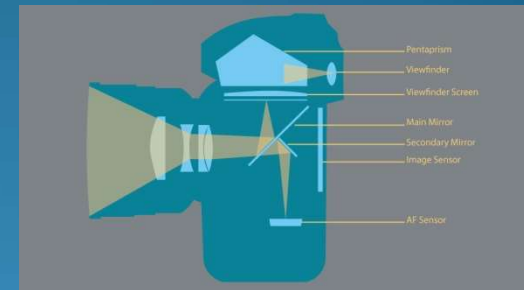
- AF points may or may not be visible & sometimes whilst shooting; *may* be selectable manually in camera menus
- Each sensor measures relative focus by assessing changes in contrast at the AF points in the image - *maximal contrast assumed => maximal sharpness.*
- “Compact” & most “mirrorless” cameras use the image sensor as the AF sensors (*using contrast detection AF*) -> *may or may not have multiple discrete AF sensors*
- OTOH, most DSLRs use separate AF sensors for *phase detection AF* - but “on image sensor” & “hybrid” AF systems are now becoming more common on those.

THE AUTOFOCUS PROCESS

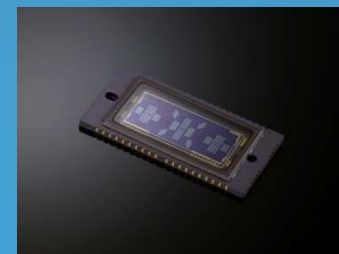
- The AF process generally works like this:
 - (1) The AF Processor (AFP) makes a small change in the focusing distance.
 - (2) The AFP reads the AF sensor (s) to assess if and by how much focus has improved.
 - (3) Using the information from (2), the AFP sets the lens to a new focusing distance.
 - (4) The AFP iteratively repeats steps 2-3 until satisfactory “focus lock” has been achieved
- The process usually completes in a fraction of a second.
But then there's “focus hunting” - for difficult subjects, the AFP may not get focus lock & so keeps repeating the sequence until it gives up => failed AF!

PHASE DETECTION AF – 1 – Physical Design

- This is used in DSLRs (& hybrids) and works like this
- Light passes through the lens, hits a mirror, is reflected up through a pentaprism & out the viewfinder until the shutters fires when the mirror flips



- The mirror centre is translucent & a sub-mirror behind it reflects light down to the AF sensor in the base of the body,
- Light from the sub-mirror is split into 2 separate images by prisms & microlenses in the sensor, each aimed at 2 lines on the AF sensor corresponding to the active AF point



PHASE DETECTION AF – 2 – AFP +Sensor

- The AFP works out how far to move the lens to bring the subject into focus, and in which direction, then drives it to that position
- If images hit the 2 lines precisely ->subject is in focus, or else the distance between the two images tells the AFP how much the lens is out of focus, and:
 - If *the two images are closer together*
 - ->lens is focused in front of the subject.
 - If *the two images are further apart,*
 - -> lens is focused behind the subject.
 - Either way, the AFP then recalculates & drives the lens to that newly calculated position.

PHASE DETECTION AF – 3 – Pro's & Cons

- **Fast & precise**- good for tracking fast moving subjects
- **Poor in low light** - less light => focus lock is difficult
- **Can't put AF points close to frame edges**
The camera focuses with the lens wide open & the frame edges are then always darker than the centre
- **Prone to errors when focusing at wide apertures.**
As phase detection AF is partly a mechanical process, & lenses have mechanical tolerances which vary
- **No AF when mirror is up** => may lose focus lock
- **Doesn't work in Live View /movie mode.**
OTOH, some cameras now combine on-sensor phase detection AF & contrast detection AF (next slide) to focus in Live View/movie modes.

CONTRAST DETECTION AF – the Differences

- Contrast detection AF works by analysing the pixels on the camera's image sensor itself on the basis that the subject is in focus when contrast is highest .
- To do that it has to push the focusing point of the lens back and forth – thus it is:
 - Works well in Live View Mode
 - Far more accurate at focusing on still subjects.
 - There is no need to “calibrate” lenses as there are no mechanical focusing errors.
 - Basically slower than phase detection AF.

HYBRID DETECTION AF SYSTEMS - 1

- Used in some mirrorless cameras/high-end DSLRs, *e.g.*
- Sony's approach:
 - Each pixel on the image sensor has 2 photo diodes - one gathers light, the other is used for phase detection AF.
- Canon's approach:
 - Their newest technology is "Dual Pixel CMOS AF" which is similar and is used in some M series mirrorless cameras, and in their DSLRs' movie mode to help the AFP track moving subject to shoot video,

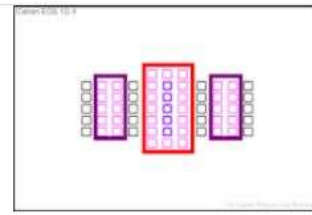
HYBRID DETECTION AF SYSTEMS - 2

- Fuji's approach:
 - It adds phase detection AF pixels in the image sensor :
 - Under each AF point lie strips of covered sensors that receive light from one side of the lens, and other sensors that receive light from the other side.
 - The AFP compares both, and, when they match, knows the subject is in focus.
 - If the subject is out of focus, it calculates how much it needs to adjust the lens to bring the subject into focus, and drives the lens there.

AF POINTS – Nos, Locations, “Power”

- Early sensors had 1-3 AF points near the image centres
- Modern sensors can have 9-399 AF points !
- Some sensors have “cross-point” AF points that are more “sensitive” than others→ more =generally better!

A **cross-type** sensor is a horizontal line sensor and a vertical line sensor at the same **AF point**, meaning that **point** is able to detect lines in both orientations – that makes it more likely that the **AF point** will be sampling a feature that has the correct orientation to activate the sensor.



- OTOH, the more AF points, then the more AFP & CPU processing power and speed is required
- Technology improvements thus drive the improvements in AF performance
- Thus “newer is (*probably*) better” – but older tech can work well if you get to know how to use it wisely!

AF POINT SELECTION OPTIONS/VARIATIONS

- Modern options (*varies between brands/models*):
 - Select a single (“Spot”) or small number (“Small Area”) of AF points to force focus on a small area - *or choose “most/all” to let the camera decide!*
 - Manually move AF point away from frame centre, &/or use “Eye Focus” where the camera “sees” what you look at & focuses on it
 - Set “Focusing Tracking” with “lock-on” if available
 - “Facial Recognition” is common in both phones & cameras - it’s really an intelligent “scene mode”
 - Choose between “AF-C”, “AF-S”, “AF-A” modes as the mode may affect the success rate (*next slides*).
 - Then customize “User settings” to suit your needs

AF MODES – “AF-C” - & the Pros & Cons

- **AF-C (“AF Continuous”/ “AF Continuous Servo”)**
 - When focus-locked on a subject, focus will try to stay on that as long as the shutter button is held ½ way down
 - Good for “action” shots, especially in “burst” mode
 - Needs plenty of AF points, a fast CPU & AFP + good programming to work well
 - Works best with many tracking points right across sensor!
 - Difficult to use in Live View mode if subject moves rapidly unless AFP & CPU refresh the screen image very quickly
 - May not work well in poor light as AFP could “hunt”,
- especially with small Aperture zoom lenses
 - Using the “Back Button Focus” method sometimes helps as that effectively locks focus on the selected subject.

AF MODES – “AF-S” - & the Pros & Cons

- AF-S (“AF Single” / “Single Area AF”):
 - Set to AF-S, the camera locks focus onto an object it considers to be “static”. You then recompose & take the shot.
 - Good for getting sharp shots of static/semi-static objects, especially in Live View (rear screen) mode
 - Shutter will won’t fire if the AFP loses focus lock, notably if the object moves very quickly &/or if automatic focus tracking is too slow
-> not good for moving objects,

AF MODES – “AF-A” - & the Pros & Cons

- AF-A (“AF Automatic mode Selection”)
 - Camera automatically selects between AF-C & AF-S modes, thus:
 - If it thinks the subject is stationary, then it uses AF-S
 - If it thinks that the subject is moving, then it uses AF-C
 - Works well for “general photography” but can get “caught out” by rapidly changing content, poor light, etc.
 - *It's the default mode, so you may want to change it!*
 - On some cameras, this mode is probably selected when the camera is set to some of the “scene modes”
→ you might not realise this is the mode, & it might then not be the most appropriate one for the shots being taken!

HOW TO CHANGE THE AF MODE?

- Varies according to brand & model, e.g.:
 - An Menu option – often buried quite deeply!
 - A physical “AF/M” (Manual) switch on the body.
 - NB: if the body does have that switch, then you still need to select the AF mode in the menus!
 - A physical slide switch on the lens – & you might still be able to use “body AF” if the body supports it
- May NOT be changeable on Bridge/Point & Shoot compact cameras,
 - *but AF-C, AF-S or AF-A could be the “implied choices” when certain “scene modes” are selected*

WHY DOES AF “GO WRONG?”

- Many reasons, e.g.!:
 - AFP selects the wrong target on image, e.g. because that is larger/brighter/nearer than “your target”
 - AFP mislead by confusing background/foreground
 - “Wide Area” AF, not “Spot”/”Small area”, selected
 - “Wrong” mode (*e.g. AF-A/AF-S, not AF-C*) selected
 - Target moves too fast for the AFP to follow
 - *especially if it is moving towards/away from you*
 - Using Live View (it’s slower!) instead of optical V/F
 - Camera body &/or lens is just not “fast enough”
 - Interchangeable DSLR lenses may need to be calibrated to the camera bodies (*due to mechanical tolerances*)
 - You didn’t follow a moving target accurately enough!

CAMERA AF SENSORS – WHO MAKES THEM?

- Although there are various camera brands, Canon & Sony actually make most of the sensors ATM, thus:
 - Canon *currently* make them only for their own use
 - Sony also supply Nikon, Fuji, Olympus, Pentax, Panasonic!
 - Toshiba, Micro/Aptina, TSMC/Renesas also make sensors
 - Samsung used to, then stopped, but is now starting again
- Most variations in camera features & performance thus result from how brands' own development teams then customise the sensors, & their bodies & firmware
- Generally, within brand model ranges, “the more you pay,” the more of those features & tweaks are enabled!
- OTOH, you don't always need “the latest & greatest” if you can get “more” out of your existing kit!

THE CAMERAS IN PHONES

- So what about the cameras in phones?:
 - On-image AF sensors that work in same general way as camera sensors – but getting very sophisticated!
 - Generally more automated, so less manual control -> *but maybe can be changed by downloadable Apps*
 - Lenses have much shorter focal length=> High DoF, *but that's changing with the use of reflex mirrors!*
 - Traditionally , have limited optical zoom capability, so rely on digital zoom, but there are new multi-lens phones with both wide angle & telephoto lenses
 - More manufacturers are supplying camera sensors - *so expect more features in new phones (at a price!)*

GENERAL ADVICE

- You can't change AF performance after buying cameras/lenses/phones (*except maybe by new firmware*) – *so think what you need & then buy carefully*
- If the option exists, always update to the latest firmware - manufacturers' websites tell you how
- Each camera is “different”, so “RTFM” & then experiment in your favourite shooting situations to find out what does/doesn't work for you
- Review the shots on the PC screen as camera screens are too small to show enough detail to really check focus accuracy
- If AF doesn't work well, try MANUAL FOCUS!! 😊

BRAND/MODEL GUIDANCE (*examples only!*)

- Canon [EOS 450D](#) [EOS 700D \(Rebel T5i\)](#),
[PowerShot SX50](#)

- Nikon [7000](#) [Coolpix 1000](#)

(NB: some different AF acronyms!)

- Olympus [E-620](#)

- Panasonic [GH4](#) [GH5](#) [FZ200](#)

- Pentax [K-70/K-3/K-1](#)

- Smartphones [Info](#)

- *If one of the above doesn't cover your camera /phone, then search for that "device +Autofocus"*