

THE DIGITAL CAMERA

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"I myself have always stood in awe of the camera. I recognise it for the instrument it is, part Stradivarius, part scalpel." – Irving Penn

Camera is the Latin word for a room, and today's camera developed from the camera obscura – a dark room with a white wall on one side and a small pinhole or lens on the other. The observer in the room could see an upside-down mirror image on the white wall, accurately projecting the scene outside the room. Before photography, painters used the camera obscura to copy perspective accurately. This developed to the device everyone knows as a camera these days.

COMPONENTS OF TODAY'S CAMERAS

Cameras all are essentially a dark box with a lens on one side and a sensor or film on the other where the lens is focused. Even the smartphone camera uses exactly the same principle.

THE LENS

A camera lens is based upon the simple convex lens or magnifying glass. With this lens a subject on one side creates an image on the opposite side of the lens where a piece of paper, a film or a digital sensor is placed. Moving the film or sensor closer to or away from the lens will focus the image.

Most camera lenses will include a variable aperture to adjust the amount of light reaching the sensor. The cheapest cameras or smartphones do not have a variable aperture.

Some cameras have a fixed prime lens, or a fixed zoom lens. Enthusiasts want interchangeable lenses to enable photography of a wide range of subjects. For more on lenses, see my notes on this topic.

THE SHUTTER

Cameras will have some form of shutter which opens and closes to regulate the time the film or sensor is exposed to light. This can be mechanical or electronic. Exposure times can be as short as 1/8000 (0.000125) second or as long as several hours. Electronic shutters have even shorter exposure times possible.

THE FILM OR SENSOR

Collects and stores the latent image. This will require development to create a photograph.

THE VIEWFINDER

The first cameras require some way of viewing what the image will look like before you take it. The early camera had a ground glass screen that the lens projected the image on. A light-sensitive plate or sheet film replaced the ground-glass screen, before the exposure was made. The camera could not be moved after focusing as the film holder was fitted blocking the ground glass screen image, and so these cameras are always tripod-mounted. Cameras of this design are now used by few photographers, and sheet film for them has to be directly imported. Ansel Adams used them for the majority of his magnificent monochrome work. Each negative could be developed specifically to the photographer's intent, which enabled Adams to apply his zone system.

One feature of looking at the image on the ground glass screen is that it is an upside down of the view of what is in front of the camera. It is dim and the photographer covered his head and the camera with a black cloak, so the image can be seen. Making hand-held shots with such a camera is impractical. To make a portable camera required the designer to incorporate a **viewfinder**, and many of today's cameras have one.

OPTICAL VIEWFINDER

Unlike electronic viewfinders, **OPTICAL VIEWFINDERS** show the scene in real time which allows the photographer to choose the decisive moment in an action shot. Because they use ambient light, they are good in bright sunlight, but may not work in near darkness.

DIRECT EYE-LEVEL VIEWFINDER

The first viewfinders were a wire frame on one side of the camera. Looking through the frame gave a good representation of the image the camera would take. The press cameras used until the 1950's had these.

These were replaced with the **DIRECT EYE-LEVEL VIEWFINDER** - tiny telescope that is on the top or side of the camera. They enabled the use of roll films, and were a part of every camera from the Box Brownie to the Leica. They are still used for a large number of fixed lens digital cameras.

These direct eye-level viewfinders have the following issues:

- Parallax error at close distance, because the viewfinder is offset. The lens hood may obscure the view through the viewfinder.
- Useful for a prime (fixed focus) lenses, but complicated for interchangeable lenses or zoom lenses.
- Useless when attaching the camera to a microscope or astronomical telescope.

The best designed of these was the Leica 35mm rangefinder cameras, which have been used by many professionals and rich amateur photographers for the last 65 years, including legendary photographers such as Capa and Cartier-Bresson. This camera design is still used today for Leica M series cameras. It features an optical/mechanical rangefinder and parallax correction mechanism.

REFLEX VIEWFINDER

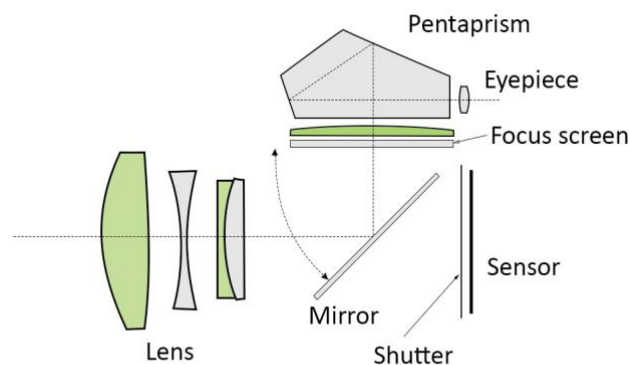
These use a mirror inside the camera which reflects the image upwards onto a ground glass focus screen. Looking down on the screen enables the photographer to see almost exactly the same image as is focused on the film or sensor. When the shutter release is pressed, the mirror flips up and then the shutter is opened and closed. Later designs had an *instant return mirror*, so that the photographer could set up the next shot. This viewfinder is still used for medium format cameras, some of which have a waist-level viewfinder.

The *Through-the-Lens (TTL)* viewfinder enables interchangeable lenses, zoom lenses, macro, microscope, and astronomical telescope photography, much of which is not possible with the direct viewfinder. Waist-level viewfinders are largely out of favour now except for medium format cameras for fashion photography.

One popular type was the twin-lens reflex, which essentially is two cameras. The top box (the viewfinder) has a fixed mirror. The film box is below being the real camera. This design is now obsolete.

SINGLE LENS REFLEX

The main feature of the SLR is its eyelevel viewfinder, which looks through the lens via a pentaprism and a mirror. The mirror flips out of the way when the exposure is made.



Having an eyelevel viewfinder is preferred for action and general photography. The SLR became the most popular camera for general photography, even into the digital camera age (DSLR). The market leaders Nikon and Canon EOS cameras have a huge range of lenses and accessories, giving very adaptable camera systems. The SLR became the only camera to use for action, sport, wildlife and similar photography, while still producing excellent images for fine art photography.

ELECTRONIC VIEWFINDERS

With the development of modern computer systems and digital cameras came the electronic viewfinder. The image focused on the sensor is amplified and displayed on a light-emitting diode (LED) screen, which may be on the back of the camera (smartphone and live view), or in an eye-level viewfinder.

Electronic viewfinders have a delay while the image is electronically processed, before it is presented on the screen. This can make it difficult to anticipate the decisive moment, because what the photographer is viewing happened a fraction of a second ago. To see the delay, pan the camera rapidly – the image may become distorted and unclear while you do this. As electronics have developed, manufacturers have reduced this delay considerably, but the lag was very noticeable on the earliest digital cameras.

One disadvantage is that the screen may be so dim it is almost impossible to see in bright sunlight. This is never a problem with an optical viewfinder. You guess and hope trying to take a smartphone photograph at the beach or in snowy scenes. Manufacturers are developing brighter screens, but it is something to check before you buy the camera. The dim eye-level viewfinder is a significant problem for spectacle wearers.

One of the big disadvantages for wildlife photography is that electronic viewfinders are continuously illuminated and use up battery life. You can watch a bird or animal for minutes or hours while you wait for the

decisive moment; all the time the battery is draining. Whereas a DSLR can take up to 1500 photos before the battery flattens an electronic viewfinder camera may only take 300 to 400 hundred. Recent battery developments have improved battery life.

An advantage of the electronic viewfinder is that it is excellent in low light situations, where it is almost impossible to use an optical viewfinder. They amplify the dim light making astrophotography possible.

LIVE VIEW

The consumer camera and smartphone only have a screen on the back, and the photograph is taken with the camera held at arm's length – the Demented Dalek pose. This is fine for snapshots, but not for action photography, particularly in dim light, where camera shake can be an issue.

The DSLR and mirrorless camera has an LED screen on the back, which is known as the Live View screen – a classic marketing misnomer. Live View really should be called several milliseconds ago view. Live view is great for tripod photography. The rear screen is great for reviewing images still in the camera, and for seeing the camera settings. More modern camera designs have touchscreens for live view, which are really convenient. Screen touching can be used to perform many adjustments and set off the shutter.

Even more convenient is the ability to live-view the camera image using a tablet, smartphone or computer screen. Newer camera designs allow communication to other computer devices with built-in Wi-Fi or Bluetooth communication; older cameras have provision for cable connection to a computer device. This enables the camera to be used remotely, and even for the image to be imported directly in Lightroom.

DIGITAL EYE-LEVEL VIEWFINDER

Whereas all digital cameras have a screen at the back, many do not have an eye-level viewfinder. The eye level viewfinder is really necessary for sports, wildlife and other action photography. It enables you to brace the camera against your face. A camera without one is fit only for snapshots or tripod shots. Many digital cameras are provided with electronic eye-level viewfinders, an essential feature to me. Some can have an accessory eye-level viewfinder that fits in the hot shoe.

HYBRID VIEWFINDER

Fujifilm has a hybrid optical and digital eye-level viewfinder in their X100 camera. This is a fixed lens camera, which an optical eye level viewfinder is ideal for. With a flick of the switch it can be converted from optical to electronic viewfinder. The advantages of the optical viewfinder – instantaneous, bright image in outdoors situation can be complemented by the advantages of the digital viewfinder – dim light performance, absence of parallax error and the lens hood does not obscure the image.

FILM FORMATS AND DIGITAL CAMERA SENSORS

Film cameras came in many sizes. Large format cameras produced much sharper images, and were favoured for high quality work. Small format cameras are ideal for general use – holiday photos, family snaps, street photography, journalism and documentary photography. With the improvement in film technology, the smaller, portable cameras produced better results. By the end of the film era, the most popular format was the 35mm film camera with an image size of 24 x 36mm. Smaller sizes were used by some snapshot cameras (Instamatic). The larger format 120 film cameras were used for professional photography – advertising, pictorial, landscape, fine art, and fashion.

Large size digital camera sensors produce higher quality, but the cost is high and the cameras heavier. The largest size sensor used by the majority of keen photographers is the same as the 35mm film frame, also known as full frame. DSLR full frame cameras can use the same lenses and accessories as their film SLR predecessors.

Camera sensor sizes are increasingly being standardised, which is great. For SLR and EVIL interchangeable lens cameras the standard sizes are:

- Full frame 36 x 24mm
- APS-C (Canon) 22.3 x 14.9mm
- APS-C (Other brands) 23.6 x 15.6mm
- Four thirds 17.3 x 13mm
- iPhone 5.79 x 4mm

NUMBER OF PIXELS

Just as when fine grain film is used, a sensor with more pixels is capable of rendering more detail. Like film, there is also a downside with having more pixels on the camera sensor. Fine grain film is much slower, that is has a low ISO. Kodachrome 25 produced fantastically detailed colour slides but at only 25 ISO required a long shutter time and care to avoid camera shake.

When buying a digital camera, the sensor size is one of the main factors in determining the quality and range of genre that the camera will cover. Sensor size is determined by the physical dimensions of the sensor and the number of pixels squashed onto it.

The number of pixels determines the size of image that can be viewed without seeing them. It is only when you make large prints that the number of pixels per unit of measurement becomes critical. For prints viewed at normal viewing distance, 300 pixels per inch (ppi) is accepted as fine enough. To fit a whole image on an A3+ print (33 x 48 cm) at 300 ppi requires 22 mega pixels (MP). A camera that produces more than 30 MP is not required for most club images. This allows for some cropping.

If you only produce digital images, a high pixel count is of no benefit. Note that digital images for club competition shall not exceed 1920 x 1080 pixels, or 2 MP.

Typical sensors for recent model cameras are as follows:

• Type	Model	Megapixels	Frame Size	Pixel Pitch μm
• Full Frame	Nikon D4S	16.6 MP	4928 x 3280	7.2
• Full Frame	Canon EOS 1D X Mark II	20.2 MP	5508 x 3667	6.5
• Full Frame	Canon EOS 5D Mark IV	30.1 MP	6720 x 4480	5.4
• Full Frame	Nikon D850	46.89 MP	8265 x 5504	4.3
• Full Frame	Canon EOS 5DsR	50.6 MP	8712 x 5808	4.1
• APS-C	Nikon D500	21.51 MP	4288 x 2848	4.1
• APS-C	Canon EOS 7D Mark II	20.2 MP	5492 x 3678	4.1
• APS-C	Canon EOS M5	24.4 MP	6018 x 4021	3.7
• Four thirds	Olympus OM-D E-M10 Mk III	16.1 MP	4608 x 3456	3.7

IMAGE NOISE

Larger sensors with fewer pixels will have larger pixels. These capture more photons of light, and therefore do not require to be highly amplified to make the sensor work at high ISO settings.

In the above table the spacing between the pixels is expressed as pixel pitch, and is in microns (thousandths of a millimetre). Those sensors with the biggest pixel pitch will have less problems with noise at high ISO.

As an example, the Canon 1D X Mark II is designed for journalism, where large images are seldom used, so the number of pixels is a low 20 MP. This allows large pixels which are capable of being used at high ISO with low noise. With the ISO at 320,000, A3 prints from this camera can be made with little noise reduction during development, and still show negligible noise.

A LARGER SENSOR CAMERA WITH FEWER PIXELS WILL HAVE LESS PROBLEMS WITH NOISE AT HIGH ISO AND A WIDER DYNAMIC RANGE.

DEPTH OF FOCUS

Depth of focus depends on lens aperture and focal length only. If you choose a camera with a full frame sensor, the normal lens is 50mm focal length. At f/2.8 there is a narrow depth of focus which gives a lovely blurred background (6cm at a focus distance of 1m), or significantly soft bokeh. It will have an angle of view of 40°.

The same lens will give the same depth of focus when used on a smaller sensor camera, but the angle of view will be smaller. If used on a Four Thirds view camera, the angle of view will be about half – 20°. A lens of equivalent view angle would have a focal length of 25 mm, but at the same aperture this will have a deeper depth of focus (13cm at 1m). Focus is less critical, but it will not have the same lovely soft bokeh.

GO FULL FRAME OR LARGER FOR SOFTER BOKEH.

CAMERA COMPONENTS AND ACCESSORIES

SHUTTER

The camera shutter is a mechanical device that opens to expose the film or sensor, and closes when the exposure time is complete. Exposure times controlled by the shutter are in the range 30 seconds to 1/8000 second. Cheaper cameras will have a reduced range of exposure times. For really long exposure times most cameras have a *Bulb setting*. Press and hold the shutter release, and the shutter remains open. When you let go, the shutter closes.

The shutter of a DSLR is just in front of the sensor - a *focal plane* shutter. Small leaf shutters within the lens are used for some cameras. There is a move to electronic shutters on EVIL cameras. The shutter on a smartphone is electronic. These electronic shutters have a high frame rate (30 frames per second) when used for action photography. However, there are reports of distortion of moving objects, because the shutter is not open completely. It scans down the frame. This also causes problems with flash photography, so it is worth checking the slowest flash synchronisation shutter speed.

The SLR gives a satisfying click and feel when the shutter is fired. The noise is mostly the mirror flipping. Nature photographers like to work as quietly as possible, and the reflex mirror slap may be unwanted. Some cameras have a silent mode, where the mirror is moved more gently. Electronic shutters could be completely silent – but the designer may add an artificial noise, or artificially darken the screen so the photographer gets a notification the photo has been taken.

The decisive moment photographer will through the feel of the shutter be able to time the exposure with precision. Those who use the spray-and-pray technique for action shots are interested in the frame rate when

the camera shutter is in continuous mode. Some electronic shutters can have frame rates of 30 frames per second. The fastest for a focal plane shutter is around 10 frames per second.

EXPOSURE METER

Until the 1960's no camera had a built-in exposure meter, but all of today's digital cameras have one. This measures the light *through the lens (TTL)*, and calculates the exposure. Exposure modes available are from fully automatic (P or A), to Manual (M).

In the *Program or Automatic* mode, the camera determines an exposure that will work, but the photographer has little or no control over aperture or exposure time.

In *Shutter Priority* mode, the photographer selects an ISO and exposure time and the exposure meter will adjust the aperture value automatically to give "correct" exposure.

In *Aperture Priority* mode, the photographer selects an ISO and aperture and the exposure meter will adjust exposure time automatically to give "correct" exposure.

In *Manual Mode*, the photographer has to choose ISO, Aperture and Exposure time. The aperture or exposure time have to be adjusted by the photographer until an exposure level indicator in the viewfinder is balanced. If the ISO is set to automatic, the Manual mode becomes automatic.

Your camera should have all these exposure modes if you want to improve your photography. For more information on exposure, aperture, exposure time, ISO, refer to my notes on Exposure.

MEMORY CARDS

Your camera should have the ability to take RAW images if you are serious about photography and want to take full control over development of your photographs. These files will be large, particularly for cameras recording 20 megapixels or more. Some cameras have an internal memory to store images, but its capacity is very limited unless the camera (eg smartphone) only shoots small JPEGs.

You will need at least one memory card to store the digital images your camera takes. The card format must suit your camera. The CF (CompactFlash) and the SD cards are the two types commonly used. If you intend to shoot video or use high speed continuous shooting on a high-end camera, a high capacity, high speed card is required. If I am travelling I take enough memory cards to hold all the images from my trip. Even though I download and process images to my laptop regularly, the cards carry my back-up copies.

Some cameras have two memory card slots, which wedding photographers love so that two copies of the image are stored as insurance against card failure. However, card quality has improved so that card failure is remote.

BATTERIES

Your camera will usually come with a battery, a high-capacity rechargeable lithium one for high end cameras. Get at least one spare, and ensure both are fully charged before you embark on a photoshoot. Don't forget to take the battery charger with you on an extended trip. You will need more batteries for mirrorless cameras, because the viewfinder is powered while you are viewing through it.

ACCESSORY INTERFACES

Most cameras have a **HOT SHOE**, that enables a *Speedlight* or *flashgun* to be coupled to the camera. Cheaper cameras have a built-in flash, but these are limited in use because they lack power.

There is also often a connection for a **REMOTE SHUTTER RELEASE**, which may be a simple cable or radio controlled.

Digital cameras have **INTERFACE CONNECTORS** so the image recorded in the camera can be displayed on a TV, computer monitor or another electronic device via a cable. They also enable download of images to a computer. Many cameras now have wireless Wi-Fi or Bluetooth connection to remote devices.

A camera with video capabilities should have provision to attach external microphones.

CAMERAS FOR ENTHUSIASTS AND PROFESSIONALS

‘People ask, ‘what camera do you use?’ I say, ‘you don’t ask a writer what typewriter he uses.’’ – Man Ray

The debate about which camera type the enthusiast or professional photographer should have as their main camera is evolving. The DSLR has been the front runner for some time, but the “mirrorless” cameras with the latest improvements in technology are now becoming the frontrunner. All development is now for the EVIL camera; SLR development has stopped.

Enthusiasts and professionals are looking for cameras to produce high quality images with a wide range of high quality third party and in-house lenses, flashes and other accessories. They need to be rugged and impervious to the weather. The modern mirrorless camera has now taken over this market.

Enthusiasts and professionals require

- Image quality for prints up to A2 size.
- Ergonomically designed professional cameras work with the full range of lenses.
- Professional cameras have knobs, buttons and dials to enable common features to be controlled quickly. In some cases, these can be programmed to adjust any function that the photographer uses more frequently. More modern cameras with touch screens give excellent control over camera adjustments.
- Professional cameras and professional series lenses are rugged, and resistant to dampness.
- Sensor size is full frame (24 x 36 mm) or larger.

DIGITAL SINGLE LENS REFLEX

The DSLR still offers the widest choice of accessories. The 35mm SLR became the most popular camera for professional and advanced amateur photographers in the days of film. DSLR cameras are based upon their film equivalents, so they can take the same lenses and other accessories. Consequently, a DSLR system covers the full gamut of photographic genre; from fine art, architecture and landscape, through portraiture, weddings, journalism, documentary, to wildlife. There are wide angle lenses for special effects and super long telephoto lenses for wildlife and sports. Special lenses include those for macrophotography and tilt shift lenses. A housing can enable the camera to be used underwater, and they can be fitted to microscopes and optical telescopes.

- All DSLR have optical through-the-lens (TTL) viewfinders. Great for action shots.
- They range in cost and size from Entry Level to Professional types, from less than \$1,000 to over \$10,000
- The DSLR is a great choice for wildlife and action photography. This is because of the absence of any lag, and use in very bright conditions. The photographer can view the subject for hours waiting for that special shot, without flattening the battery.

A DSLR can take excellent videos, but the optical viewfinder cannot be used while you are shooting video. If you shoot a lot of video, a mirrorless system might be more appropriate.

THE MIRRORLESS OR EVIL CAMERA

The so-called mirrorless camera really should be known as the Electronic Viewfinder Interchangeable Lens or EVIL camera to distinguish it from those that do not have interchangeable lenses or electronic viewfinders, such as Instamatic and smartphone cameras. They do not have an optical eyelevel viewfinder, only an electronic one. EVIL cameras have now largely superseded the SLR.

The first mirrorless cameras were for amateurs and had small APS-C or Four Thirds sensors and were with fixed prime or zoom lenses. As these cameras are light and small they are ideal for travel photography.

Recently EVIL cameras with larger sensors and interchangeable lenses have appeared. Systems have been marketed by Sony, Fuji, and Leica. Now that Nikon and Canon have produced several full frame EVIL cameras; the market is opening up. These cameras can be used with existing lenses and accessories produced for SLR cameras.

One big advantage of the EVIL camera is that there does not have to be space for the mirror. This means the camera to lens mount distance can be shortened, and lenses can be designed that protrude inside the camera without fear of colliding with the flipping mirror. The new EVIL full frame cameras come with a new range of lenses where the lens designer has taken advantage of this greater freedom. They offer high quality, larger apertures and less weight. There has been a dramatic increase in the number of new lenses recently, particularly high quality ones.

If you have a Canon or Nikon SLR system, because of the new lens mount, you will need an adapter to fit your existing SLR lenses to the EVIL camera. This is really a spacer with the necessary electrical contacts for focus and aperture control. The performance of your existing lenses will not be impaired in any way.

The eye-level electronic viewfinder does have the ability to show a lot more information than an optical one. It can display a histogram, horizon level, highlight detail and even magnify the image. It works exceptionally well in low light, and can be used for video photography. You get a preview of the image before it is taken, showing if it will be badly exposed or has a grossly adjusted white balance. Some of the latest electronic eye level viewfinders have advanced autofocus system, with a large number of focus sensors, and the ability to track a face or an eye as it moves over the frame.

These new EVIL cameras suffer the disadvantages of the eye level electronic viewfinder – lag before display, short battery life, and dim viewfinder in bright light. The performance improvements at low light level because of higher sensitivity for focusing and the exposure meter, and reduced weight without the mirror and pentaprism are major advantages.

ADVANCED COMPACT CAMERAS

Photographers that want a lightweight camera, that will fit into a handbag or large pocket would consider an advanced compact camera as a second camera. You can take control of exposure by changing the aperture and exposure time. Some of these cameras are excellent, such as the FUJI X100 series and Leica Q cameras. Some professionals will have one of these in their bag.

THEY FEATURE:

- Built-in prime or zoom lens
- Rear screen for Live View viewfinder, reviewing images and menu selection of functions
- Optical or electronic eye level viewfinder (recommended, but not all models)
- Pop-up flash and hot shoe
- Full control of exposure (Program, Aperture Priority, Shutter Priority and Manual)

ADVANTAGES

- Low size and weight. Great for candid work.
- Good to excellent quality images

DISADVANTAGES

- Limited to built-in lens (range of focal length and focusing distance)
- Limited to good light

OTHER CAMERA TYPES

MEDIUM FORMAT CAMERAS (HASSELBLAD, PHASE ONE, LEICA S, FUJI GFX 550S)

These are cameras that have sensors larger than Full Frame (24 x 36 mm), up to, 60 mm x 60 mm. They are capable of producing magnificently detailed large images, up to 1.5 metres wide. They have a wide dynamic range of up to 15 stops, which means they will tackle high contrast subjects and still have excellent shadow and highlight detail.

This class of cameras can also be considered to include digital backs that can be fitted to medium format film cameras.

These cameras require their own range of lenses and accessories, which makes them rather expensive and heavy.

They are used for fine art, landscape, fashion and advertising photography by professionals. Think Tony Hewitt, Christian Fletcher, Adam Monk.

GOPRO SPORTS CAMERAS

There are interesting additions to the digital camera range. GoPro cameras are designed for active sportspeople to take cycling, skiing or snorkelling. While they take photographs impossible with other cameras, they are unsuitable for fine art photography.

POINT AND SHOOT CAMERAS

I have not talked much at all about consumer cameras. They are fixed lens cameras, with zoom or prime lenses, small sensors, lightweight, and little or no ability for the photographer to control exposure. The viewfinder is a live view screen usually. They are limited in the range of subjects they can tackle.

This type of camera really has lost out to smartphone cameras and is disappearing from the market.

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