Seeing Through: Camera Viewfinders and Microscope Eyepieces

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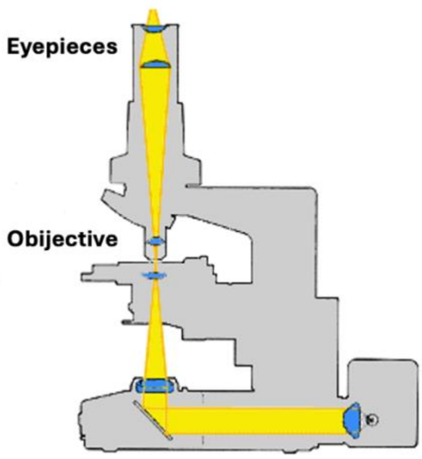
When we look through a camera or a microscope, we are doing essentially the same thing: we entrust our vision to an optical system that modifies reality. The viewfinder helps us decide how to photograph the world; the microscope eyepiece allows us to see what the world conceals. Yet behind these two seemingly distant instruments lie surprisingly similar optical principles. Two different instruments, one common purpose: guiding our gaze beyond the limits of the human eye.

Two instruments, the same function: the camera viewfinder is used to compose an image before taking a photograph, while the microscope eyepiece allows us to observe an already magnified image. In both cases, however, we are not looking directly at reality, but at an image filtered and constructed by lenses.

The Microscope Eyepiece

The microscope eyepiece is part of the system responsible for the total magnification of the specimen: the objective lens produces a magnified image of the specimen, while the eyepiece magnifies it further so that it can be observed by the human eye. Total magnification is given by the product of the two magnification factors, for example:

10× (eyepiece magnification) × 40× (objective magnification) = 400× (total magnification)



Optical Groups of the Compound Microscope

When acquisition devices such as a camera or a photomultiplier are used, the sample is no longer observed directly through the eyepiece. However, “eyepiece-type” lenses may be positioned in front of the different image-recording systems. These lenses perform the same optical coupling function, although they may have different magnifications depending on the device being used.

But beyond magnification, there is another fundamental parameter indicated on eyepieces that is often overlooked: the Field Number (FN). The Field Number indicates the diameter of the observable field of view through the eyepiece, (expressed in millimetres).

To calculate the actual area of the sample that can be observed, the following formula is used:

$$\textit{Actual field-of-view diameter} = \frac{FN}{\textit{Objective magnification}}$$

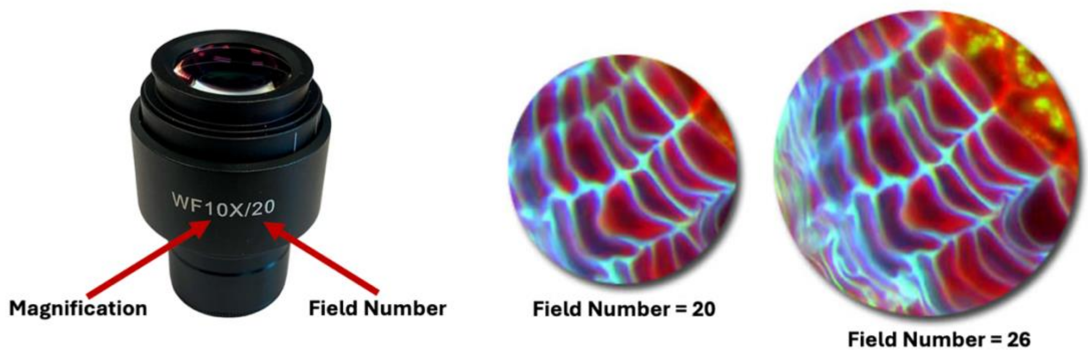
For example:

- eyepiece with FN = 20
- objective magnification: 40×
- actual field-of-view diameter ≈ 0.5 mm

The Field Number (FN) has not always been as large as it is in modern microscopes: its evolution reflects the progress of optical microscopy. In older microscopes, particularly those used up to the mid-20th century, the observable field was relatively limited, with typical values around FN ≈ 16–18. This limitation was mainly due to optical aberrations: as one moved away from the centre of the image, image quality deteriorated rapidly, so the field of view was kept relatively small to maintain a sharp image.

In historical optical microscopes, particularly from the late 19th century through much of the 20th century (from Ernst Abbe's work in the 1870s–1890s to the standard systems of the post-war period) eyepieces were not optically neutral components, but compensating elements. They actively contributed to correcting residual aberrations deliberately left in the objectives, particularly in achromatic objectives and those with high numerical aperture, according to an optical design in which the objective and eyepiece were conceived as an integrated pair. In classical systems developed by manufacturers such as Carl Zeiss in Jena, Leica Microsystems (the successor to Leitz), as well as Olympus and Nikon throughout the 20th century, the objective and eyepiece were therefore designed as complementary optical components rather than as independent elements.

With the introduction of more advanced optical systems, such as plan and apochromatic objectives, and the adoption of infinity-corrected optical systems, aberration correction became concentrated almost entirely in the objective. The eyepiece consequently lost its role as an "active corrector" and became essentially neutral and standardized. As a result, towards the end of the 20th century, microscopes with Field Numbers (FN) of 20–22 became increasingly common. Modern microscopes can reach even higher values, up to FN 26. It was somewhat like moving from a 4:3 television to a 16:9 screen. This allows significantly larger portions of the specimen to be viewed at once, improving both the efficiency of observation and the quality of microscopic analysis.



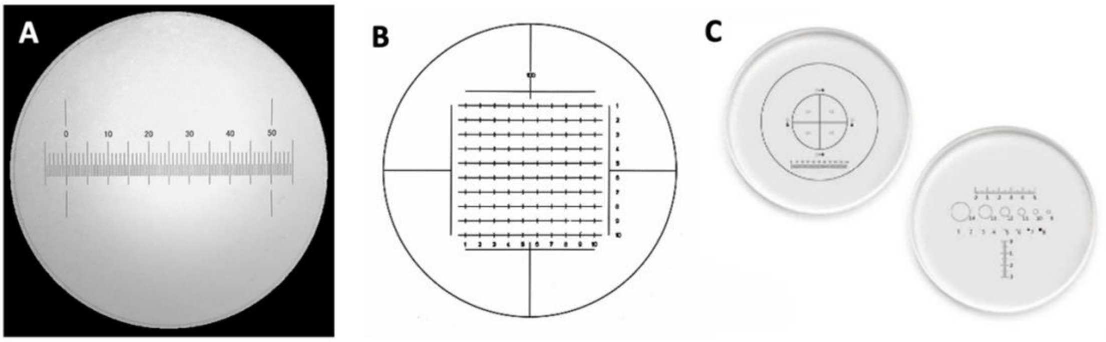
Variation in Field-of-View Size with FN

Increasing the Field Number (FN) is therefore not merely a technical parameter; it reflects several major advances in modern optics and microscopy:

- Improved lenses: the development of more advanced materials and manufacturing techniques has made it possible to produce objectives and eyepieces with superior optical performance.
- Reduced aberrations at the edges of the field: improved correction of chromatic and geometric aberrations has enhanced image quality even in peripheral regions.
- Introduction of plan optics: these systems provide an image that remains sharply focused across the entire field of view, eliminating the field curvature typical of older optical systems.
- Integration with digital sensors: wider fields are now essential for making the most of cameras and digital acquisition systems, providing more complete and informative "widefield" images.

In historical microscopy, the eyepiece was not merely an observation tool, but also a measurement instrument. From the late 19th century through the 20th century, systems from manufacturers such as Carl Zeiss and Leica Microsystems often incorporated reticles, graduated scales, or micrometers into their eyepieces, allowing the specimen to be measured directly within the field of view. Observation thus became immediately quantitative: image and measurement were one and the same.

In this sense, the eyepiece was not a neutral component, but a scientific interface. Interchangeable eyepieces, modular optical systems, and the advent of digital imaging gradually made it less practical to integrate complex corrections or measurement scales directly into the eyepiece. Measurement functions have progressively shifted to sensors, software, and digital imaging systems.

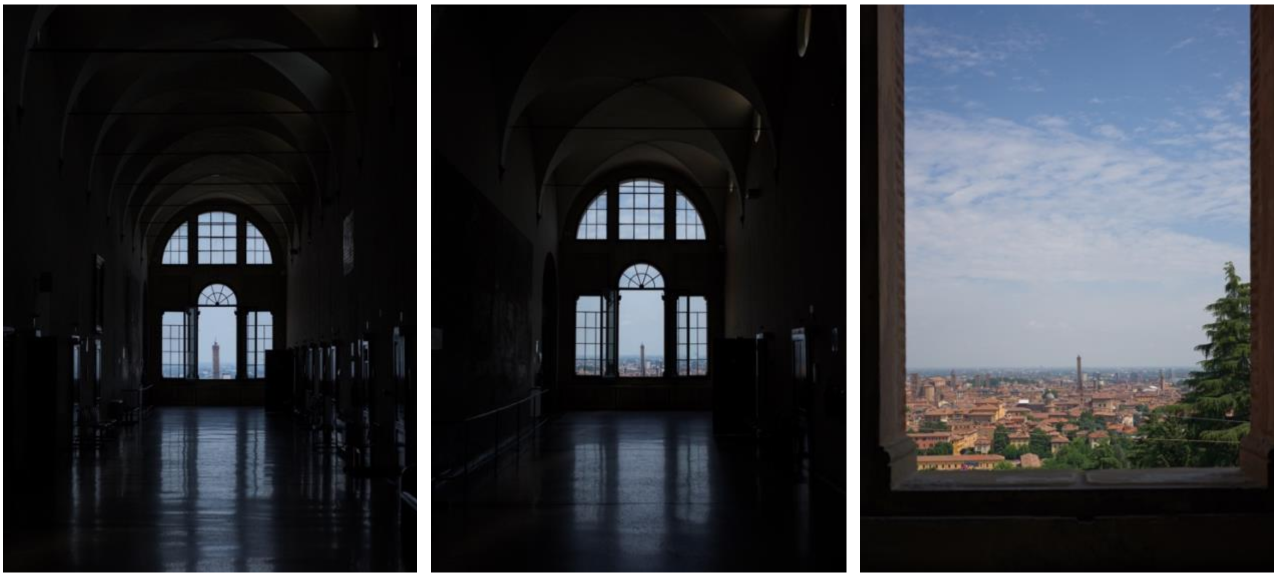


Micrometer Eyepieces: A) Reticles with linear scales for direct measurements within the field of view; B) 10×10 or modular grids for cell counting and density measurements; C) Circular or linear micrometers with calibrated divisions (e.g., 0.1 mm per division))

Microscopes often use two eyepieces to provide binocular vision, allowing the specimen to be viewed with both eyes. This arrangement offers both physiological and ergonomic advantages. The first reason is related to the natural functioning of human vision: our eyes work together, and the brain combines the two slightly different images received by each eye, resulting in a more stable, comfortable, and less tiring visual experience than monocular observation. Binocular vision also contributes to improved spatial perception. However, in standard optical microscopes, it does not produce true three-dimensional vision of the specimen: the image remains essentially two-dimensional. For this reason, the observer should learn to maintain a relaxed, "looking into the distance" type of vision, similar to looking at a distant landscape, rather than forcing the eyes to focus as they would when viewing something close up. This approach makes observation more stable, comfortable, and sustainable, even during long periods of microscope work.

Tunnel Vision and the Telescope-like Effect

The Field Number does not only determine how much of the specimen we can observe; it also influences the visual experience of observation itself. In older microscopes, or with eyepieces having a low Field Number, the observable portion of the specimen is very limited. The image appears as a small bright circle surrounded by black, almost as if looking through a tube. This phenomenon is often perceived as a “tunnel vision” effect. This phenomenon also has an interesting perceptual counterpart: the impression that the image appears more “magnified” or immersive when the field of view becomes narrower. This is related to the telescope-like effect, in which a reduction in the field angle increases the perceived sense of scale and proximity of the observed object, even though the actual magnification does not change. The same perceptual principle can be experienced when viewing the Asinelli Tower in Bologna through the window at the end of the Manica Lunga, the 162-metre-long corridor of the monumental complex of San Michele in Bosco, along which the cells of the Olivetan monks were once arranged. The narrow field of view of the long corridor acts as a perspective frame: by isolating the tower from its urban surroundings, it enhances its visual presence and makes it appear closer and more dominant than when it is viewed directly through the window.



Telescope-like effect at the Rizzoli Orthopaedic Institute: The closer you get, the smaller the Asinelli Tower appears

In this sense, the tunnel effect is not merely a restriction of peripheral vision, but also a perceptual amplifier: by reducing the surrounding context, the brain recalibrates relative scale and gives greater “visual weight” to the central object. The same mechanism can be experienced when looking through a telescope or a microscope eyepiece, where a restricted field of view not only selects the information reaching the eye, but also transforms it into a subjective experience of magnification.

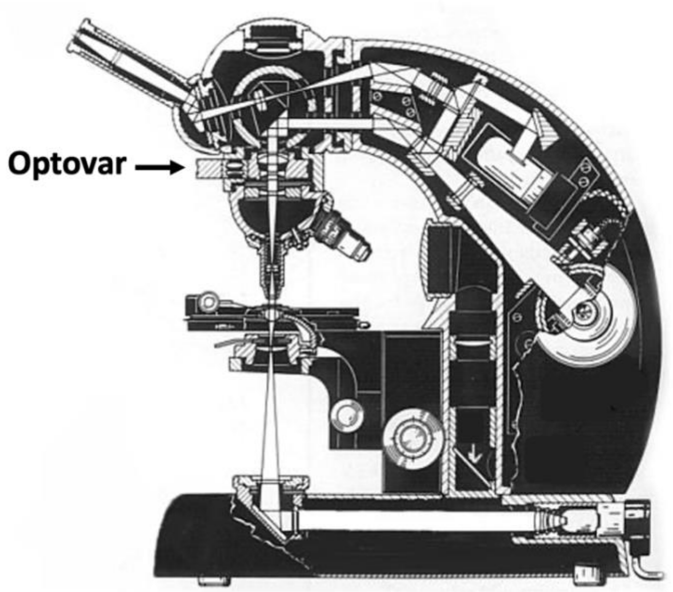
Optovar

The name Optovar derives from “optical variation” and refers to a system that allows the magnification to be varied optically without changing either the objective or the eyepiece. This is achieved by inserting a variable-factor intermediate module between the primary image and the final observation plane. In practice, it works as a selectable optical magnifier, typically with settings such as:

- 1,6×
- 2,5×
- 5,0x

The Optovar became increasingly widespread in research microscopy from the late 1950s and especially during the 1960s, eventually becoming a standard solution in Carl Zeiss modular systems during the 1970s and 1980s, particularly in laboratory microscopy and metallography. Its decline began in the late 1980s and 1990s, coinciding with the widespread adoption of infinity-corrected optical systems and, above all, the transition to digital imaging. This change was not merely technological but also concerned the architecture of the optical system: variable optical magnification was progressively replaced by broader combinations of objectives, digital sensors, and software-based magnification, offering greater precision, improved repeatability, and higher system standardization. Moreover, compared with a more direct optical path, the Optovar inevitably introduces greater complexity into the light path and may result in slight reductions in brightness and contrast.

In summary, the Optovar emerged as an elegant solution for providing visual flexibility in analog microscopy, and gradually lost its relevance as this flexibility was transferred from the optical domain to the digital one.



Internal Optical Layout of the Carl Zeiss Photomicroscope III (1975)

The history of camera viewfinders: from the external eye to the digital image

The evolution of the camera viewfinder tells the story of photography itself: the transition from indirect and approximate observation to an increasingly faithful and informative representation of reality.

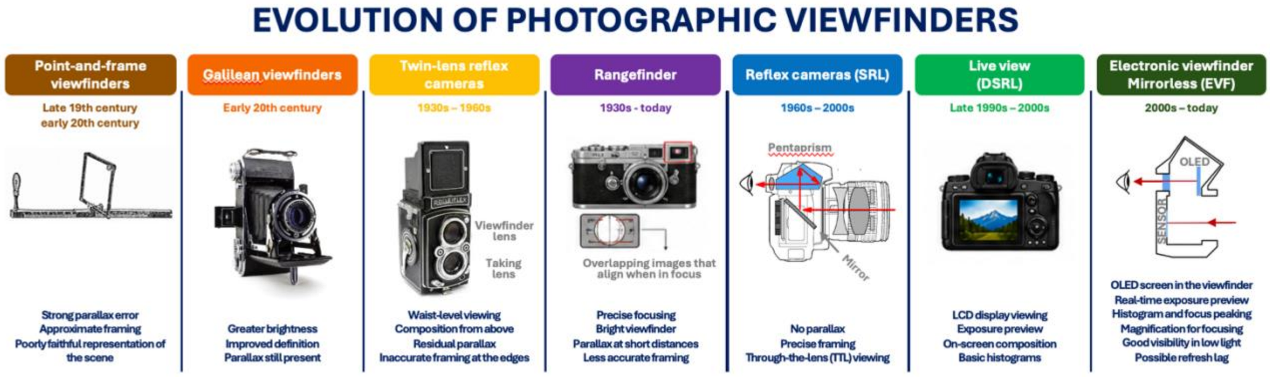
The earliest cameras used extremely rudimentary systems, such as external pointer viewfinders or simple metal frames separated from the lens. These viewfinders were imprecise, subject to parallax error (what was seen did not exactly coincide with what was being photographed), and provided only a general indication of the framing: the photographer "estimated" the scene rather than actually seeing it. An intermediate development was represented by improved Galilean viewfinders, still separate from the main optical system but brighter and more clearly defined, although still affected by parallax. A historical example is the Ferrania 6×9, a typical Italian medium-format camera of the post-war period.

At this point, we should mention the rangefinder viewfinder, an optical system that does not look directly through the lens, but uses a separate window to display the scene. Focusing is achieved by superimposing two images: as the lens focusing ring is rotated, the two images coincide when the subject is in focus. This type of viewfinder provides a bright and continuous view, without blackouts, and also allows the photographer to observe what is happening just outside the frame. However, precisely because it is not aligned with the lens, it introduces parallax, especially at close distances, requiring some experience for precise composition. Rangefinder viewfinders came into use in photography during the 1920s and 1930s. The earliest rangefinder systems were actually separate devices or devices coupled to cameras as early as the 1910s, but their widespread adoption came with Leica precision compact cameras. A fundamental milestone was 1932, when the Leica II first integrated the rangefinder permanently into the camera body, making it a practical and reliable focusing system. From that point onward, the rangefinder viewfinder became standard on many professional and reportage cameras, particularly until the widespread adoption of SLRs in the 1960s, which gradually reduced its use but not its relevance in specific fields such as reportage and street photography.

A major leap forward came with twin-lens reflex cameras, such as the famous Rolleiflex 6×6. In this system, one lens is used to take the photograph while a second lens is used exclusively for the viewfinder. The image is projected onto an upper viewing screen (waist-level finder) and observed from above. A major advantage was the comfortable viewing position for composition, but the system was still limited by parallax errors (the viewfinder and taking lens do not coincide perfectly) and by the difficulty of accurately determining the framing at the edges. It was an elegant system, but not yet "perfectly faithful."

The real revolution came with single-lens reflex (SLR) cameras. For the first time, the photographer could see exactly what the lens saw. This was made possible by an inclined mirror and a pentaprism that corrected the image. The key advantages were the absence of parallax, precise framing, and direct control over depth of field. This system became the standard for decades in photography.

The next step, intermediate between SLR and mirrorless cameras, was Live View, which introduced real-time viewing of the image directly on an LCD screen. The latest evolution is the Electronic Viewfinder (EVF), used in modern mirrorless cameras. In this case, the scene is no longer viewed through a direct optical system; instead, the image is captured by a sensor and displayed in real time on a small screen, generally an OLED. The main advantages are numerous: it provides a realistic preview of the final exposure, integrates overlaid information such as histograms, levels, and focus peaking, and allows digital magnification to facilitate focusing. It also provides effective viewing in low-light conditions. One limitation of early systems was possible image refresh delay ("lag"), which has now been almost completely eliminated in advanced models. In this way, the photographer no longer simply observes the scene, but rather a real-time simulation of the final photograph, with all parameters already applied. This transforms the viewfinder from an observation tool into a genuine real-time analysis system. An advanced example of an EVF is the one used in the Leica SL3, which features a 5.76-million-dot OLED electronic viewfinder, although viewfinder quality does not depend solely on resolution.



From the external eye to the digital image

What really makes a modern viewfinder "good"

When discussing high-end viewfinders, such as those found in professional cameras, it is easy to think that everything comes down to resolution. Indeed, the number of "dots" is often the most heavily advertised specification: values range from around 5.76 million to more than 9 million in the most advanced models, such as the Sony A7R V. However, this figure alone is not enough to guarantee a truly superior viewing experience.

One often underestimated factor is the quality of the internal optics of the viewfinder. Even when the digital image has extremely high resolution, it still must pass through an optical system before reaching the eye. If these lenses are not well designed, distortion at the edges, slight chromatic aberrations, or an overall impression of reduced sharpness may appear, diminishing the perceived quality of the image. Another crucial factor is the frame rate, that is, how smoothly the image is refreshed. A 60 Hz viewfinder may be sufficient in many static situations, but when tracking moving subjects, the difference compared with systems operating at 120 Hz or higher becomes evident: the scene appears more natural and continuous, with virtually no perceptible delay.

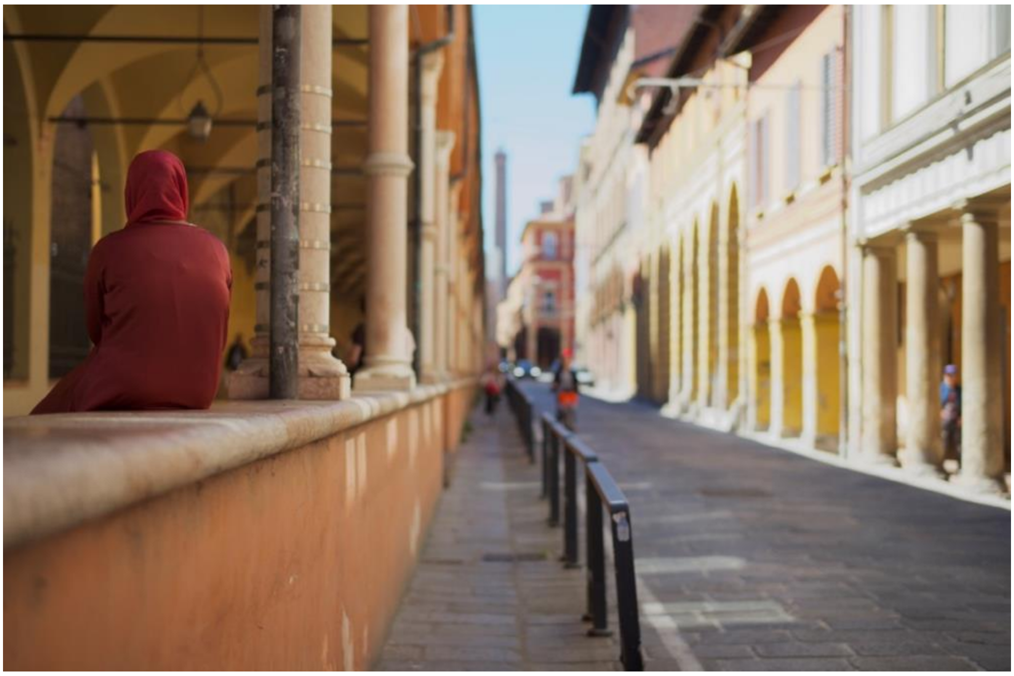
This smoothness is precisely what eliminates the annoying "lag" effect that can compromise shooting accuracy. In addition to these factors, there is dynamic range, together with display brightness. A good electronic viewfinder does not simply display the image; it interprets it: it keeps shadows visible without crushing them into black and preserves highlights without clipping them. In this way, the photographer can already anticipate the result of the photograph with considerable accuracy.

Conclusions

While the microscope remains a purely optical instrument, the electronic viewfinder becomes something more complex: a fusion of vision and computation, in which what we see is already an interpreted representation of reality. Both are instruments designed to mediate and enhance human vision, but they do so in complementary ways. The viewfinder allows the photographer to organize visual space before taking the photograph: it helps compose the frame, select what enters the image, and anticipate the final result. In this sense, it does not modify what is seen but guides the construction of the representation. The microscope eyepiece, by contrast, has an opposite yet equally mediating function: it provides access to details that would otherwise remain invisible, making structures too small for the human eye to perceive observable. Here, vision is not only organized but also extended beyond its natural limits. In both cases, the optical instrument does not simply "show" an image, but actively participates in the way that image is constructed.

In the microscope, magnification is the result of a system of lenses that modifies the path of light rays, producing a virtual image larger than the actual object. In a camera viewfinder, by contrast, image formation serves to provide a preview of the scene, allowing the observer to decide how it will be recorded, while in electronic viewfinders this preview becomes an interpretation. In summary, the microscope and the viewfinder—with their optical and electronic developments—are not simply observation tools, but devices that transform vision, making it more controlled, more conscious, and, above all, more extensive than the limits of the human eye.

From this perspective, the rangefinder viewfinder represents a particularly meaningful synthesis: a system in which vision is neither completely immersive nor entirely mediated by electronics but is constructed through a direct relationship between the eye, space, and focusing. The superimposition of images provides not only technical precision, but also a form of active attention, in which the photographer remains constantly engaged with the scene. It is precisely this quality that has made the rangefinder a favored tool in auteur street photography: discreet yet present, fast yet reflective, capable of encouraging a way of looking that does not intrude upon reality but passes through it. In this sense, urban settings such as Strada Maggiore become emblematic places, where the rangefinder makes it possible to capture gestures, relationships, and details of everyday life without interrupting the natural flow of the scene.



Leica M10R – Summilux 50mm