

# Precision Inspection

## The critical role of video frame rate in digital microscope-based stent inspection

Optical inspection of stents is a high-stakes, multi-faceted process that relies on non-contact imaging to catch microscopic burrs, sharp edges, surface flaws, verifying drug coatings, and measuring vital strut dimensions in these life-saving medical devices. Because a single defective stent can have severe consequences, these inspections are conducted at various stages of production and often involve a mix of manual and automated techniques.

Dedicated Stent Inspection Workstations with advanced Digital Microscopes are replacing traditional stereo microscopes for manual or semi-automated inspection and quality control of stents. While modern 4K digital microscopes offer high resolution images and excellent ergonomic benefits for operators, they present distinct optical and operational challenges compared to stereo microscopes.

Despite their clear advantages, optical inspection of stents with digital microscopes can be challenging due to a combination of the complex physical properties of the stent and the inherent limitations of digital imaging technology. The biggest challenges include achieving a clear real-time view of the cylindrical 3D surfaces without glare or blur related to the system's digital 2D images and video frame rate.

In this article, we discuss the impact of frame rate (FPS) on video image quality,



*Fig 1. A modern 4K digital microscope, U50s from INSPECTIS with 60 FPS video frame rate configured for stent inspection.*

a critical parameter that directly affects operator efficiency, accuracy, and fatigue during real-time inspection and quality control of stents.

### What is Video Frame Rate and Why it Matters

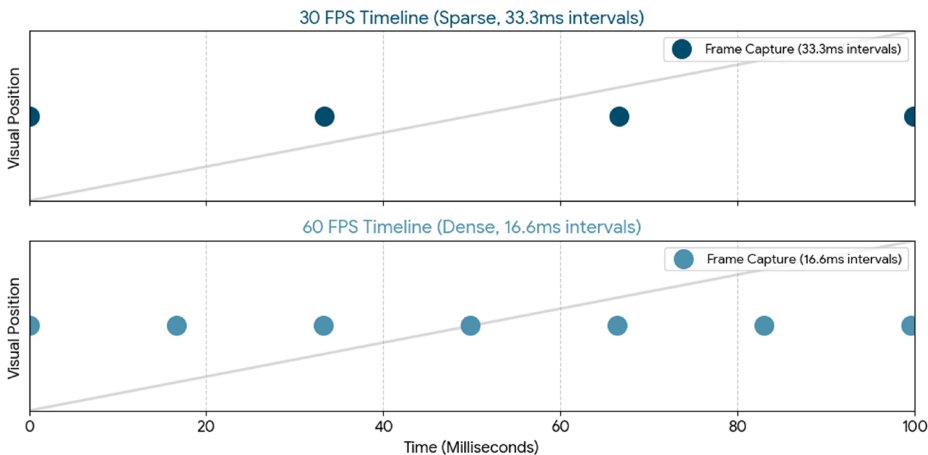
At its most basic level, frame rate is simply the number of individual still pictures (frames) your camera captures and displays on your screen as live video every single second. Frame rate of a Digital Microscope explicitly dictates the minimum possible time gap between when the object

under inspection moves and when the camera can physically deliver a new picture. At 30 FPS the camera captures an image once every 33.3 milliseconds. At 60 FPS the gap drops to 16.6 milliseconds per frame. By doubling the frame rate, you cut this inherent mathematical waiting time in half, resulting in faster responsiveness.

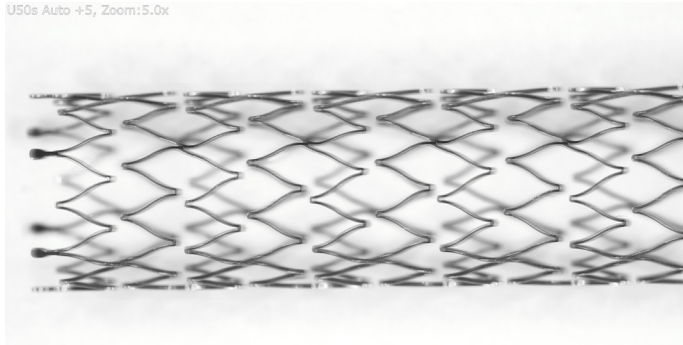
The graph below shows how a 60 FPS camera captures double the amount of visual information in the exact same 100 milliseconds timeframe compared to a 30 FPS camera.

### Impact of Low Frame Rate on Optical Inspection

Low frame rates actively degrade image clarity, accuracy, and usability, especially in stent inspection that requires constant, smooth movement over curved surfaces. Rubbery lag, strobe light effect, and motion blur are three specific effects of low frame rates that directly impact image quality, operator efficiency, and fatigue.



*Fig 2. Illustration of 30 FPS and 60 FPS visual information capture at a 100-millisecond window of time.*



### Rubbery Lag

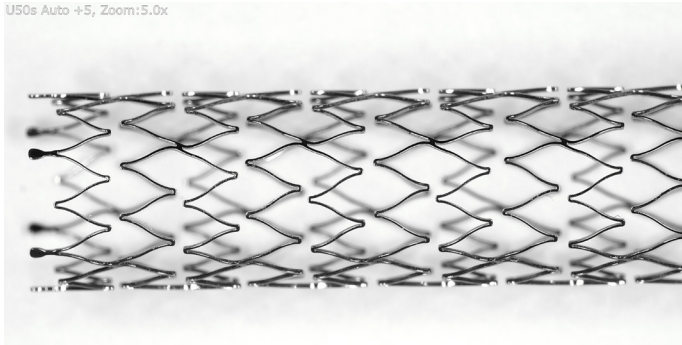
Lag in a digital microscope is the time delay between a physical event occurring under the lens (such as rotating a stent) and the event appearing on the screen. When the lag exceeds 50 milliseconds, it triggers the disorienting, “rubbery” hand-eye mismatch that disrupts motor skills and causes operator fatigue. Low frame rate is one of the primary causes of lag.

When an operator attempts to micro-manipulate or spin a stent under a 4K/30 FPS system, the combination of the 33.3ms frame-gap and data processing lag creates a “rubbery” hand-eye mismatch. A 4K/60 FPS digital microscope with two times faster sensor readouts and faster data processing electronics, delivers nearly zero-latency live images.

The primary physical consequence of video lag in inspection work is increased physical fatigue, particularly in the neck, back, eyes, and dominant hand. The accumulation of these physical impacts often leads to increased inspection time as the operator moves slower and more deliberately to perform quality control. Prolonged exposure to high-latency systems can lead to chronic ergonomic injuries, underscoring the importance of low-latency imaging systems.

### Strobe Effect

Instead of a continuous flow of motion, the image turns into a series of distinct, frozen “snapshots” that jump from one position to the next. Stents are often inspected while rotating on a mandrel. Let’s say it takes exactly 2 second to make a full 360° rotation. At 30 fps the camera captures the stent at 0°, 6°, 12°, 24°, and so on. The stent moves 6 degrees between each frame. On the screen, your brain sees a clear image of the stent teleporting 6 degrees across the screen 30 times a second, which is not enough to be perceived as a smooth and fluid movement. If your camera is 60 FPS, it captures the stent at 0°, 3°, 6°, 12°, ... The distance the stent moves between each frame is 3 degrees. These tiny jumps on screen are too small for your eyes to notice. The motion looks smooth and fluid. When you view a strobing stent, your brain is constantly chasing ghosts, recalculating direction, and fighting false alarms. You will miss a micro-crack not because your eyes are bad, but because your brain is so busy trying to figure out where the stent is that it has no processing power left to figure out what the stent looks like.



**Fig 3. Illustration of “ghost image” of a stent under rotation. Right side with 4K/60 FPS digital microscope. Left side with 4K/30 FPS.**

### Motion Blur

To inspect the outer and inner surfaces of a stent, operators spin the stents on a rolling mandrel rapidly under the camera. Microscopic cracks, tiny burrs, or subtle drug-coating voids disappear entirely during movement at low video frame rate. At 60 fps frame rate, individual frames are refreshed every 16.6 milliseconds, effectively “freezing” moderate motion and vibrations of stents under inspection. This ensures surfaces and edges of the laser-cut metal remain sharp and perfectly defined, allowing the operator to catch defects mid-motion without stopping.

### Conclusion

Modern 4K digital microscopes offer exceptional image clarity and ergonomic benefits, ideal for stent inspection, QC, measurements and documentation. In addition to resolution power, image sensor dynamics, pixel density, and lighting, the camera’s frame rate is a key factor. Frame rates of 30 FPS or lower introduce visible and subtle drawbacks affecting both video rendering and operator fatigue, ultimately reducing inspection precision and throughput.

**Fig 4. Illustration of “motion blur” caused by lateral movement of stent under inspection. Right side with 4K/60 FPS digital microscope. Left side with 4K/30 FPS.**

