AR GROUP - 10

Video See-Through Displays

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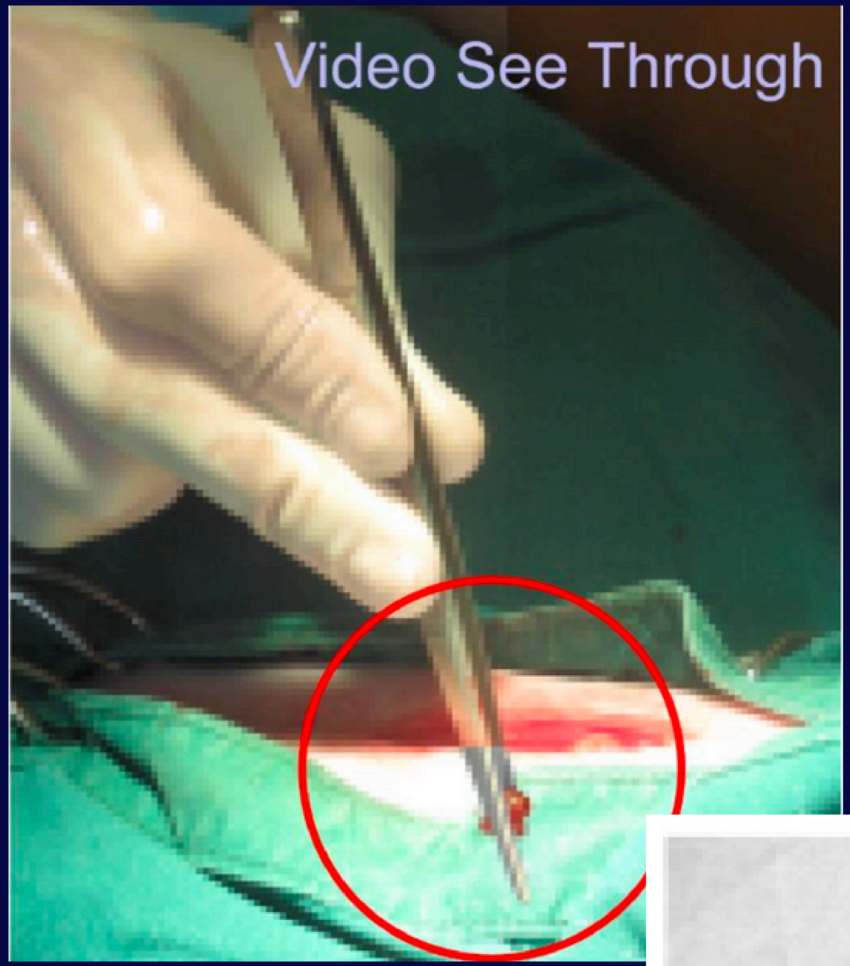
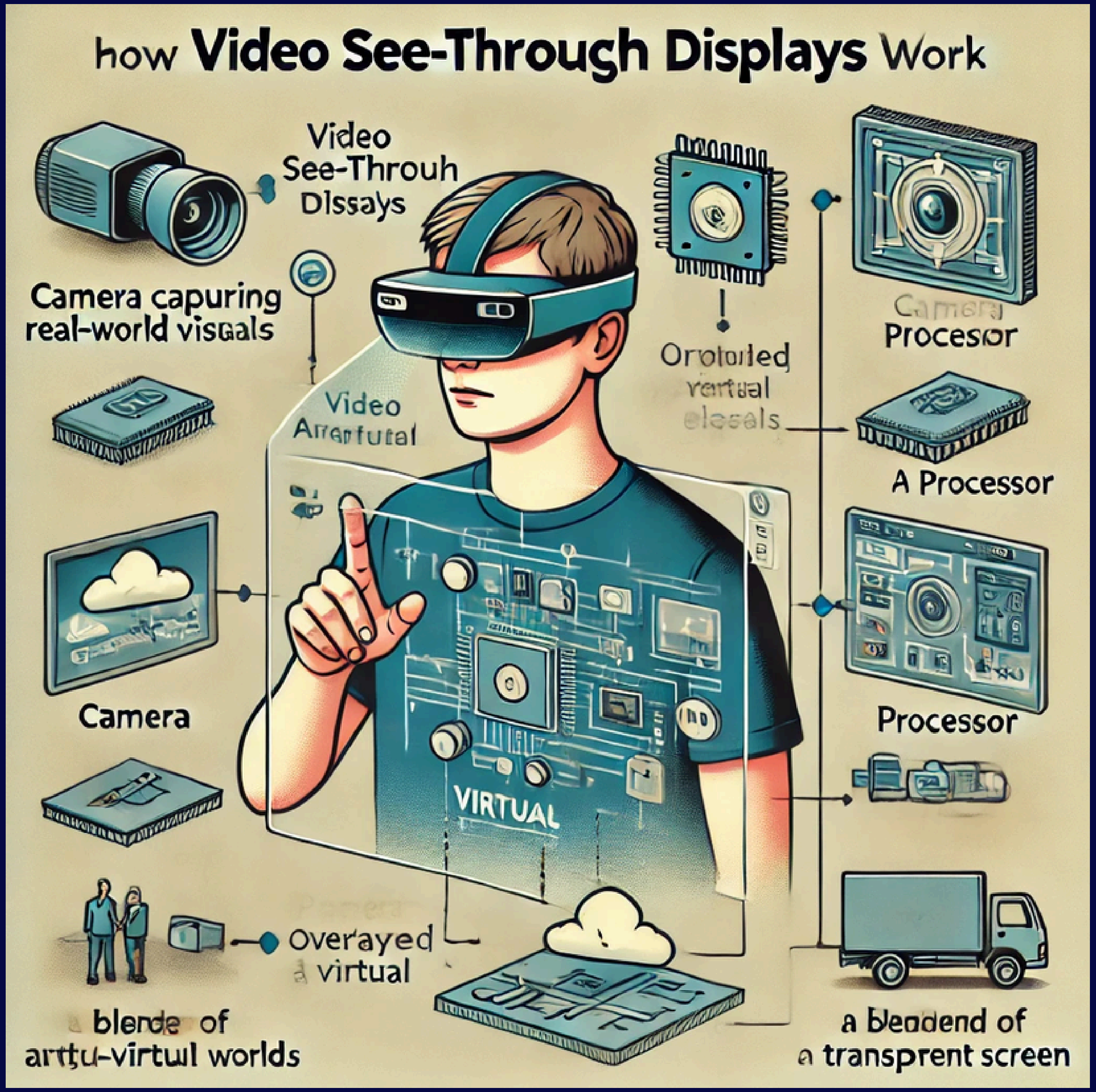
What is Video See-Through (VST)?



Video See-Through (VST) is a technology in augmented reality (AR) that allows users to view both digital content and the real world through a transparent or semi-transparent display. By layering digital information directly onto a live view of the physical environment, VST enhances the user's perception of their surroundings. It is most commonly implemented in devices like augmented reality glasses, head-mounted displays (HMDs), and transparent screens in smart devices.

This can be useful when you need to experience something remotely:
a robot which you send to fix a leak inside a chemical plant; a
vacation destination that you're thinking about.
• This is also useful when using an image enhancement system: a
thermal imagery, night-vision devices, etc.

How Video-See Through Displays Work

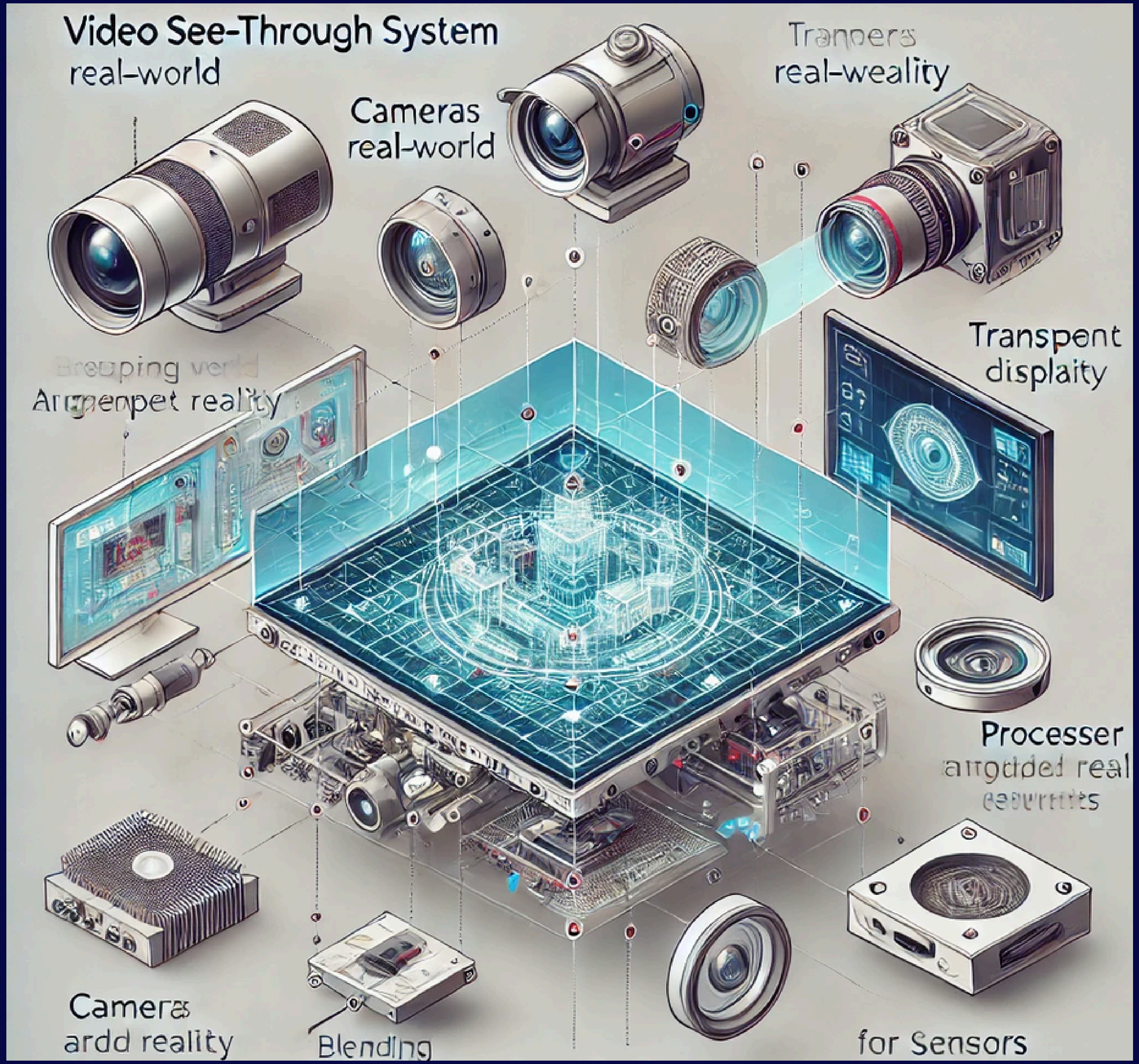


VST systems work by capturing the real-world environment with cameras and combining it with digital content, displayed in real-time on a transparent screen. Users interact with both the physical and virtual environments simultaneously.

Steps:

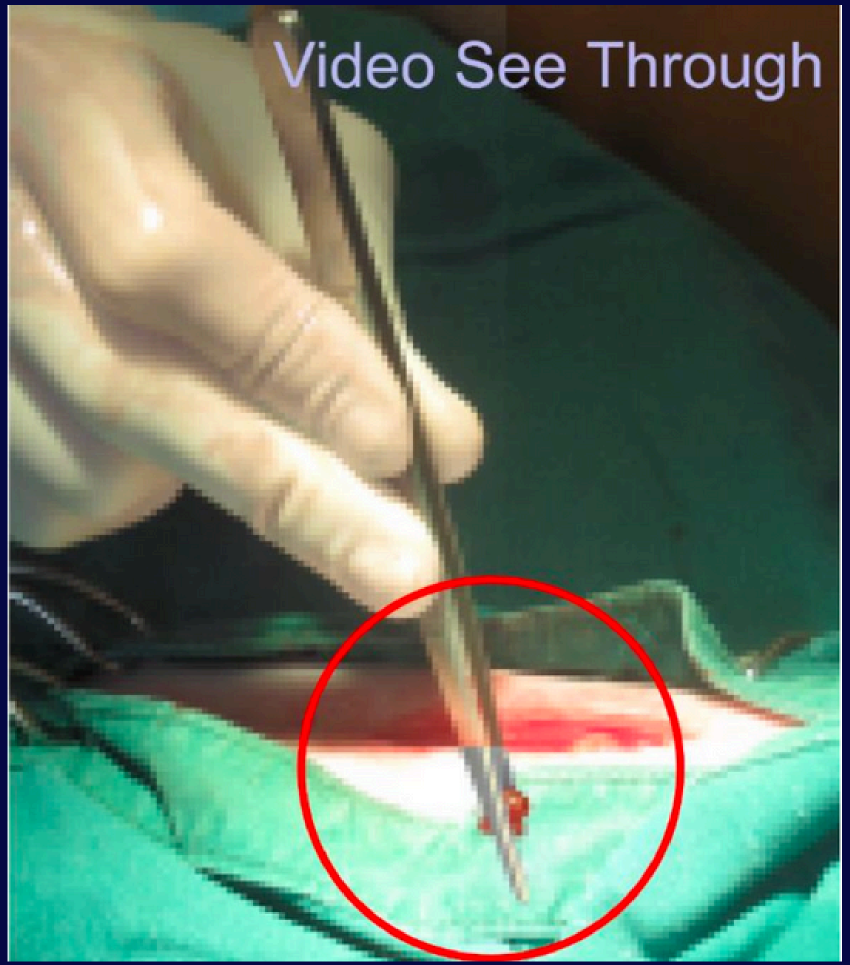
- **Capture**: Cameras capture real-world surroundings.
- **Processing**: Images are processed to align digital content.
- **Display**: The combined feed is shown on a transparent screen.

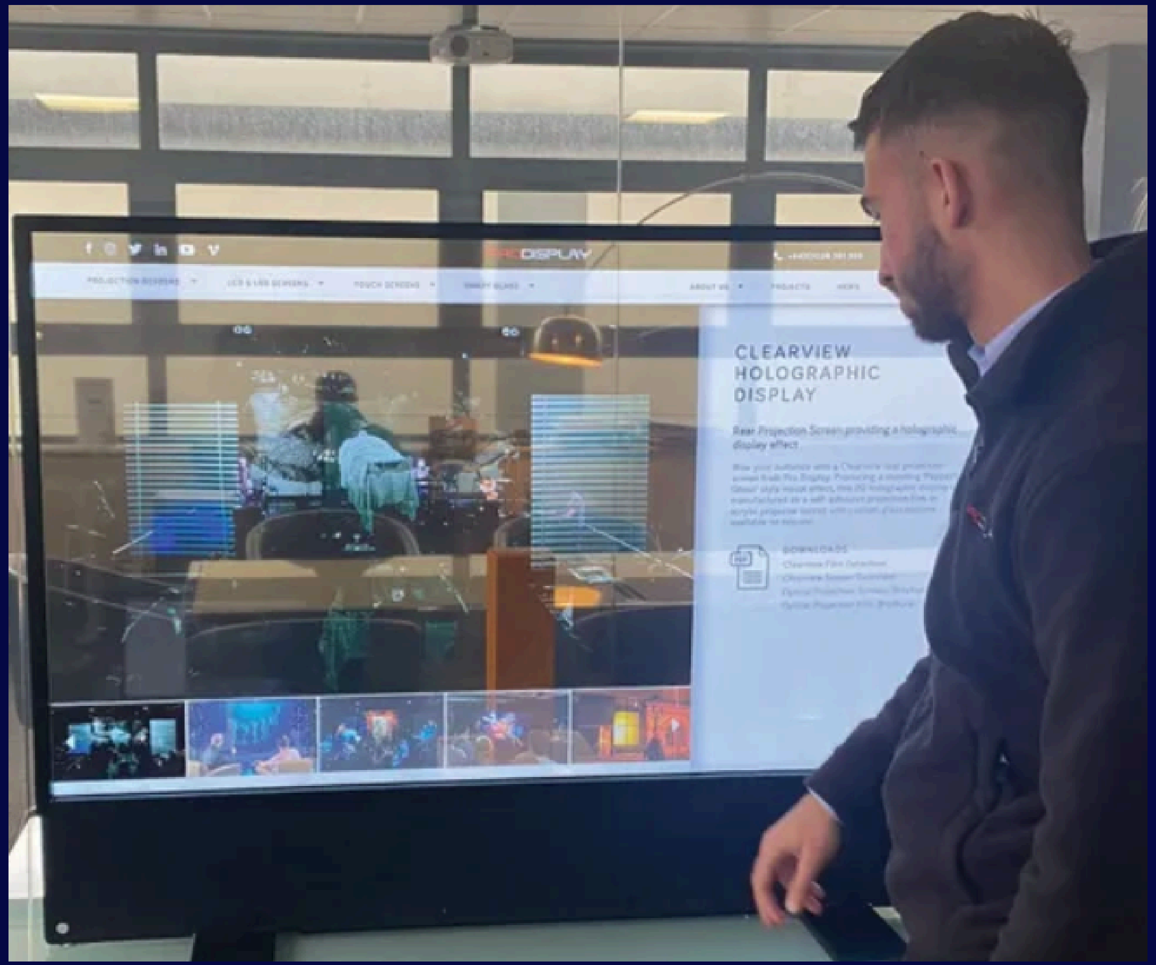
Key Components of Video See-Through Systems

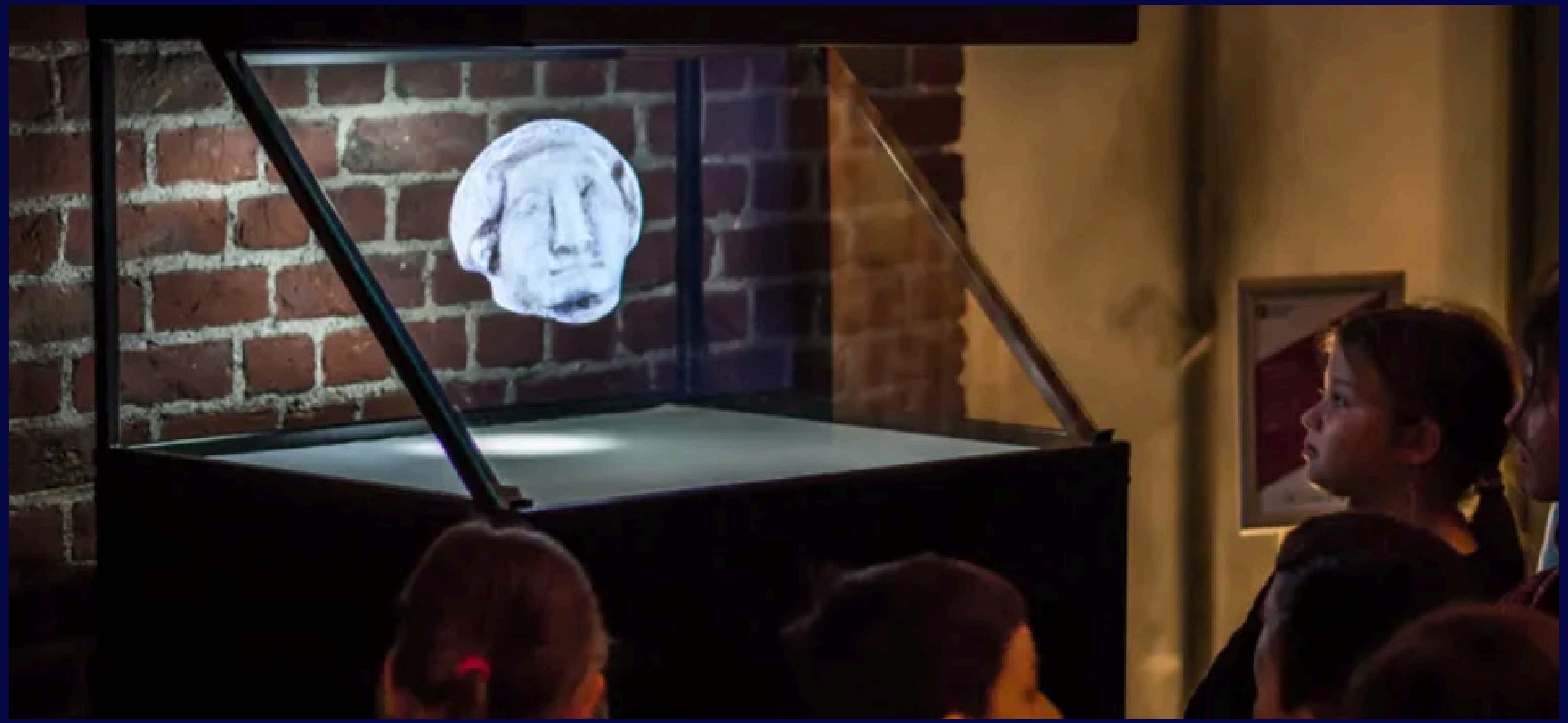


- **Display Screen:** The see-through or semi-transparent screen showing combined visuals.
- **Cameras:** Capture real-world surroundings in real-time.
- **Processing Unit:** Aligns and combines real-world visuals with digital overlays.
- **Sensors:** Track user’s position and orientation to align content accurately.
- **Power Source:** Battery or wired connection powering the display and processing units.
- **Image Suggestion:** Labelled diagram of a VST system.

Applications of Video See-Through Displays







- **Medical Field:** Surgeons use VST displays for enhanced imaging during complex procedures.
- **Industrial Training**: VST displays guide workers through tasks by overlaying instructions.
- **Military and Aviation**: VST displays improve situational awareness by integrating maps, sensor data, and tactical information.
- **Retail and Advertising**: Digital overlays create interactive shopping experiences.
- **Entertainment and Gaming**: Used for augmented reality games and experiences.
- **Image Suggestion**: Grid of various industries, each showing an example of VST applications.

Examples of Video See Through Displays

Fig. 1

Fig. 2

Fig. 3

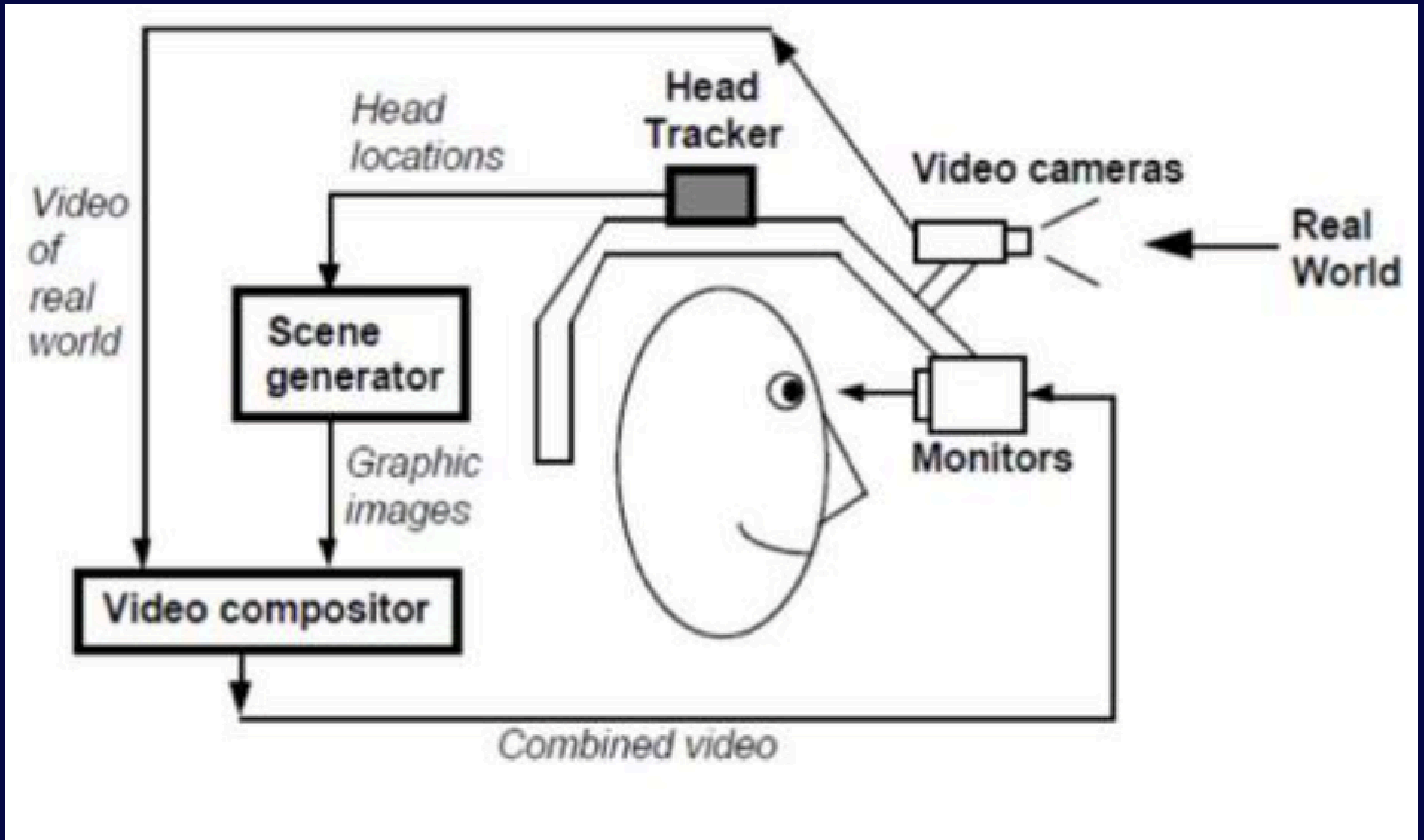
Fig. 4

Video see through displays provide consistency, accurate pixel registration , adaptable brightness and contrast but they black out with display fails, which you will see more about in the following slides.

A few examples include:

- AR headsets like Magic Leap One (Fig. 1) and Nreal Light which augment content onto video feeds.
- Smartphone based AR like Google AR core or Apple ARKit
- HUDs with cameras like Automotive HUDs which are cars with video cameras to enhance real world imagery.
- VR headsets (for mixed reality). An example is Oculus Quest 2 (Fig. 2) with Passthrough Mode which is a headset with external cameras to show the environment while overlaying digital content.
- Digital compound microscopes (Fig. 3) incorporate video feeds and heads-up displays giving magnified images overlaid with analytical data.
- COASTAR (Fig. 4) was the first commercial parallax-free video see-through HMD.

Conceptual Diagram



Working of a video see-through head-mounted display :

1. Real World Capture:
    - The HMD uses head-mounted video cameras to capture the user's view of the real world.
    - This provides a live feed of the environment surrounding the user.
2. Virtual World Generation:
    - A scene generator creates graphic images representing the virtual world.
    - These images are generated based on the user's location and interactions.
3. Video Composition:
    - The real-world video and virtual images are combined.
    - This can be done using chroma-keying or depth-information techniques.
4. Display:
    - The combined video is displayed on the monitors in front of the user's eyes.
    - This creates a blended view of the real and virtual worlds.

Taxonomy

Video see-through displays in augmented reality (AR) can be categorized based on their optical design and display technology:

HoloLens 2

An ergonomic, untethered self-contained holographic device with enterprise-ready applications to increase user accuracy and output.

Optical Design
- Optical combiners: Overlay virtual content onto real world.
- Head-up displays (HUDs): Project images onto transparent surfaces.
- Waveguide displays: Use waveguides to guide and project images.
- Freeform optics: Use complex lens shapes for wider field of view and reduced distortion.

Display Technology
- LCDs: High resolution, low power, color accuracy.
- OLEDs: Thinner, wider viewing angles, better contrast.
- MicroLEDs: Higher brightness, faster response times, longer lifetimes.

Popular Examples
- Microsoft HoloLens: Waveguide and freeform optics with LCDs.
- Magic Leap One: Waveguide-based design with OLED displays.
- Oculus Quest 2: AR capabilities using pass-through cameras.

Comparison Table :

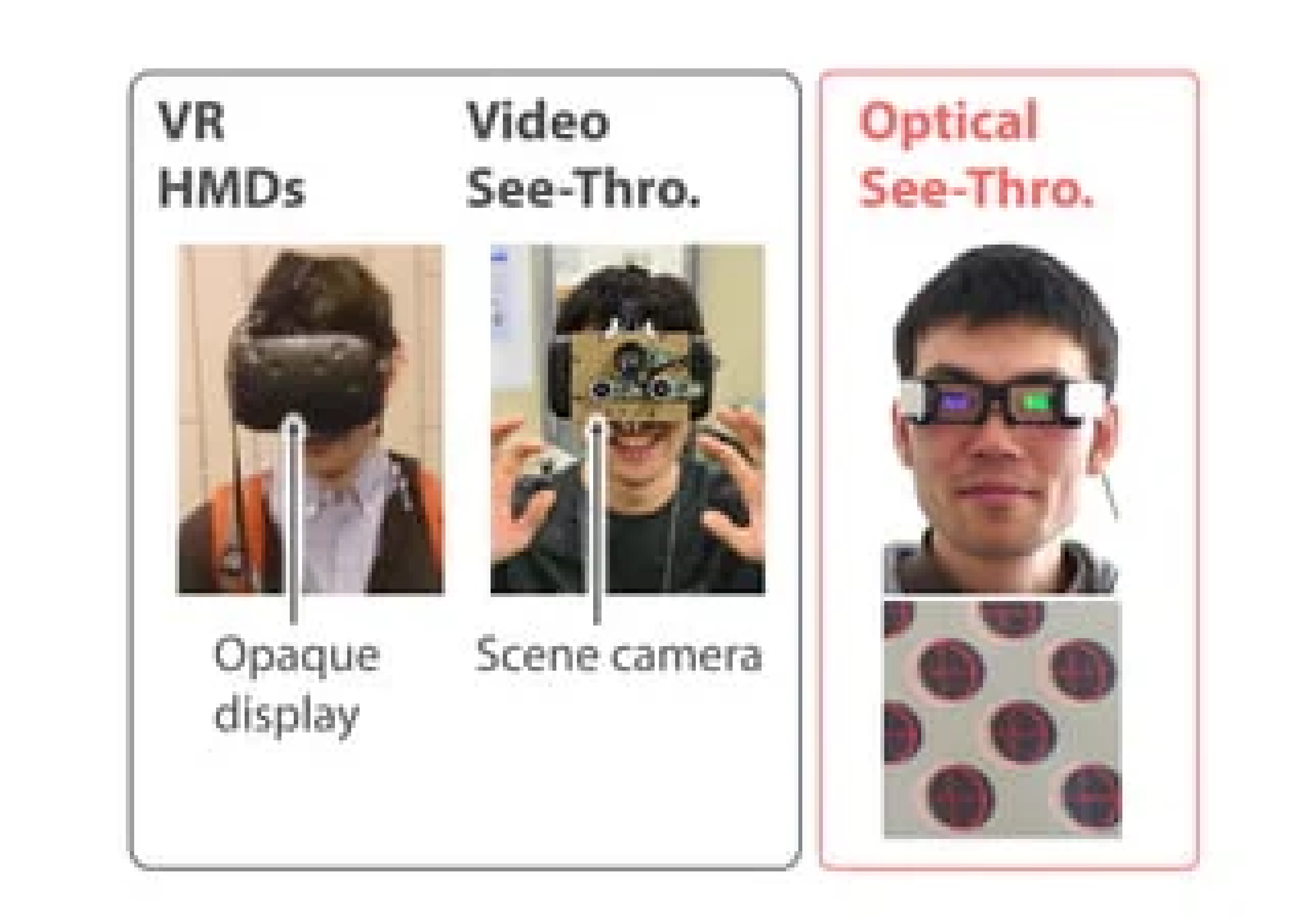


Fig. 1

Aspect	Optical-See Through	Video-See Through
Brightness Control	Dependent on external ambient light	Can be controlled digitally
Contrast Management	Limited due to environments natural light	Adjustable by system
Real World Detail	Always available , unaffected by display	Can lose detail with high brightness
Flexibility	Low , fixed by external light	High , display can adapt to lighting

Brightness Comparison

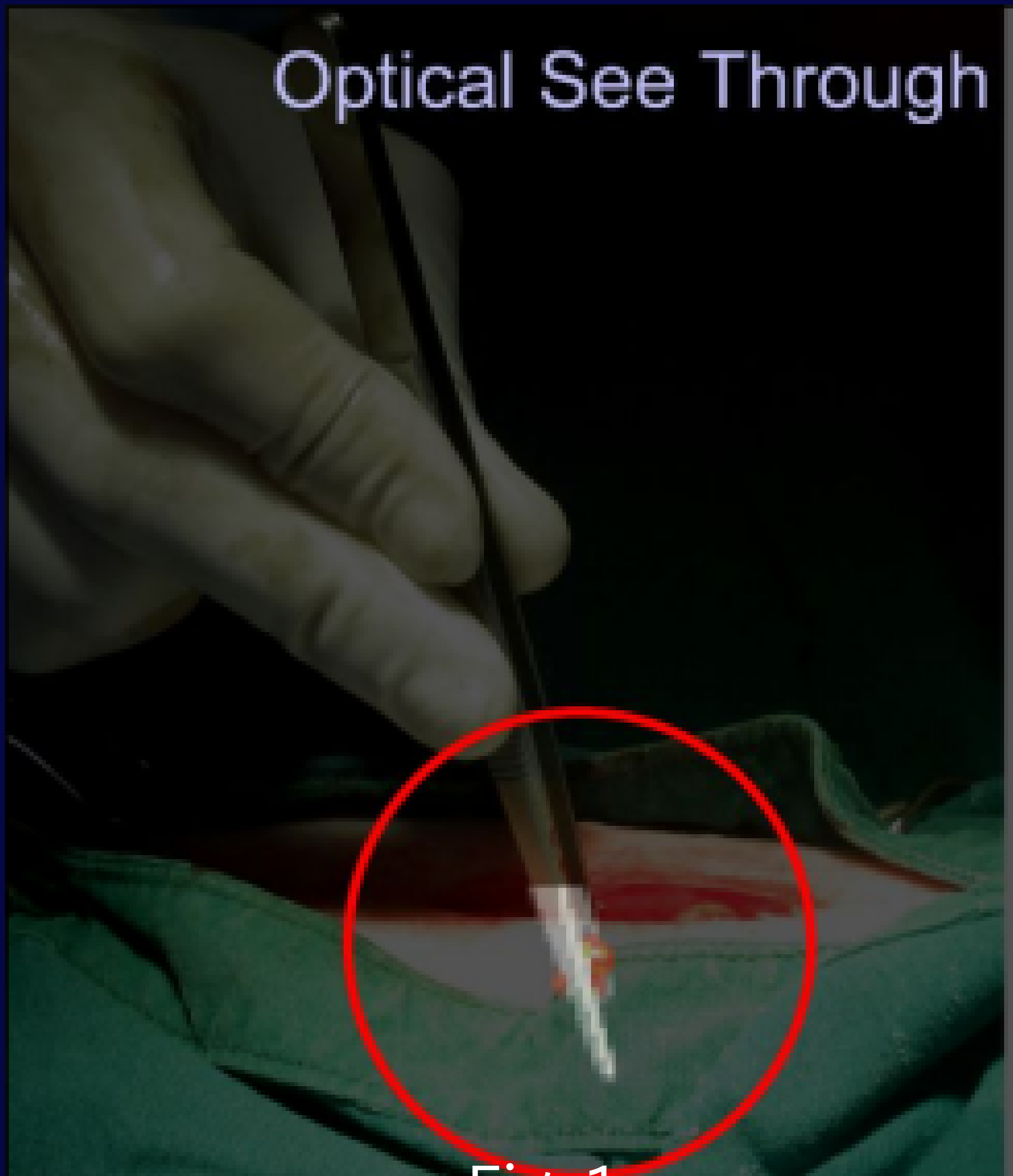


Fig. 1

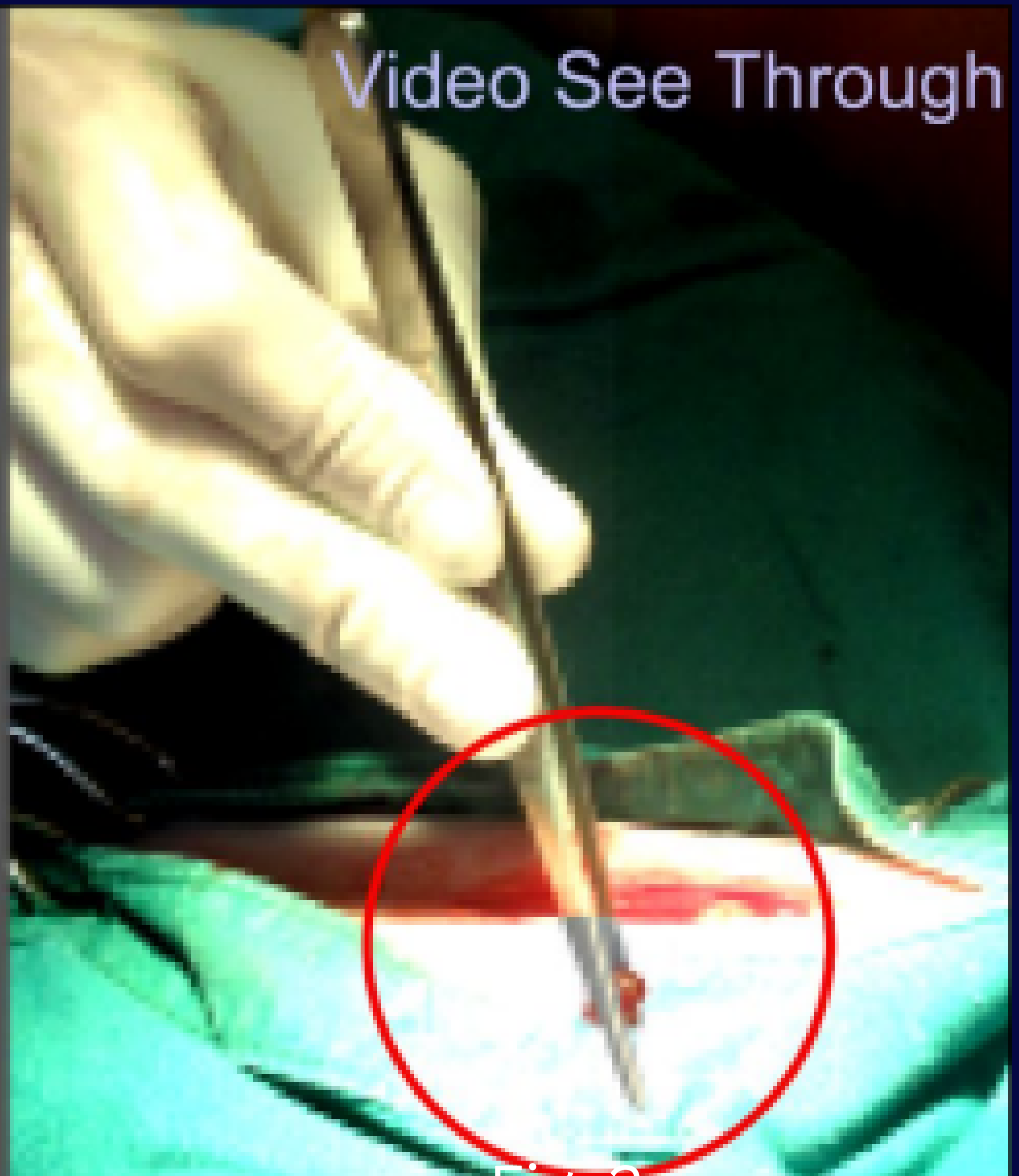


Fig. 2

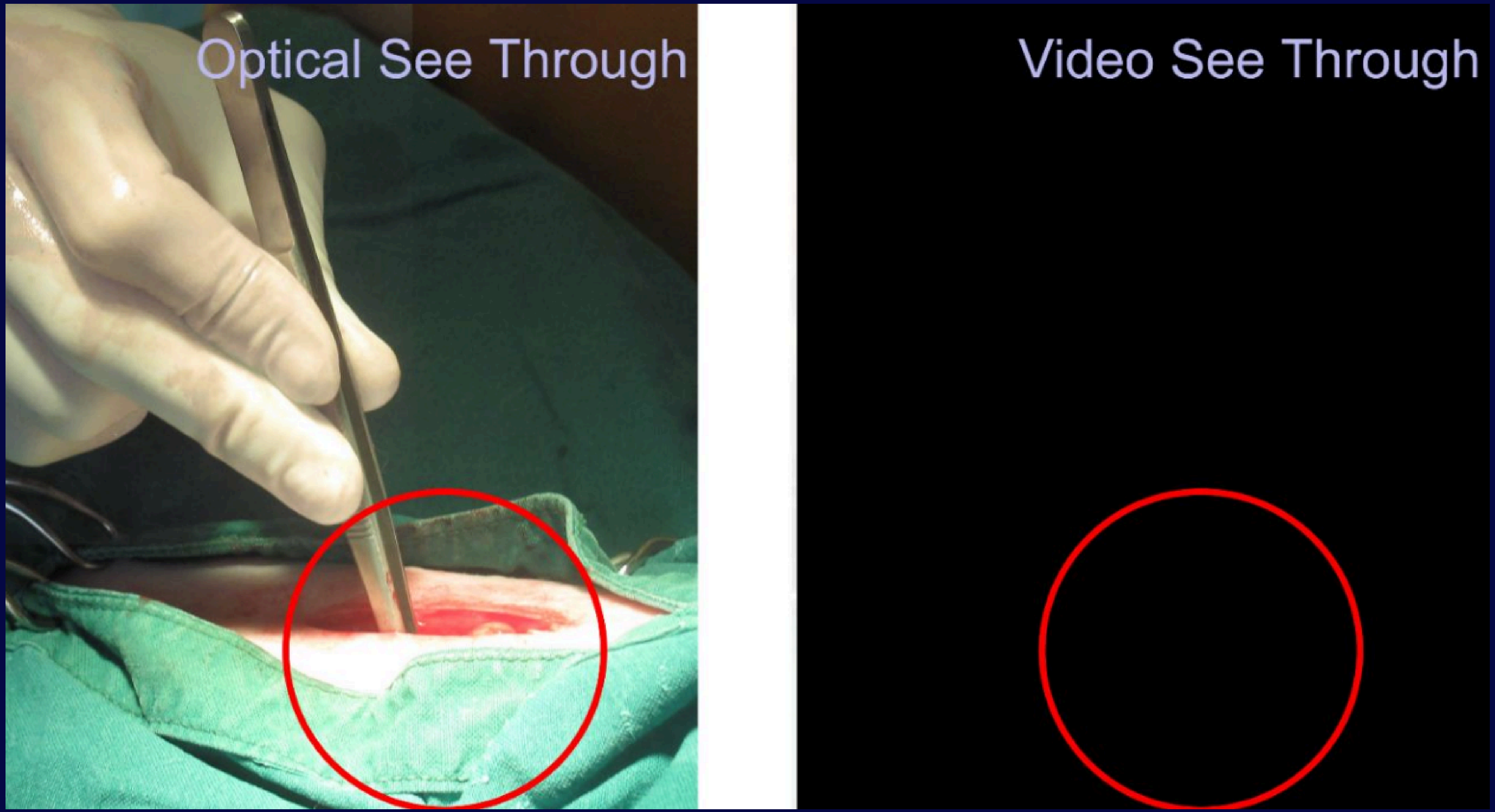
Optical See-Through Displays:

- **Fixed Brightness**: The real-world scene is directly visible through transparent optics, and display brightness is dependent on external light.
- **Limited Control**: Brightness cannot be modified as it relies on the ambient light in the environment.
- **Stable Real-World Visibility**: No loss of real-world detail, as the display doesn't affect the real-world brightness

Video See-Through Displays:

- **Adjustable Brightness:** Displayed image brightness can be controlled digitally, offering more flexibility.
- **Real-World Brightness Impacted:** As the video feed depends on cameras, brightness is adjusted by the system, potentially enhancing or diminishing real-world visibility.
- **Risk of Overexposure or Loss of Detail:** If the display contrast or brightness is too high, real-world details can be lost or washed out.

Failure Comparison



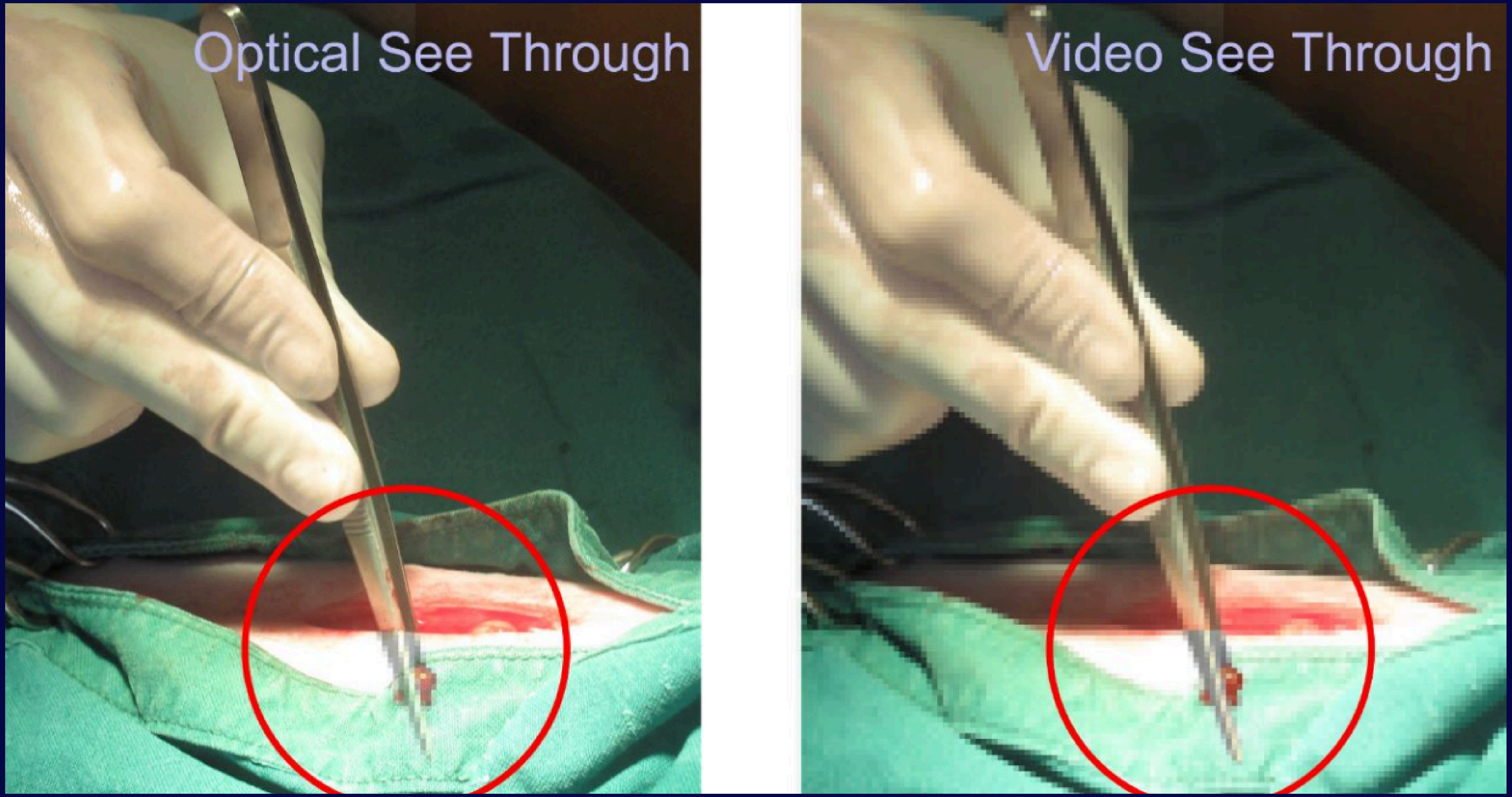
Optical See-Through Displays:

- **Display Dependency**: TVST systems depend entirely on a screen to show both the real world and augmented content. If the display fails (e.g., goes blank), users lose all visibility of their surroundings, leading to a complete loss of situational awareness.
- **Critical Situations**: In high-stakes environments like surgery or aviation, a display failure can be catastrophic, causing surgeons or pilots to lose crucial visual information for decision-making, which may lead to severe consequences.

Video See-Through Displays:

- **Display Dependency:** DOST systems use transparent displays, enabling users to see the real world directly. If the system fails, users can still view their surroundings, helping maintain awareness and reducing risks in critical situations.
- **Critical Situations:** While OST systems can face challenges, they let users continue seeing the real world, providing a safety net. For instance, surgeons can still view the surgical field even if augmented overlays are lost

Image Quality Comparison



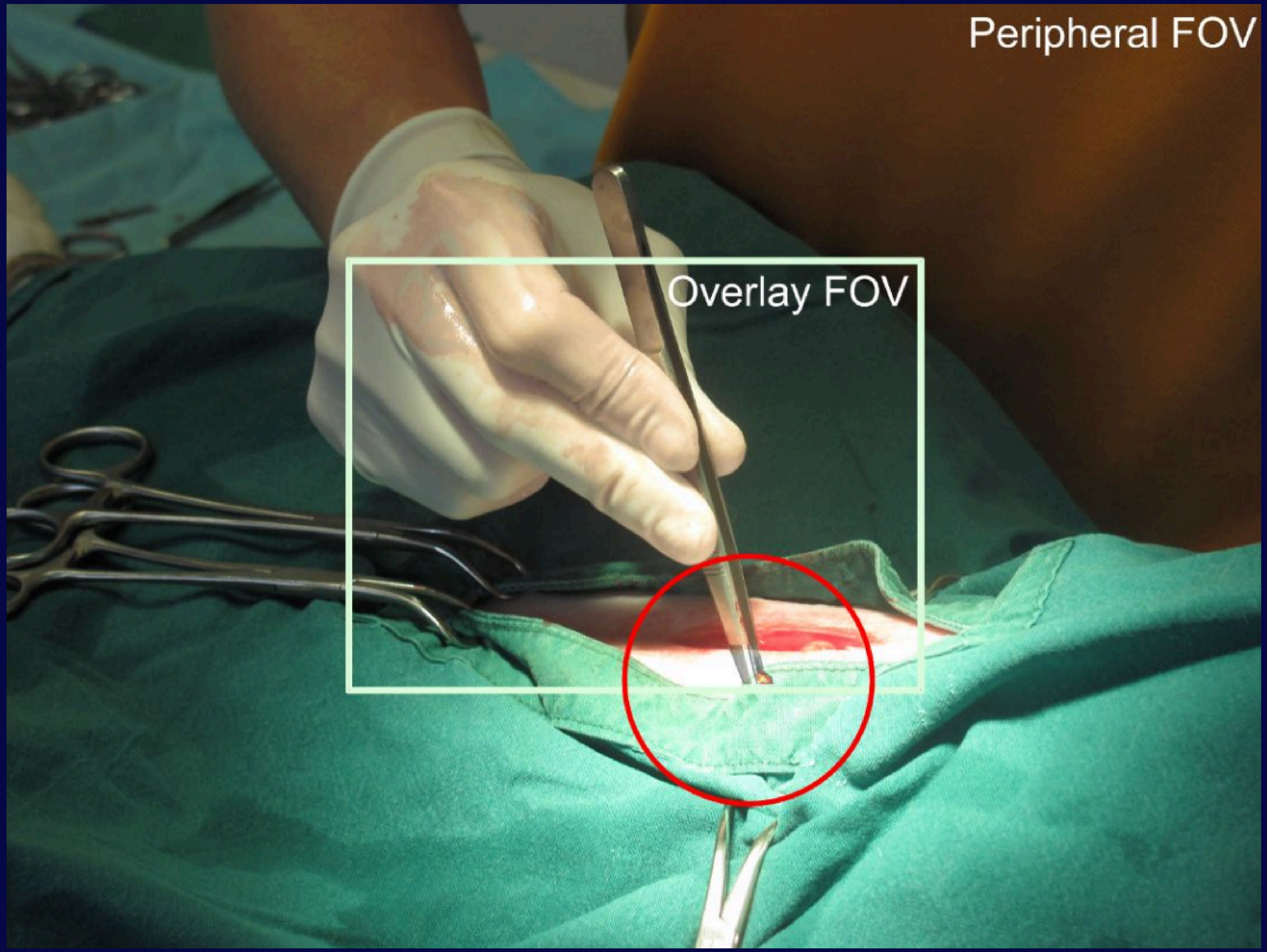
Optical See-Through Displays:

- **Real-World Clarity**: OST displays offer high-quality visuals of the real world, but clarity can be inconsistent due to lighting or misalignment issues, affecting precision tasks.
- **Augmented Content Issues:** Augmented elements can suffer from resolution artifacts, making overlays appear less sharp and complicating user interactions.

Video See-Through Displays:

- **Camera Dependency:** VST systems depend on camera quality; low resolution or poor lighting can lead to a compromised view of the real world.
- **Consistent Overlays:** VST provides more uniform augmented content, but the overall image may lack sharpness compared to OST, affecting how well overlays blend with the real environment.

Field of View Comparison



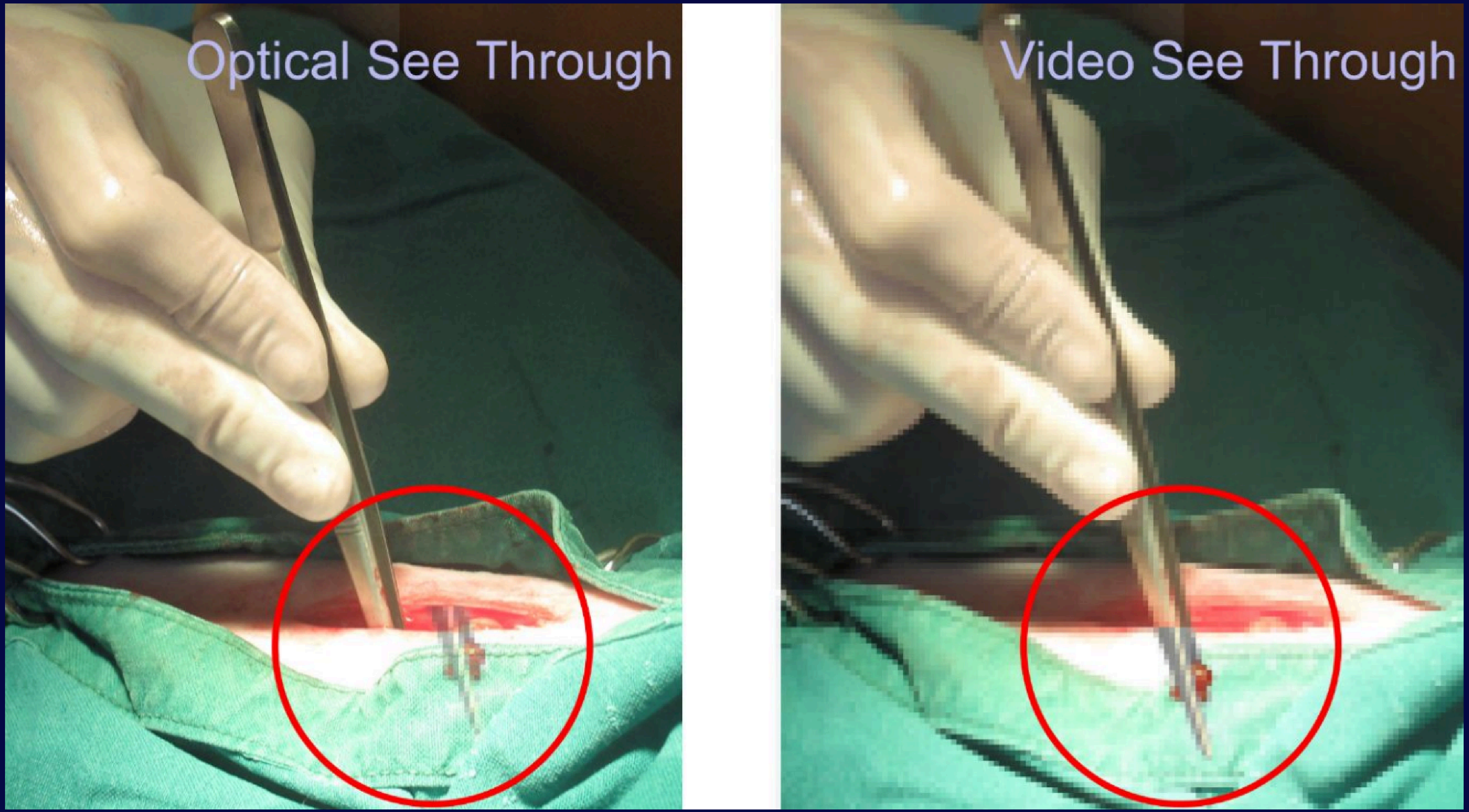
Optical See-Through Displays:

- **Wider Peripheral Awareness**: OST systems generally provide a wider peripheral field of view, allowing users to maintain awareness of their surroundings outside the overlay area. This helps in navigating real-world environments more effectively.
- **Overlay Limitations:** While the real-world view is broad, the area where augmentations are visible (overlay FOV) can still be limited, which may restrict interaction with augmented content..

Video See-Through Displays:

- **Narrower Field of View:** VST systems typically have a more limited field of view, which can restrict the visible area for both real and augmented content, potentially impacting user experience.
- **Defined Overlay Area** The overlay area is clearer but confined; users may find it harder to engage with the augmented content while also being aware of their real-world surroundings.

Registration Comparison



Optical See-Through Displays:

- **Calibration Challenges**: OST systems can experience issues with eye-to-display calibration. Insufficient calibration may lead to distracting offsets between real-world objects and their augmented counterparts, affecting user experience.

- **Visual Misalignment:** If the optical components are misaligned, users may see augmented elements that do not correspond accurately to real objects, creating confusion during interaction.

Video See-Through Displays:

- **Easier Registration:** VST systems can achieve pixel-accurate registration more easily since they rely on digital processing of the video feed, allowing for precise alignment of augmentations with real-world elements.

- **Consistent Overlays:** The ability to process images digitally ensures that augmented content remains consistently aligned, reducing the likelihood of misalignment and improving the overall user experience.

Advantages of Video See-Through Displays

- Enhanced Reality Experience: Seamlessly blends digital and real-world visuals for immersive interaction.
- Remote Assistance and Collaboration: Enables real-time remote guidance by overlaying instructions on real objects.
- Versatile Applications: Used across various fields, including medical, military, and industrial sectors.
- Reduced Eye Strain: VST displays reduce strain by allowing the viewer to focus naturally on transparent screens.
- Image Suggestion: Infographic listing the advantages.

Disadvantages of Video See-Through Displays

- Limited Field of View: Some displays have a restricted field of view, reducing the user’s immersion.
- High Power Consumption: Continuous use of cameras, sensors, and screens drains power quickly.
- Processing Delays: Real-time overlay of visuals can create lag if the processing power is insufficient.
- Costly Technology: Manufacturing high-quality, transparent screens with cameras and sensors is expensive.
- Image Suggestion: Visual of a VST display with icons indicating power, cost, and other limitations.

Conclusion

Overview of Video See-Through (VST) Technology in AR

- <u>Definition:</u> Video See-Through (VST) technology in augmented reality (AR) systems combines real-world video feeds from cameras with digital content to create an immersive augmented experience. Users view both real and virtual elements through a transparent display.
- <u>How it Works:</u>
  - Real-World Capture: Cameras capture the user's surroundings.
  - Virtual Content Generation: Digital graphics are generated based on user location and interactions.
  - Composition & Display: The real and virtual feeds are combined and displayed on monitors, providing an augmented experience.
- <u>Examples:</u>
  - AR Headsets: Devices like Magic Leap One and Nreal Light overlay virtual content on video feeds.
  - Smartphone AR: Google ARCore and Apple ARKit enhance real-world visuals using a smartphone's camera.
  - Automotive HUDs: Heads-up displays with cameras improve situational awareness in vehicles.
  - Mixed Reality Headsets: Oculus Quest 2 uses Passthrough Mode for blending real-world visuals with virtual elements.