**📸 1. Image Capture**

**Devices Used:**

* **Digital Cameras**, **Smartphones**, **Scanners**
* Equipped with **image sensors** like **CMOS** or **CCD**

**Process:**

* Light from the scene hits the **image sensor**.
* The sensor converts light into **electrical signals**.
* Each sensor element (called a **pixel**) measures light intensity (and color with filters).
* Signals are digitized via an **analog-to-digital converter (ADC)**.

**🧮 2. Digital Image Representation**

**Grayscale Image:**

* Stored as a 2D matrix.
* Each element (pixel) has a single value (e.g., 0–255 for 8-bit) representing brightness.

**Color Image (RGB):**

* Represented as **three 2D matrices** (Red, Green, Blue channels).
* Each pixel is a triplet like (R,G,B)(R, G, B)(R,G,B), e.g., (255, 0, 0) for pure red.

**Image File Formats:**

* Common formats: **JPEG**, **PNG**, **BMP**
* May use **compression** (lossy or lossless) to reduce file size.

**🎥 3. Video Capture**

**Devices Used:**

* **Video Cameras**, **Webcams**, **Smartphone Cameras**

**Process:**

* Captures a sequence of **images (frames)** over time, typically **30 or 60 fps**.
* Each frame is processed and stored similarly to a still image.

**Video Representation:**

* Stored as a sequence of image frames + audio (if present).
* Video formats: **MP4**, **AVI**, **MOV**, **MKV**
* Use **codecs** like H.264, HEVC to compress video efficiently.

**⚙️ Data Storage and Resolution**

* **Resolution**: number of pixels, e.g., 1920×1080 (Full HD)
* **Bit Depth**: number of bits per pixel, e.g., 8-bit, 24-bit
* Higher resolution and bit depth = better quality but larger size

**Summary Table:**

| **Aspect** | **Image** | **Video** |
| --- | --- | --- |
| Basic Unit | Pixel | Frame (sequence of images) |
| Data Structure | 2D (grayscale) / 3D (RGB image) | 3D (frames × height × width × channels) |
| Sensor Type | CMOS, CCD | CMOS, CCD |
| Format Examples | JPEG, PNG, BMP | MP4, AVI, MOV |

2. Image and video processing is **foundational** to computer vision because it enables machines to interpret and analyze visual data, just like humans do. Here's why it's so important:

**🔍 1. Preprocessing for Better Input**

* Raw images/videos often have **noise**, **poor lighting**, or **blurriness**.
* Image processing techniques like **filtering**, **denoising**, **contrast enhancement**, and **normalization** prepare data for accurate analysis.

**Example**: Enhancing low-light surveillance footage for object detection.

**🧠 2. Feature Extraction**

* Processing allows for extracting **edges**, **textures**, **shapes**, and **colors**—which are critical for recognizing objects or patterns.
* Techniques like **SIFT**, **HOG**, or **Canny edge detection** rely on processed input.

**Example**: Facial recognition systems rely on detecting facial features.

**🧾 3. Compression & Storage**

* Videos and high-res images require large storage.
* **Compression algorithms** (e.g., JPEG, H.264) reduce size while maintaining essential visual information.

**Example**: Streaming services use compressed video to deliver content efficiently.

**🧭 4. Motion Analysis & Tracking (for Video)**

* Video processing detects **movement**, tracks **objects**, and estimates **trajectories**.
* Used in **autonomous vehicles**, **sports analytics**, and **surveillance**.

**Example**: Tracking a football in a sports broadcast.

**🔐 5. Real-time Decision Making**

* Efficient image/video processing enables real-time CV applications like:
  + **Self-driving cars**
  + **Augmented Reality (AR)**
  + **Robotics**

**Example**: An autonomous drone uses image processing to detect obstacles and avoid collisions instantly.

**🤖 6. Input to AI Models**

* Most computer vision models (e.g., CNNs) require processed and standardized input.
* **Image resizing**, **normalization**, and **augmentation** improve model performance.

**Summary Table:**

| **Benefit** | **Description** |
| --- | --- |
| Preprocessing | Clean and prepare data for analysis |
| Feature Extraction | Identify meaningful patterns and structures |
| Compression & Storage | Efficient data management |
| Motion Analysis (Videos) | Track and analyze movement over time |
| Real-time Decisions | Power immediate responses in intelligent systems |
| AI Model Input | Ensure high-quality input for training/inference |