APPLICATIONS OF COMPUTER VISION

How It Powers Modern Technology

Linear Algebra

Real-World Applications of Computer Vision

- **Facial Recognition:** Unlocking phones, security surveillance
- **Self-Driving Cars:** Object detection, lane recognition
- **Medical Imaging:** Diagnosing diseases from X-rays & MRIs
- **Retail & Shopping:** Self-checkout, customer behavior analysis
- **Augmented Reality (AR):** Snapchat filters, virtual try-ons

How Object Tracking Works at the Backend

- Frame Extraction: The video is broken into individual frames.
- Image Representation: Each frame is stored as a matrix of pixel values (RGB or grayscale).
- Noise Reduction: Filters like Gaussian Blur
- $G(x, y) = (1 / (2 * \pi * \sigma^2)) * \exp(-(x^2 + y^2) / (2 * \sigma^2))$
- smoothen the image to remove unwanted variations

Feature Extraction

SIFT (Scale-Invariant Feature Transform)

- Converts an image into a set of key points.
- Uses Eigenvectors and PCA (Principal Component Analysis) to find the most important features.

ORB (Oriented FAST and Rotated BRIEF)

- Uses dot products and vector normalization to match objects.

HOG (Histogram of Oriented Gradients)

- Uses gradient vectors (calculated using derivatives) to detect edges.

Mathematical Backend:

- Eigenvectors & Principal Component Analysis (PCA): Extract important features.
- Convolution Operations: Apply filters to detect edges and patterns.

Motion Estimation

Optical Flow (Vector-Based Tracking)

- Estimates object movement based on brightness consistency between frames.

- Uses the Lucas-Kanade method, solving a system of equations:

- $0 \approx I_x u + I_y v + I_t$

- where:
- Ix , Iy are image gradients,
- Vx , Vy are object velocities,
- It is the temporal change in intensity.

THANK YOU