Lecture 1: Introduction to Computer Vision & Image Formation

CIS 6217 – Computer Vision for Data Representation

College of Computer Science, King Khalid University

Learning Outcomes

- Define computer vision and explain its importance in modern applications.
- Understand the historical context and evolution of computer vision.
- Describe the basics of image formation: geometry, photometry, and representation.
- Recognize the relationship between pixels, color spaces, and digital image structure.

What is Computer Vision?

- A field of AI that enables computers to interpret and process visual information from the world.
- Mimics human visual perception using algorithms and models.
- Bridges image/video data and decision-making processes.

Applications of Computer Vision

- Self-driving cars and autonomous navigation.
- Medical imaging and diagnostics.
- Facial recognition and biometrics.
- Augmented and Virtual Reality.
- Robotics, drones, and industrial automation.

Historical Development of CV

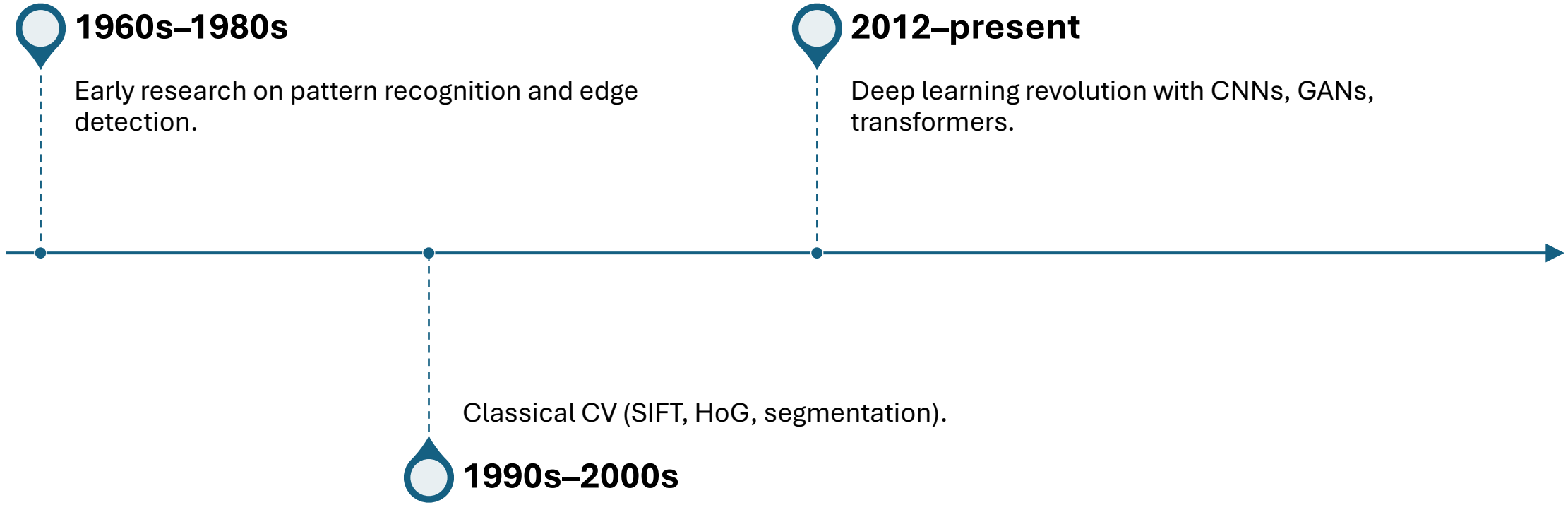


Image Formation

Forsyth & Ponce defines image formation as combined process *“Geometry tells us where the light goes; radiometry tells us how much arrives.”*

Image Formation: Geometry

- Geometry explains how 3D scenes are mapped onto a 2D image plane.

Pinhole camera model: light rays projected onto a 2D plane.

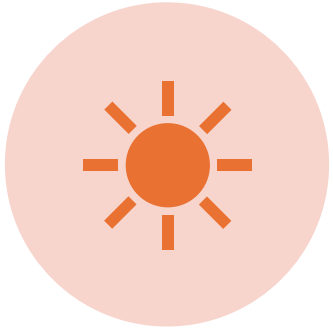
Perspective projection and vanishing points.

Parameters: focal length, field of view, aperture size.

Image Formation: Photometry

- Radiometry provides the physical quantities (energy per area, per solid angle) that explain brightness and contrast in images.

INTERACTION OF LIGHT WITH OBJECTS: REFLECTION, ABSORPTION, TRANSMISSION.



BRIGHTNESS, CONTRAST, AND INTENSITY LEVELS.

ILLUMINATION CONDITIONS IMPACT CAPTURED IMAGE QUALITY.

Digital Image

A **digital image** is a **2D array of intensity values** (pixels).

Digital Image Representation

- An image is stored as a 2D array (matrix) of pixels.
- Each pixel represents intensity (grayscale) or RGB values (color).
- Resolution: number of pixels along width and height.
- Aspect ratio: proportional relationship between dimensions.

Intensity & Color Representation

- Grayscale images: each pixel has a single intensity value (brightness).
- Color images: typically represented using channels (RGB = Red, Green, Blue).
- Each channel usually stored with 8 bits (values 0–255).
- Thus, a color pixel = [R, G, B].

Color Models

- RGB: Red, Green, Blue (additive model).
- HSV: Hue, Saturation, Value (better for color-based segmentation).
- YCbCr: Luminance + chrominance components (used in video compression).

Digital Image as a Matrix

- In memory, an image is stored as a matrix (array).
  - Grayscale: H × W matrix.
  - Color (RGB): H × W × 3 array.
- Example: A 256×256 RGB image = 256 × 256 × 3 = ~200K values.

Image Data in CV

- Stored as multidimensional arrays (height × width × channels).
- Image.shape = (H, W, 3) for RGB images.
- Libraries: OpenCV, Pillow, PyTorch, TensorFlow.

Python Example: Image Handling

- Load and display an image with OpenCV.
- Convert image to grayscale.
- Explore pixel values and channels.

References

- Computer Vision: A Modern Approach – Forsyth & Ponce (2010)