INTRODUCTION TO CNN

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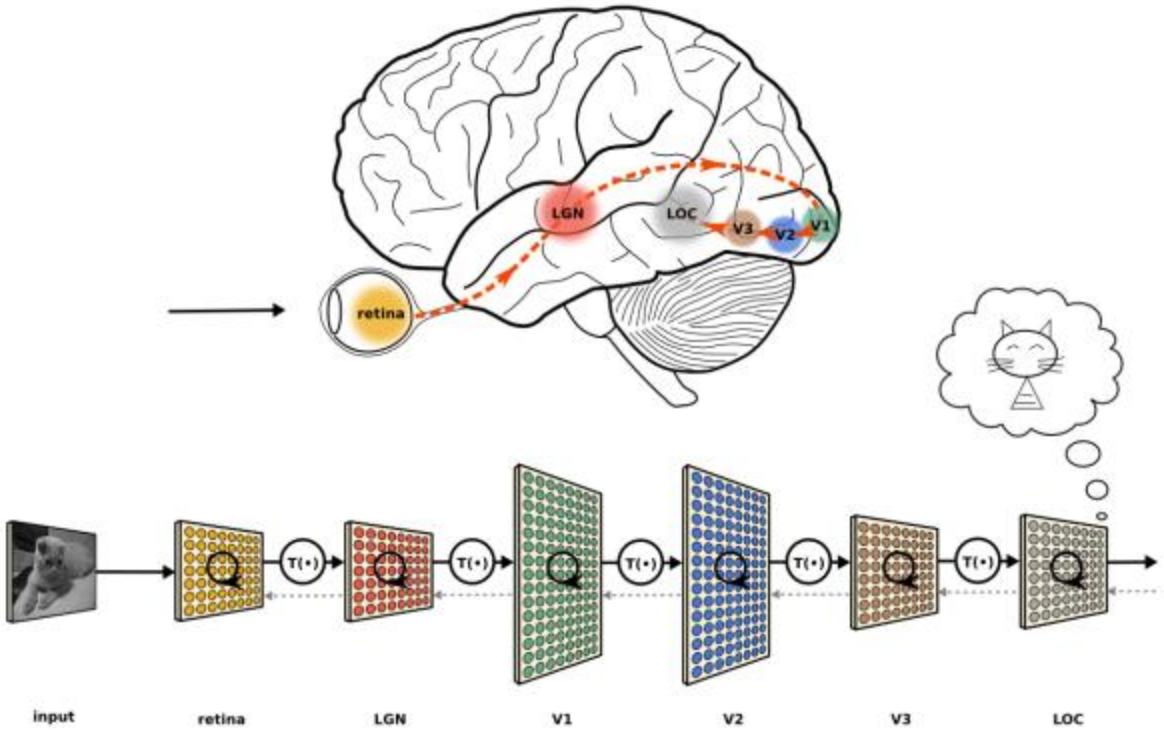
AGENDA

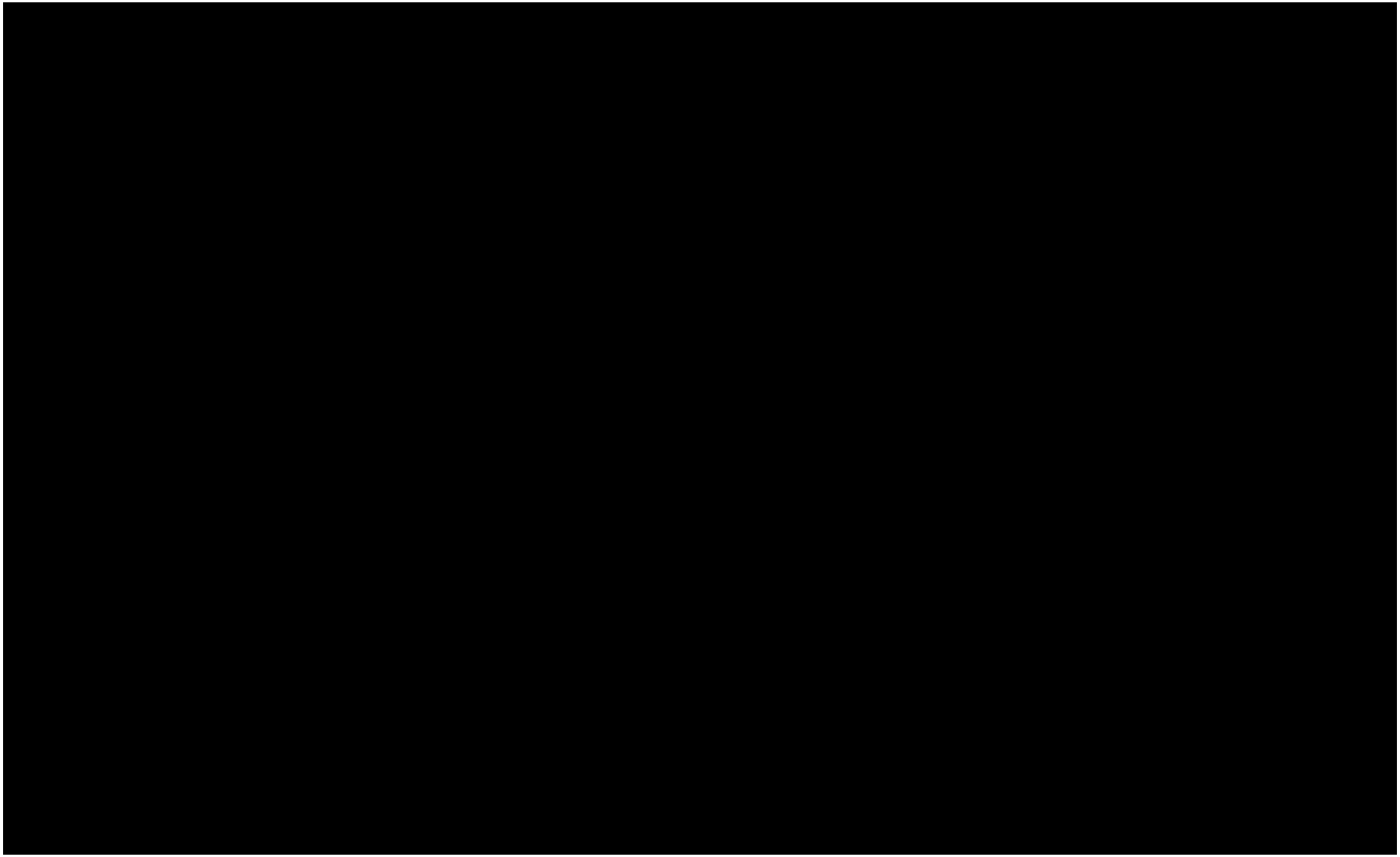
- History
- How CNN works
- Image channels
- What is convolution operation
- 1D convolution
- Feature Detector
- Feature Detection Examples

CNN HISTORY

Biological Inspiration: CNNs were inspired by the hierarchical structure of the human visual cortex, as studied by Hubel and Wiesel in 1962, where neurons respond to specific features in a hierarchical manner.



Hubel and Wiesel Cat Experiment



Hubel and Wiesel Cat Experiment

- Convolutional neural networks (CNNs) are inspired by early visual system research.

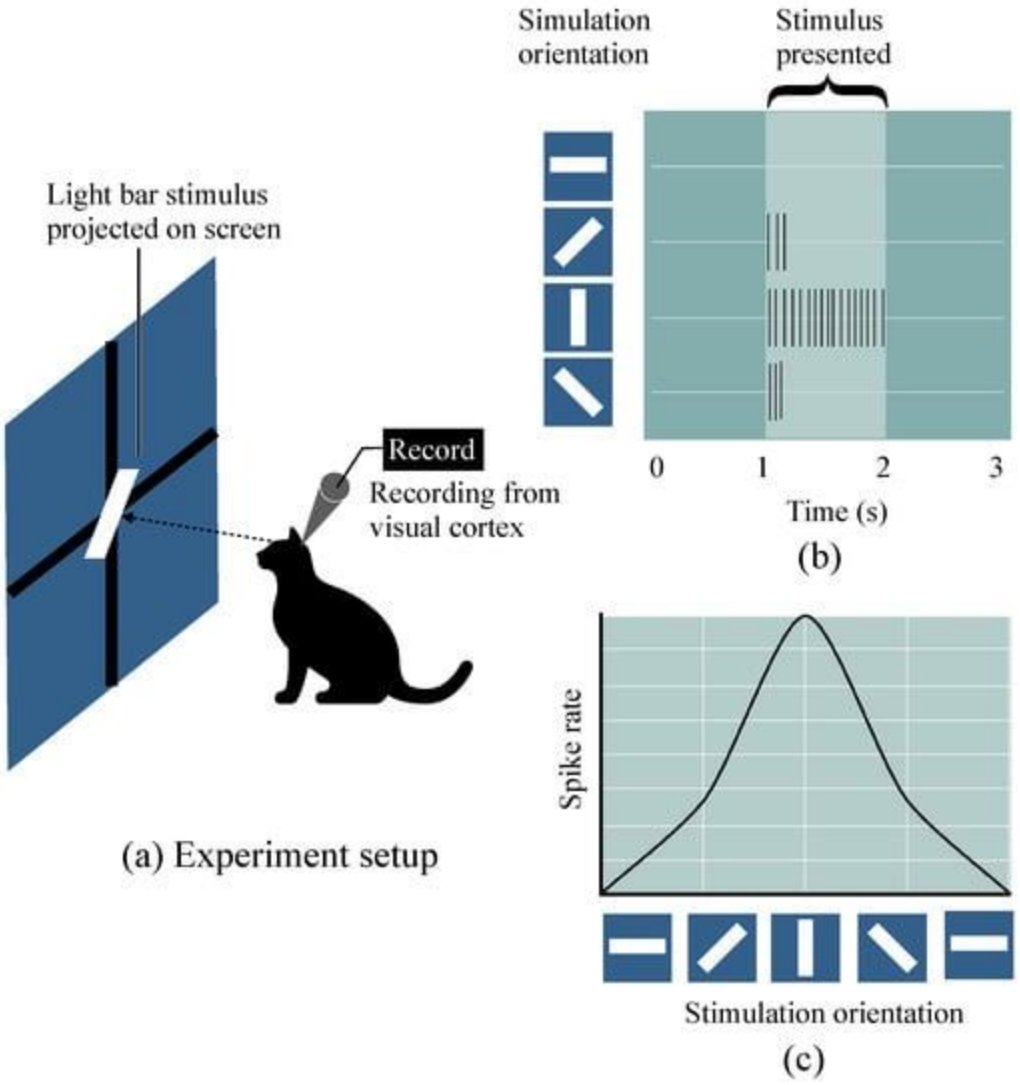
- In 1962, Hubel and Wiesel discovered neurons in the primary visual cortex respond to specific, simple visual features, like oriented edges.

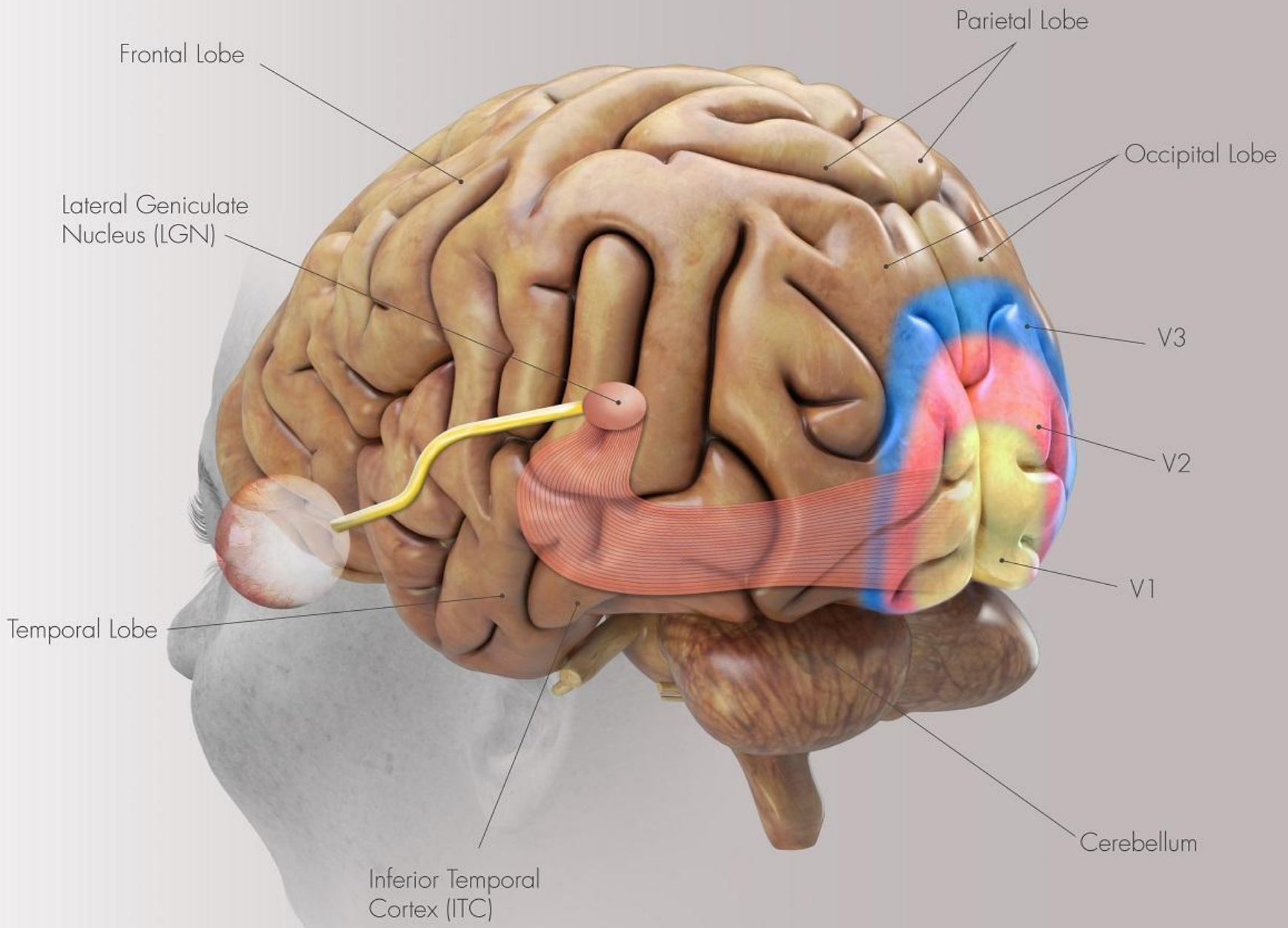
Hubel and Wiesel Cat Experiment

- They identified two types of cells:
  - **Simple cells**: Respond to specific orientations at precise locations.
  - **Complex cells**: Show spatial invariance by pooling inputs from multiple simple cells.

- This selectivity to particular features and increasing spatial invariance formed the basis for CNNs.

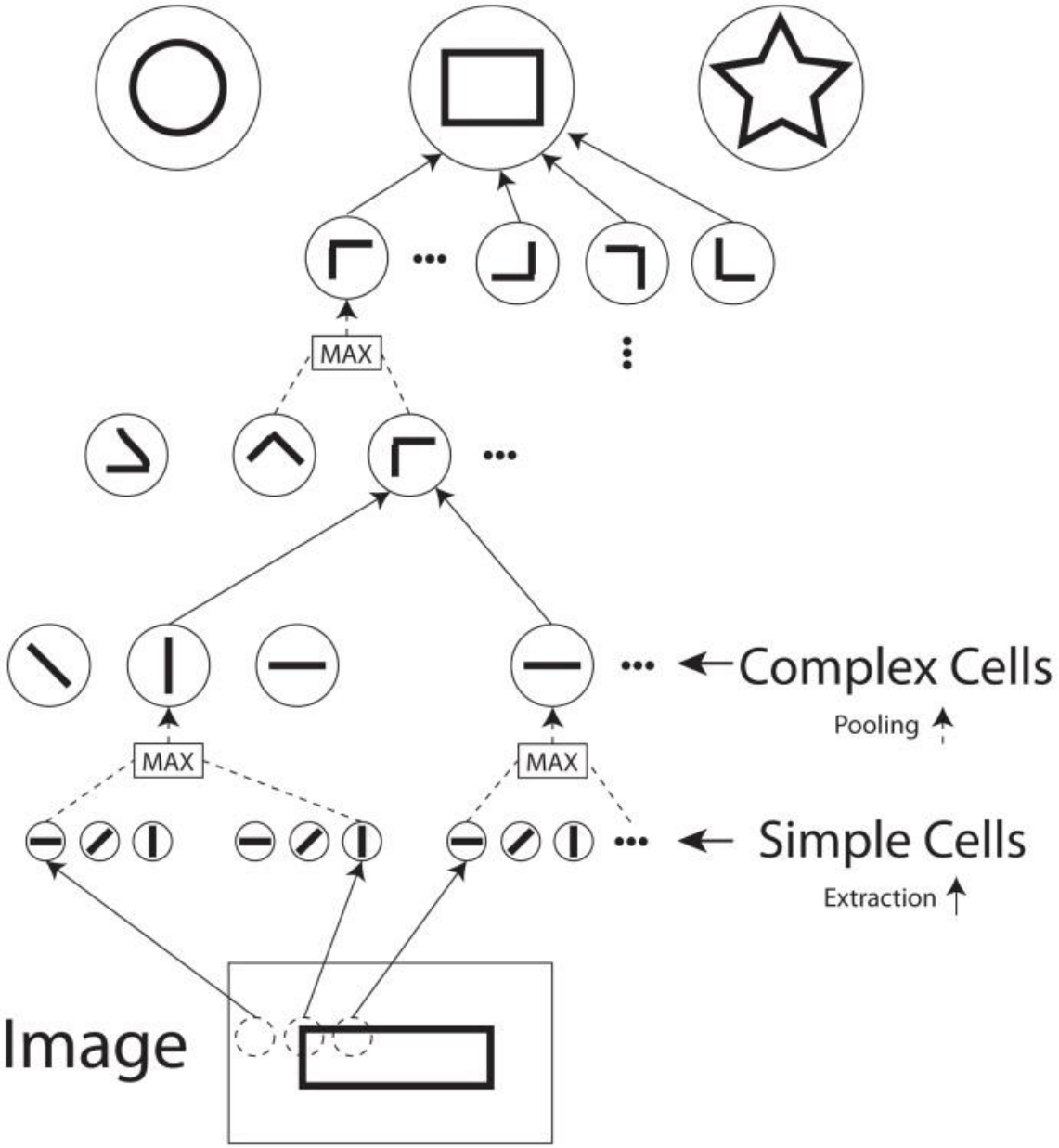
- CNNs use these principles to detect and process visual patterns effectively.


Light bar stimulus
projected on screen
Record
Recording from
visual cortex
(a) Experiment setup
Simulation
orientation
Stimulus
presented
0
1
2
3
Time (s)
(b)
Spike rate
Stimulation orientation
(c)



Human Visual System

Visual Cortex working



- Visual processing in the brain is hierarchical–one layer feeds into the next, computing progressively more complex features. This is the inspiration for the “layered” design of modern feed-forward neural networks

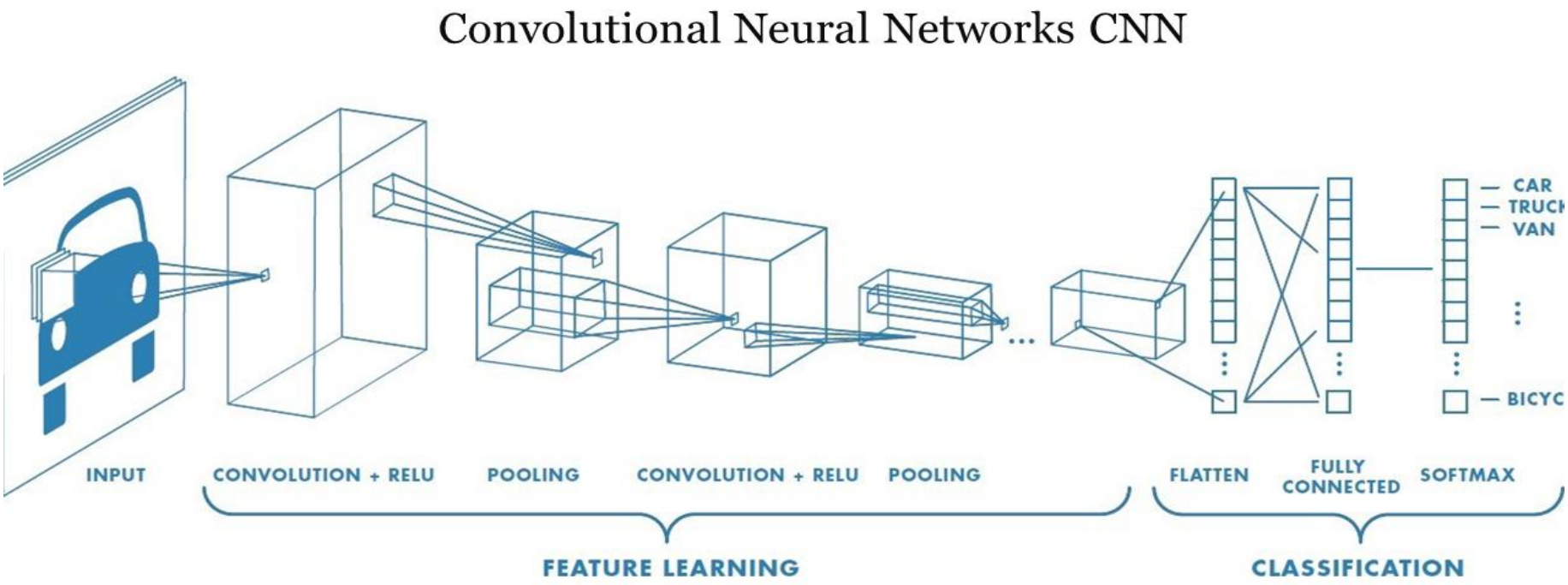
CNN Stepping Stones

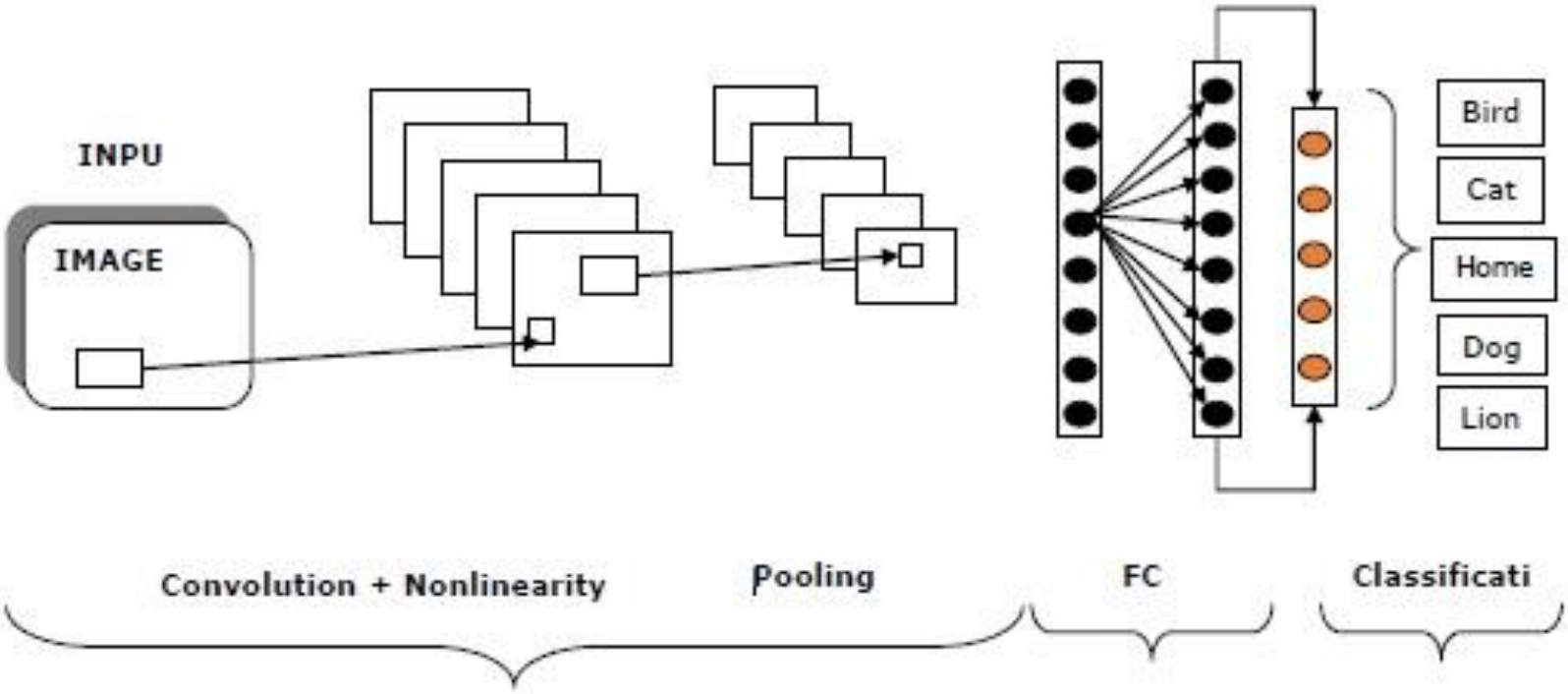
- **Early Research**: In 1980, Kunihiko Fukushima introduced the Neocognitron, an early artificial neural network model for pattern recognition, which laid the groundwork for CNNs.res in a hierarchical manner.

- **First Major Example**: In 1989, Yann LeCun et al. trained a small CNN using backpropagation for handwritten digit recognition, demonstrating the potential of CNNs.

- **AlexNet Breakthrough (2012)**: The breakthrough for CNNs came with AlexNet, designed by Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton, which won the ImageNet competition with a significantly lower error rate.

Architecture



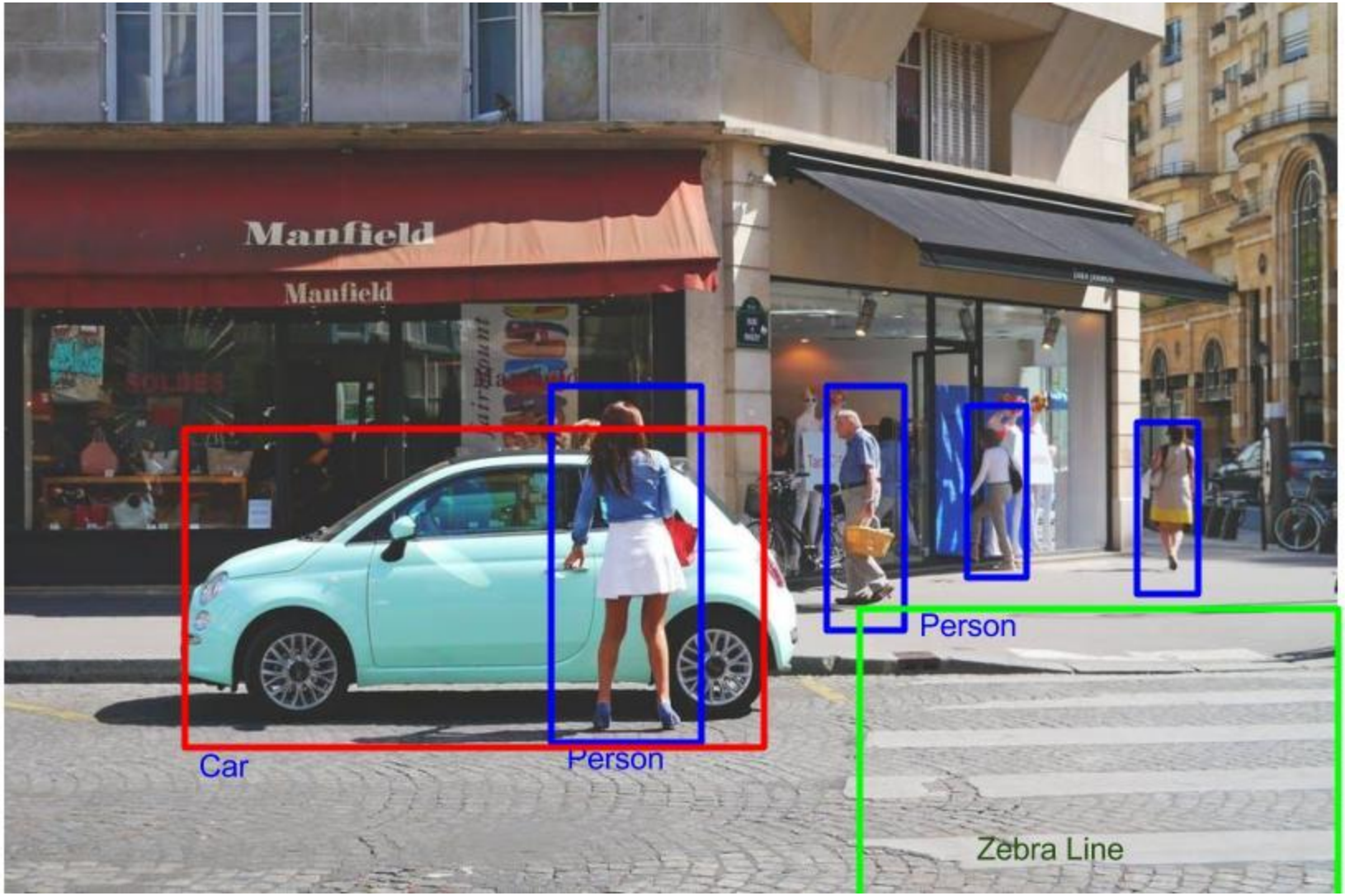


Architecture of CNNs

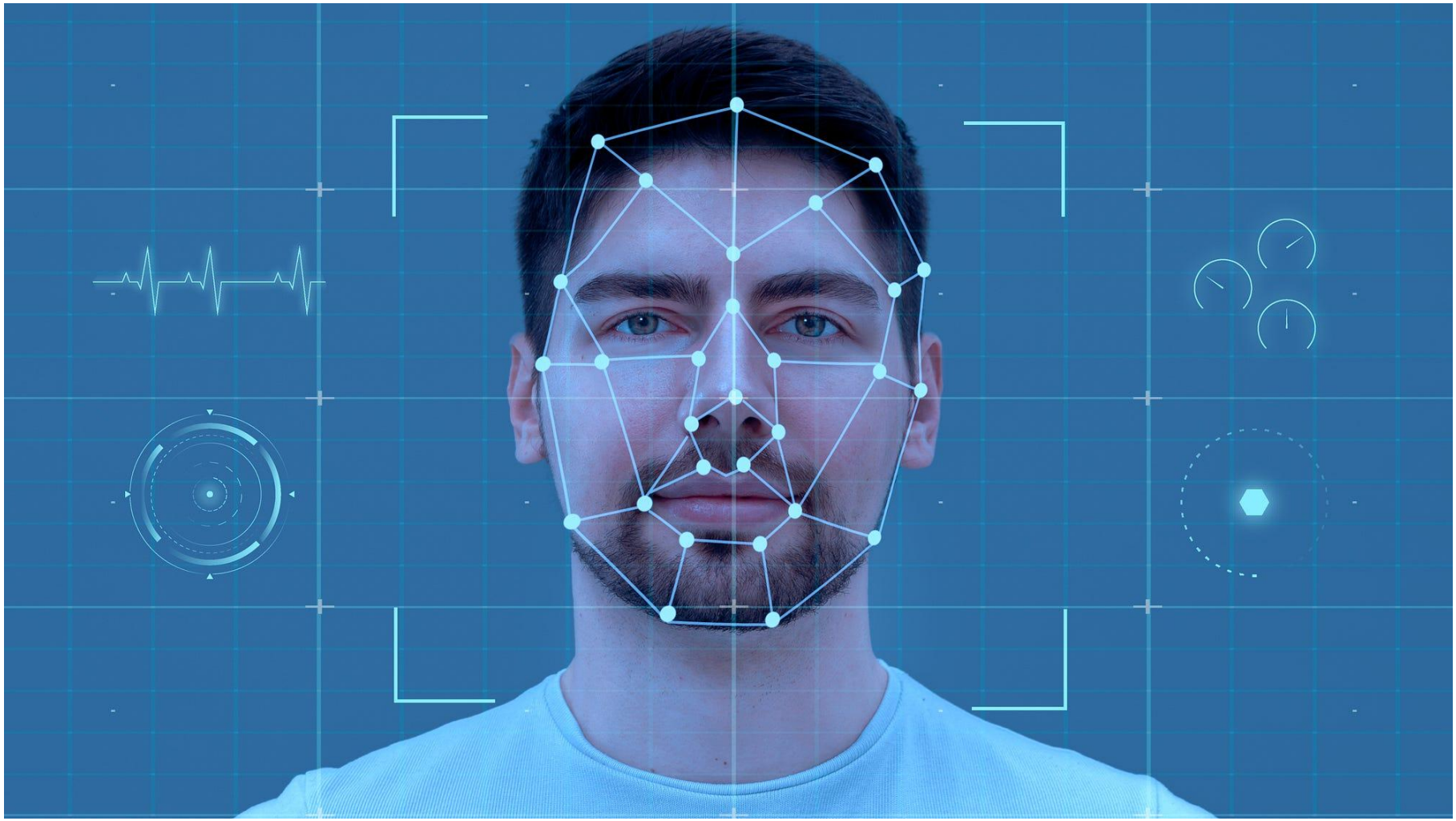
Example of Digit

CNN APPLICATIONS

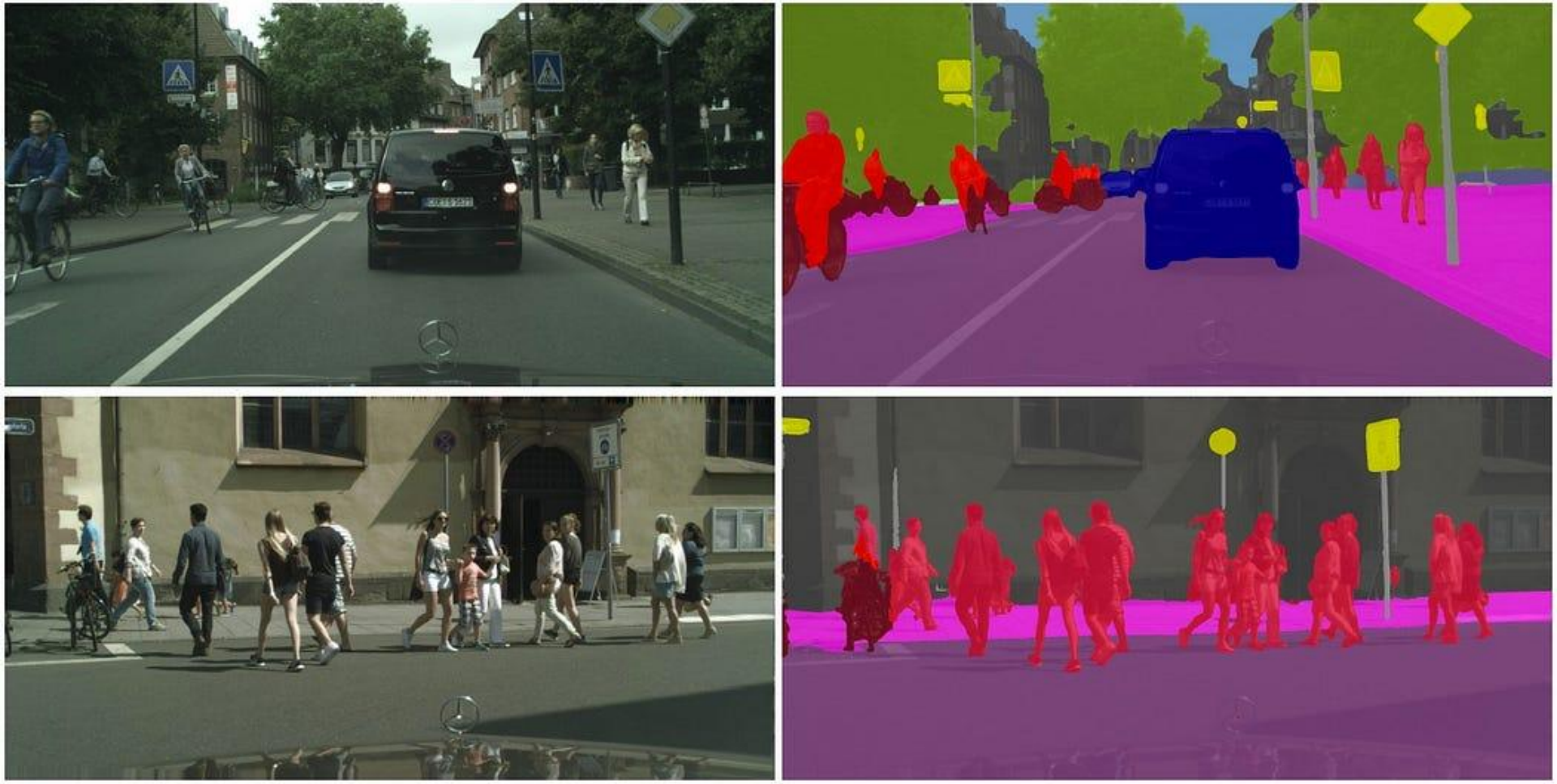
Object Detection



Face Recognition



Semantic Image Segmentation



Human Pose Estimation