

# Applied Machine Learning

## Convolutional Layers

# Convolutional Layers

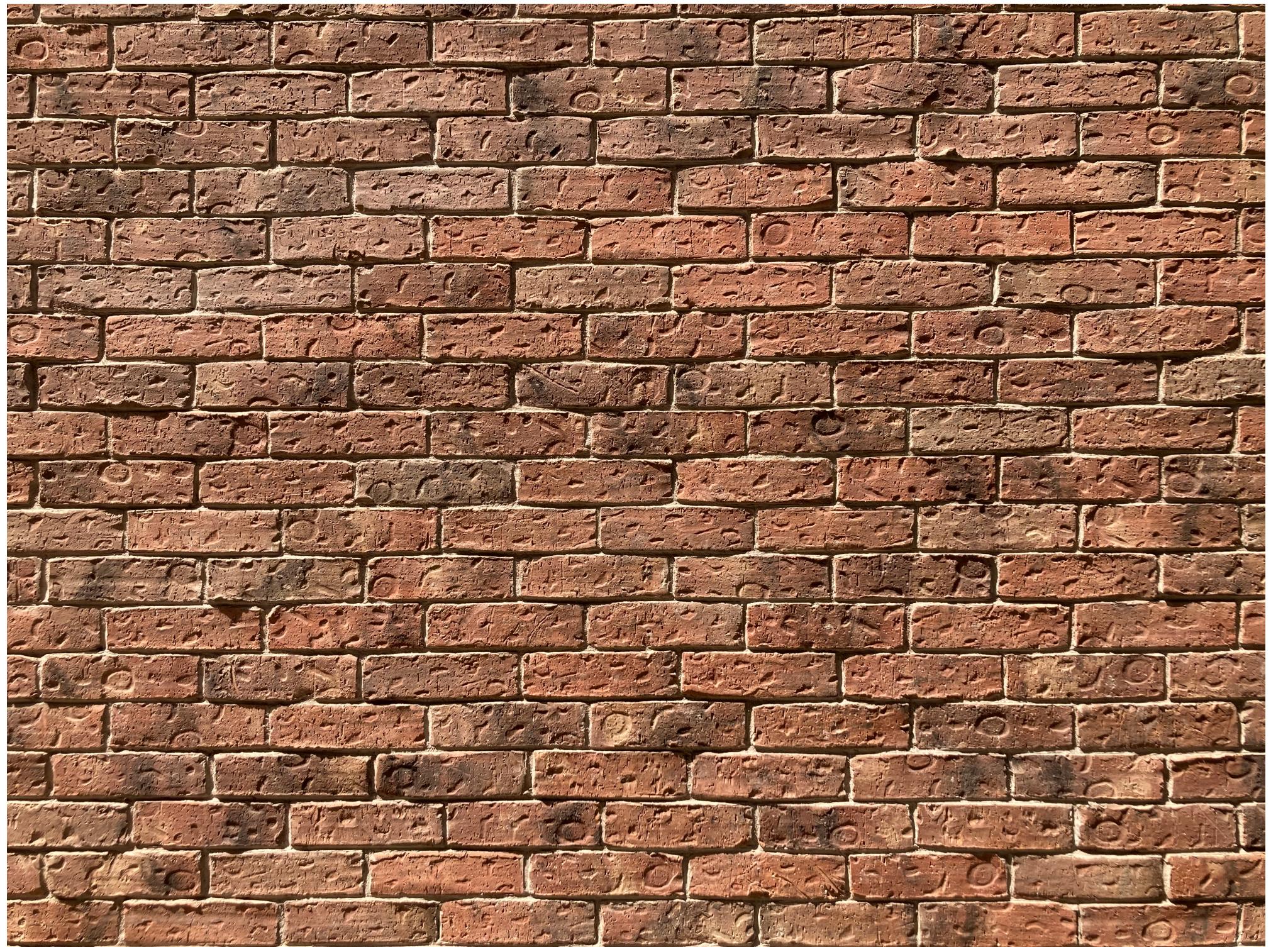
- Image classification
- Convolution operator
- Feature maps
- Convolutional layer

# Image Classification with Neural Networks

- Image Classification
  - Patterns in Images
  - Convolution operation to detect patterns
- Feature Maps
  - Convolutional layers for Neural Networks
  - Stacking convolutional layers

# Information in Images

- Images
  - places
  - people
  - animals
  - objects
- Classification of whole image
- Detection: classification of images within the image



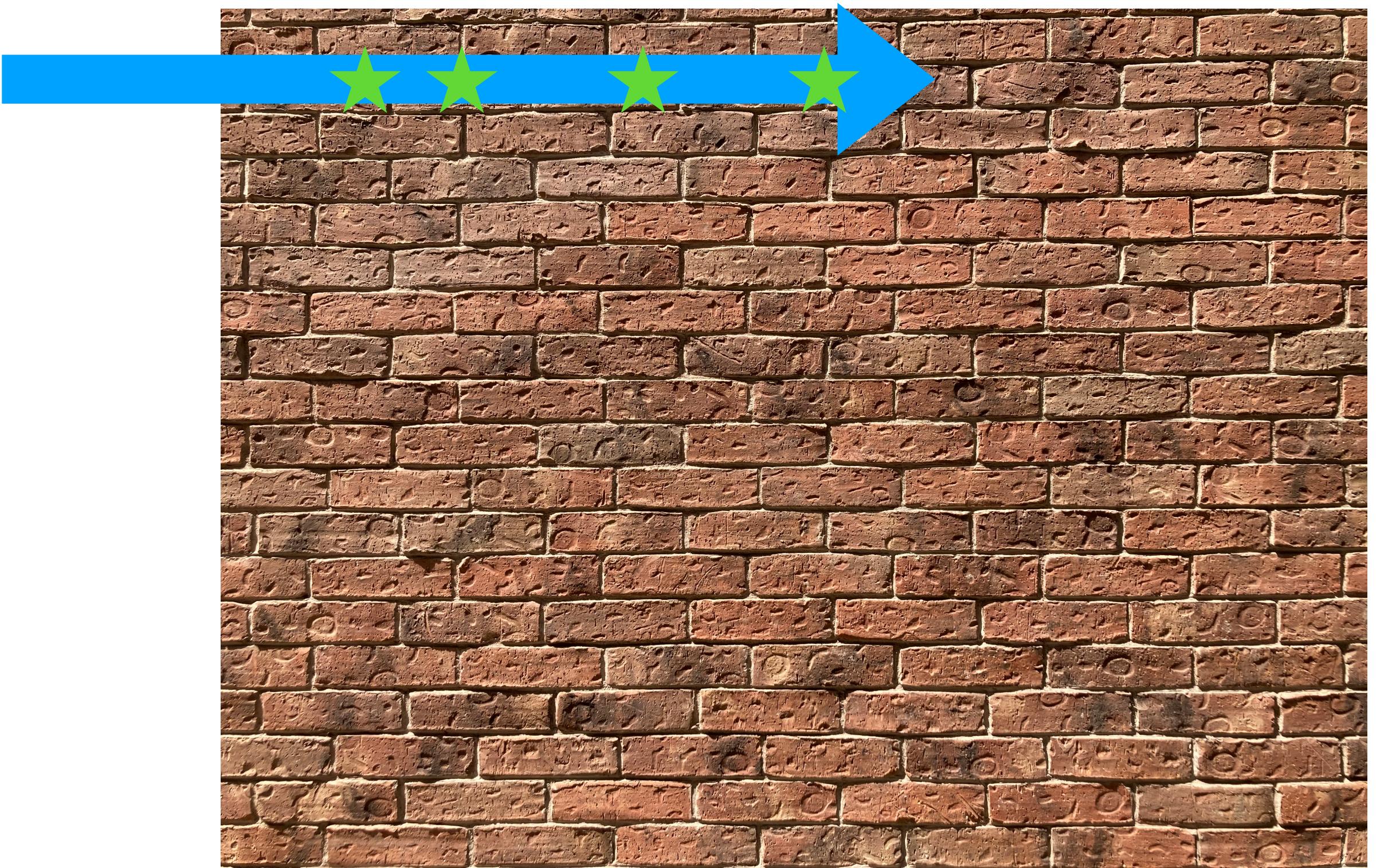
# Image Classification

- Small local patterns in objects
  - edges
  - corners
  - dominant colors
  - textures
- Composition of patterns
  - small figures or shapes
- More composition
  - larger objects



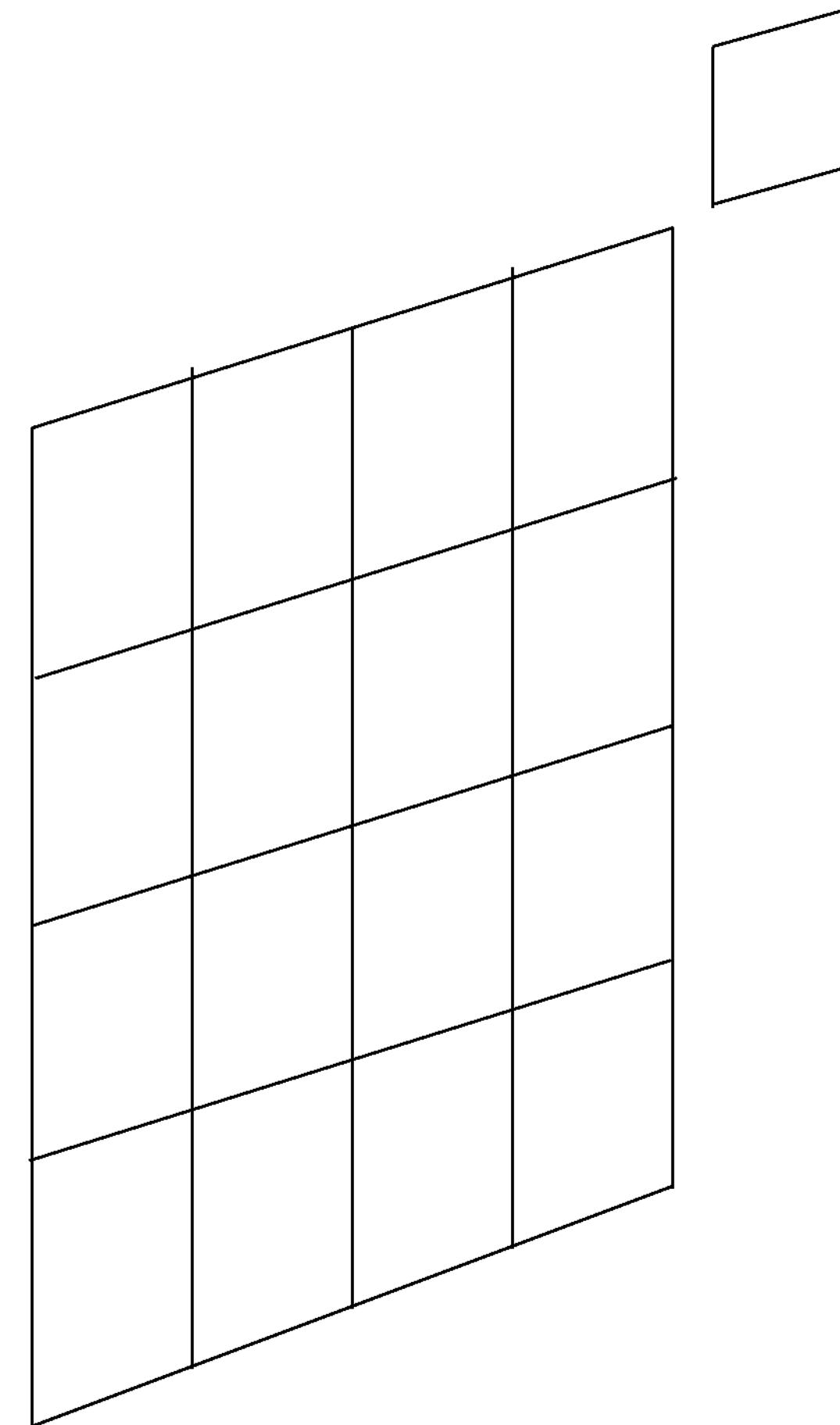
# Convolution Overview

- Convolution at a high-level
  - Form a small pattern image
  - Slide pattern over the image
  - When pattern matches image region
    - activation pixel at output
  - Output: image encoding activation information



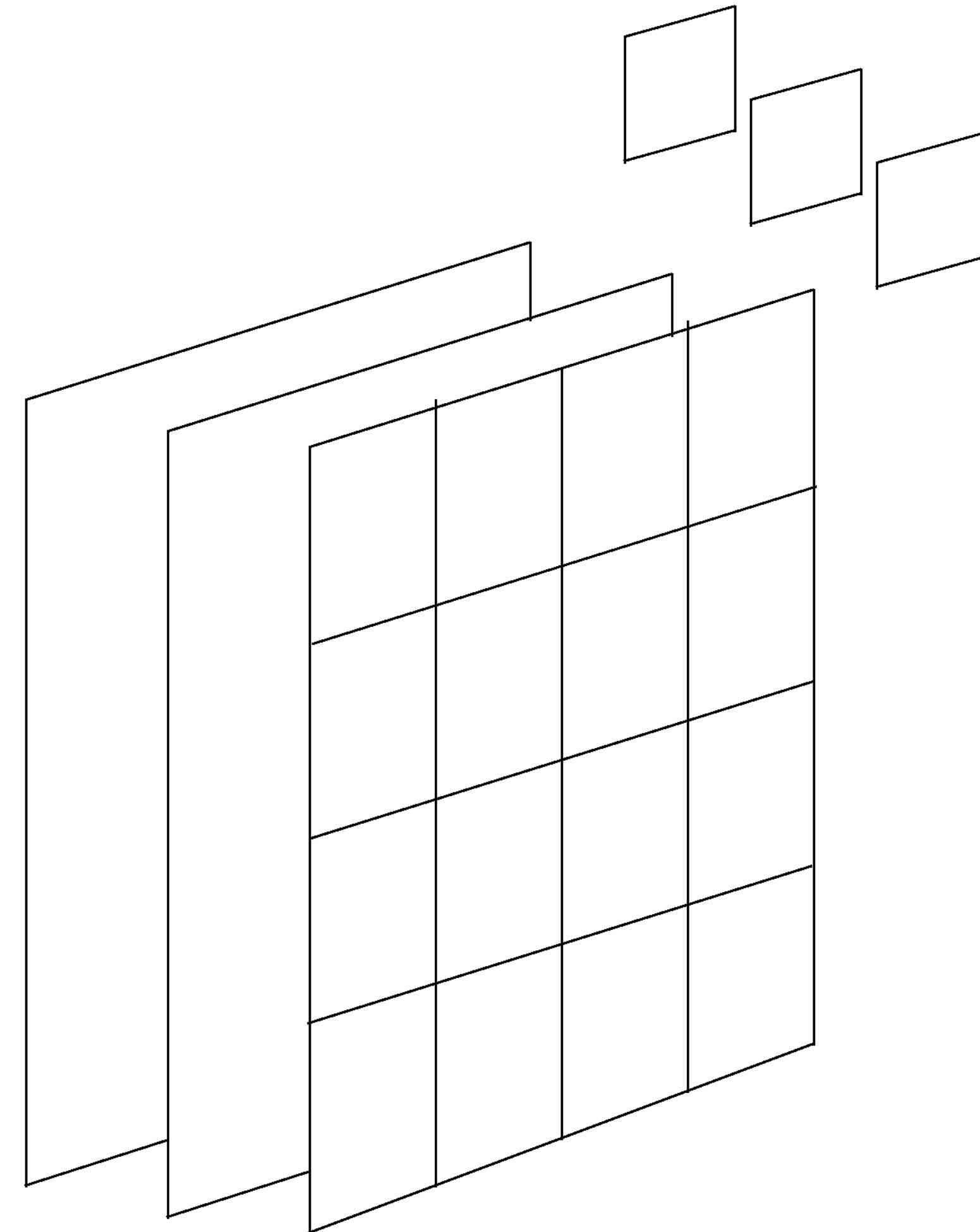
# Feature Maps

- The output of convolving an image and a pattern encodes matches of patterns around pixels
- Form a collection of different small patterns
  - Apply convolution with each pattern
- Feature Map
  - Stack convolutions
  - 1 slice per pattern



# Convolutional Layer

- Layer of units
  - inputs: image pixels
  - parameter weights: patterns
  - outputs: feature maps
- Stacks of convolutional layers
  - to learn patterns with higher structure from patterns learned at previous layers



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