第8讲 深度学习基础2
——特征可视化

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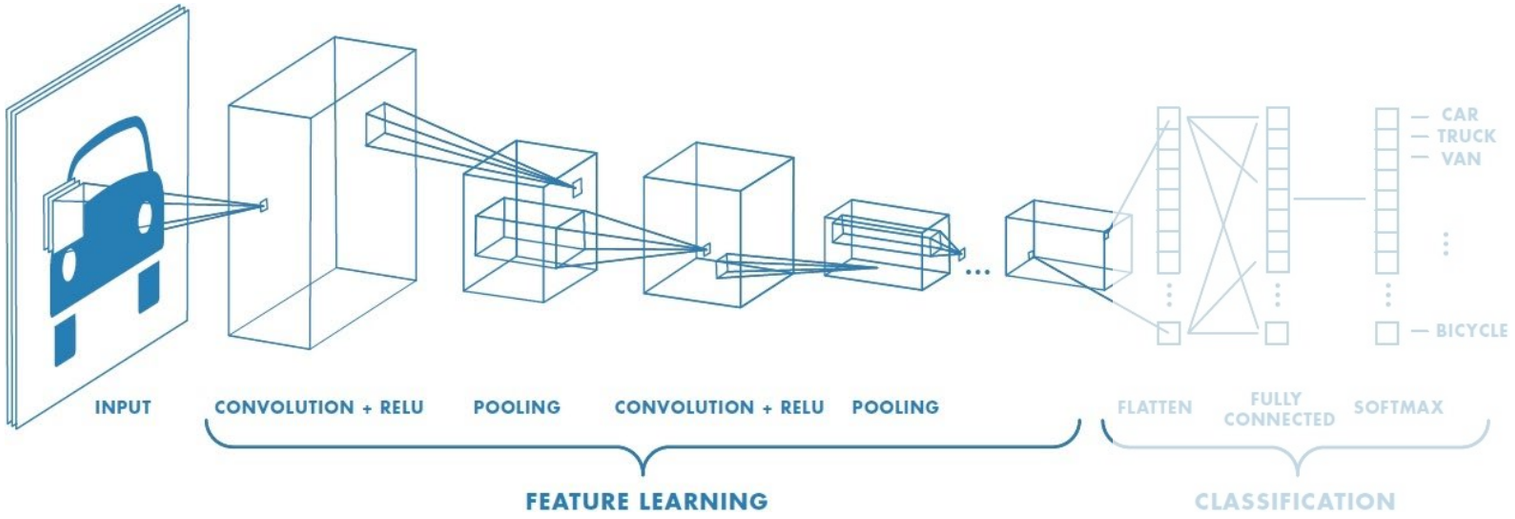
杭州电子科技大学

- 为什么要用卷积?
  Convolution，…
- **卷积神经网络**
  Architecture, Pooling, …
- 学什么?
  Feature extraction，…
- 怎么学?
  优化算法, 数据增强, 数据归一化, …
- 经典卷积神经网络
  AlexNet, VGG, ResNet, …

Convolutional Neural Network

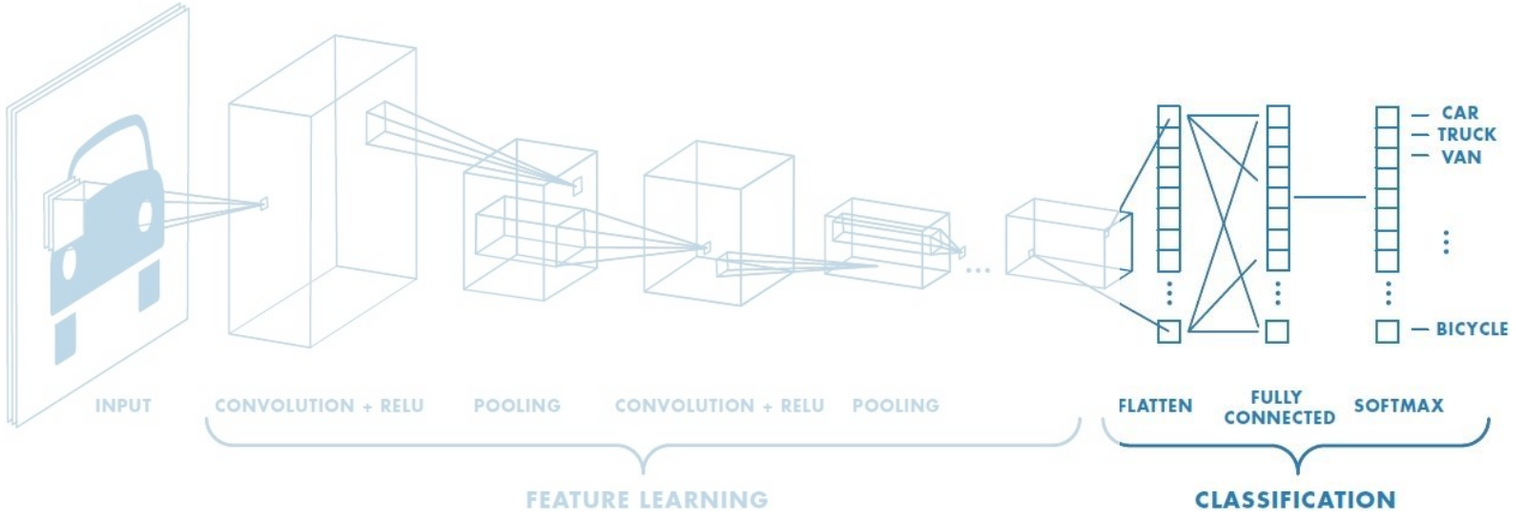
CNNs for Classification: Class Probabilities



1. Learn features in input image through **convolution**
2. Introduce **non-linearity** through activation function (real-world data is non-linear!)
3. Reduce dimensionality and preserve spatial invariance with **pooling**

Convolutional Neural Network

CNNs for Classification: Class Probabilities



CONV and POOL layers output high-level features of input

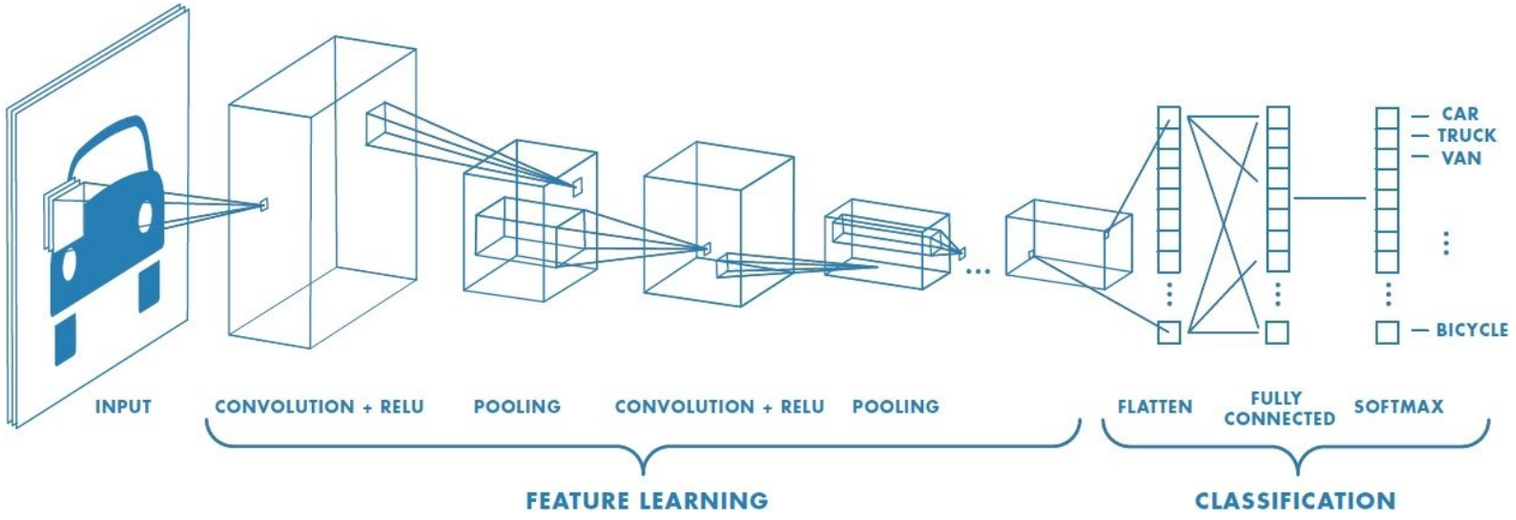
Fully connected layer uses these features for classifying input image

Express output as **probability** of image belonging to a particular class

$$\text{softmax}(y_i) = \frac{e^{y_i}}{\sum_j e^{y_j}}$$

Convolutional Neural Network

CNNs for Classification: Class Probabilities

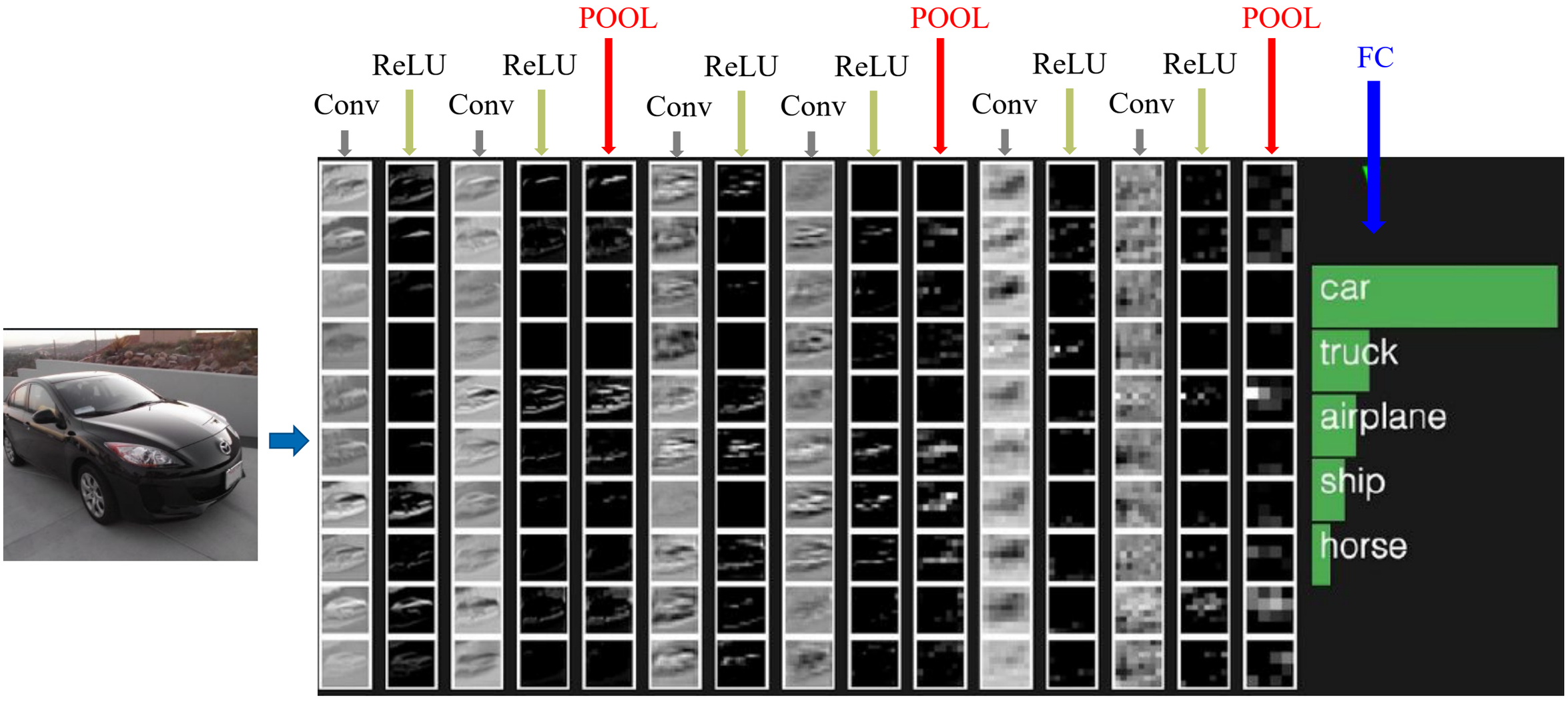


Learn weights for convolutional filters and fully connected layers

Backpropagation: cross-entropy loss

Hebbian learning rule $J(\boldsymbol{\theta}) = \sum_i y^{(i)} \log\left(\hat{\boldsymbol{y}}^{(i)}\right)$

Convolutional Neural Network

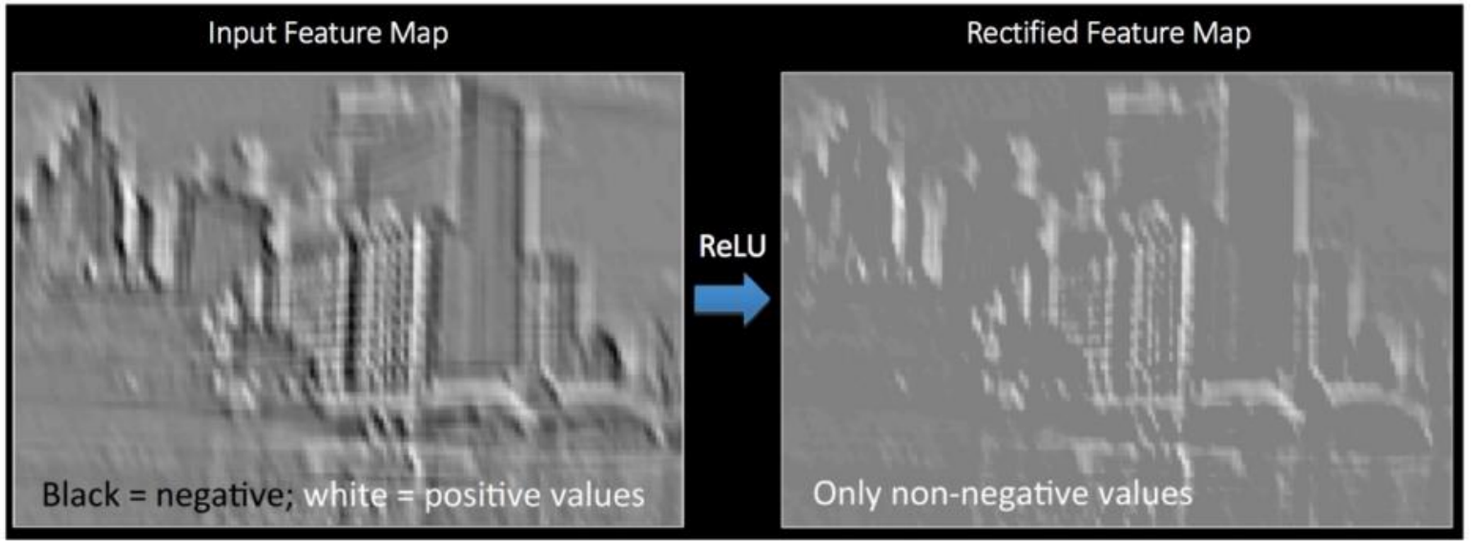


Convolutional Neural Network

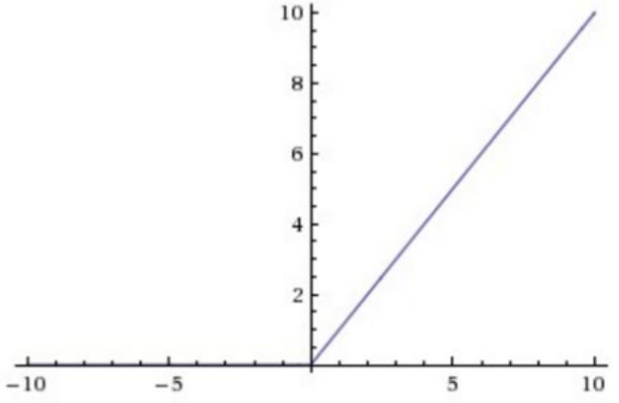
Introducing Non-Linearity

Apply after every convolution operation (i.e., after convolutional layers)

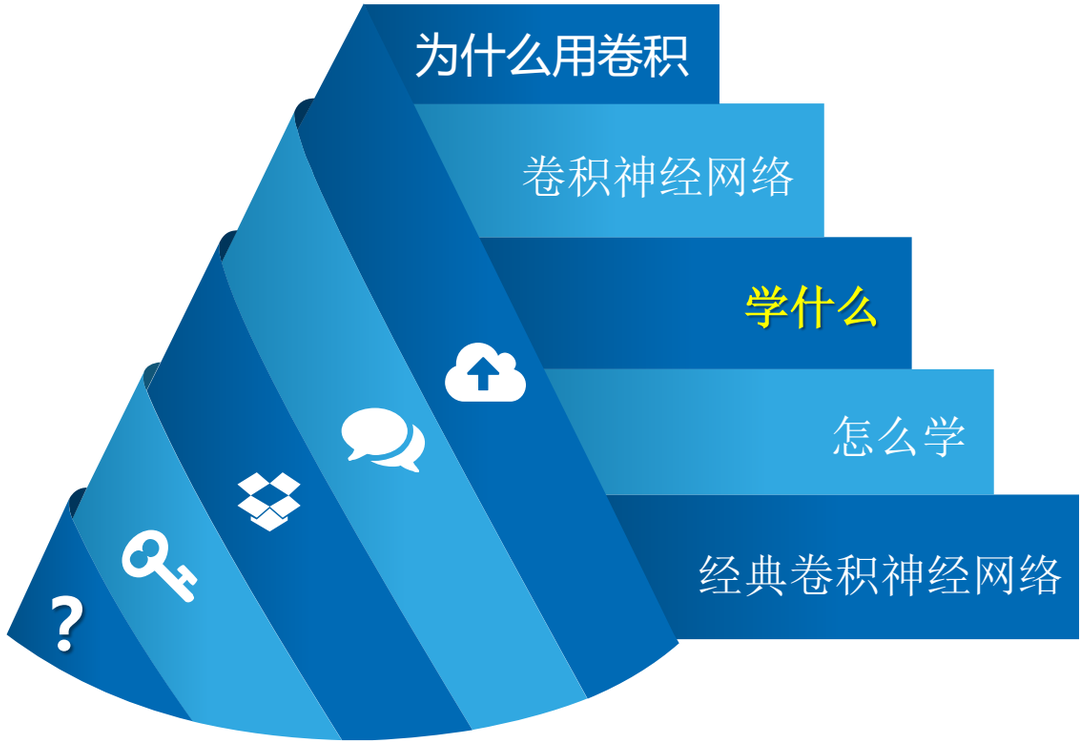
ReLU: pixel-by-pixel operation that replaces all negative values by zero. **Non-linear operation**



Rectified Linear Unit (ReLU)



$g(z) = \max(0, z)$



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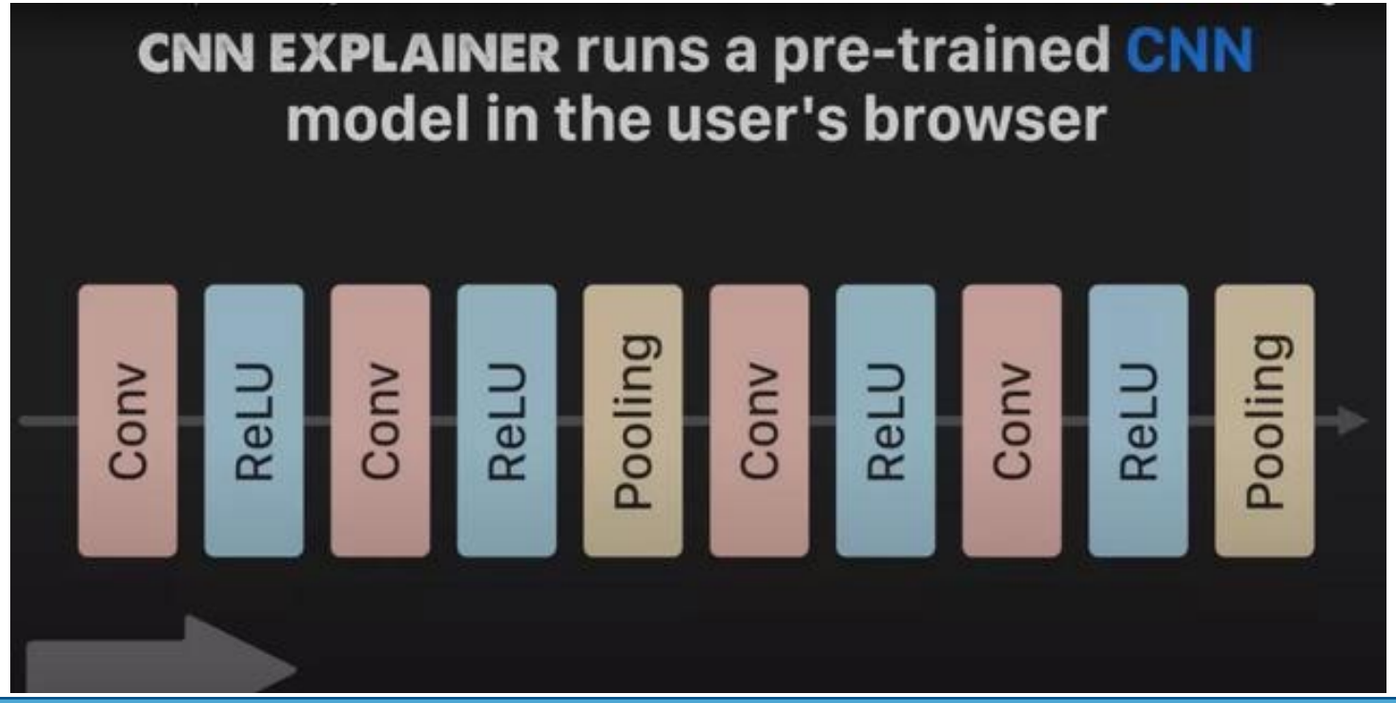
Learning Convolutional Neural Networks with Interactive Visualization.

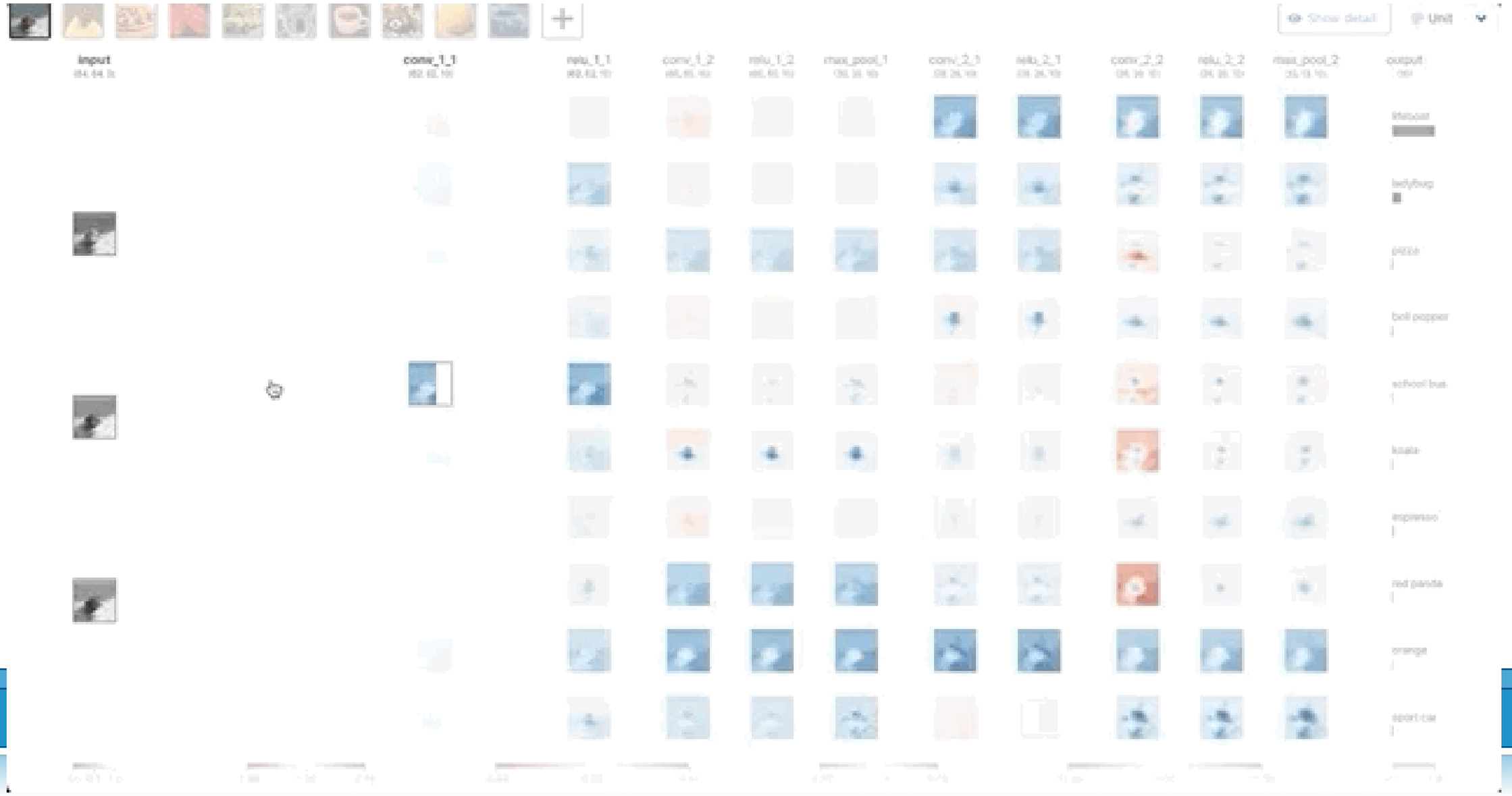
项目地址：https://github.com/poloclub/cnn-explainer
网页地址：https://poloclub.github.io/cnn-explainer/
arXiv 地址：https://arxiv.org/abs/2004.15004

Wang, Zijie J., Robert Turko, Omar Shaikh, Haekyu Park, Nilaksh Das, Fred Hohman, Minsuk Kahng, and Duen Horng Chau. arXiv preprint 2020. arXiv:2004.15004.

卷积神经网络交互式可视化工具——CNN 解释器（CNN Explainer）
这个解释器展示了一个 10 层的神经网络，包含卷积层、激活函数、池化层等。



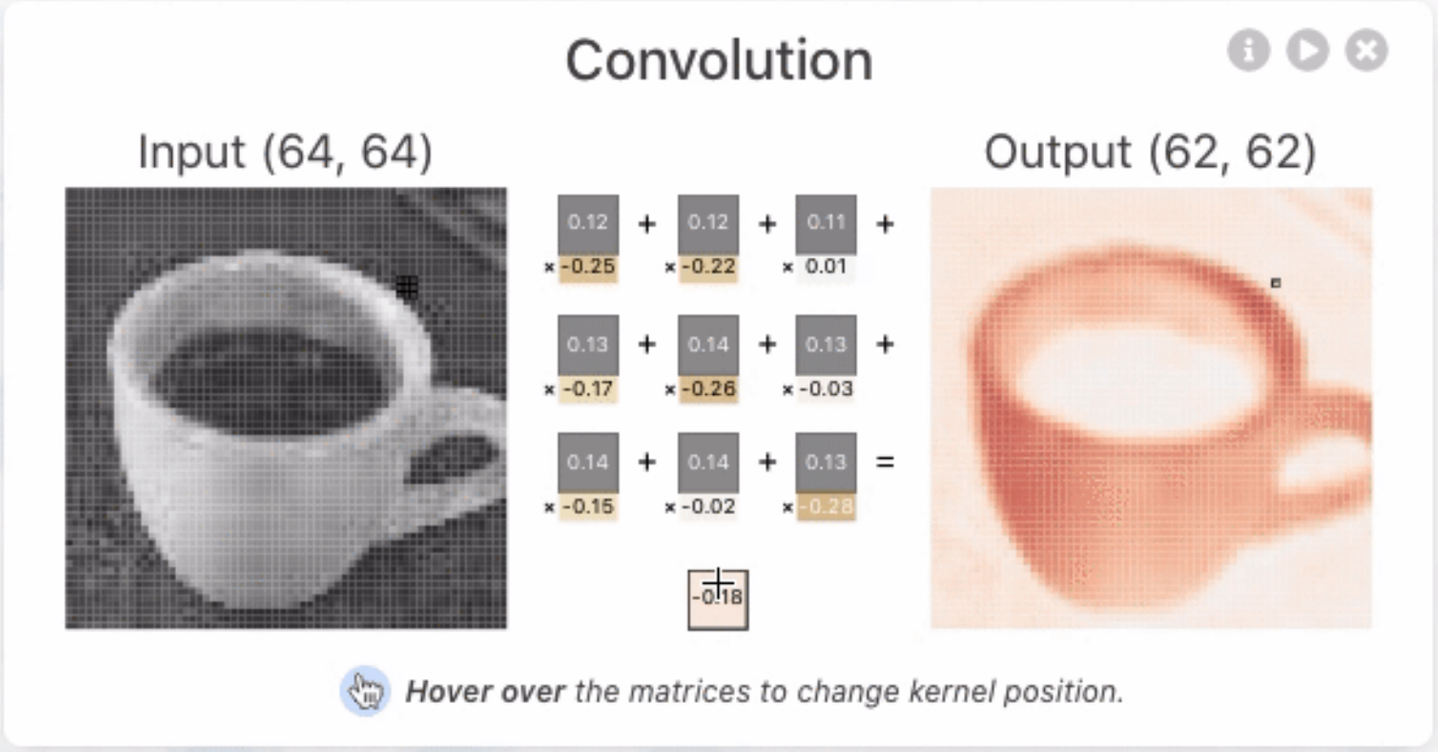
CNN Explainer 使用 TensorFlow.js 加载预训练模型进行可视化效果，交互方面则使用 Svelte 作为框架并使用 D3.js 进行可视化。

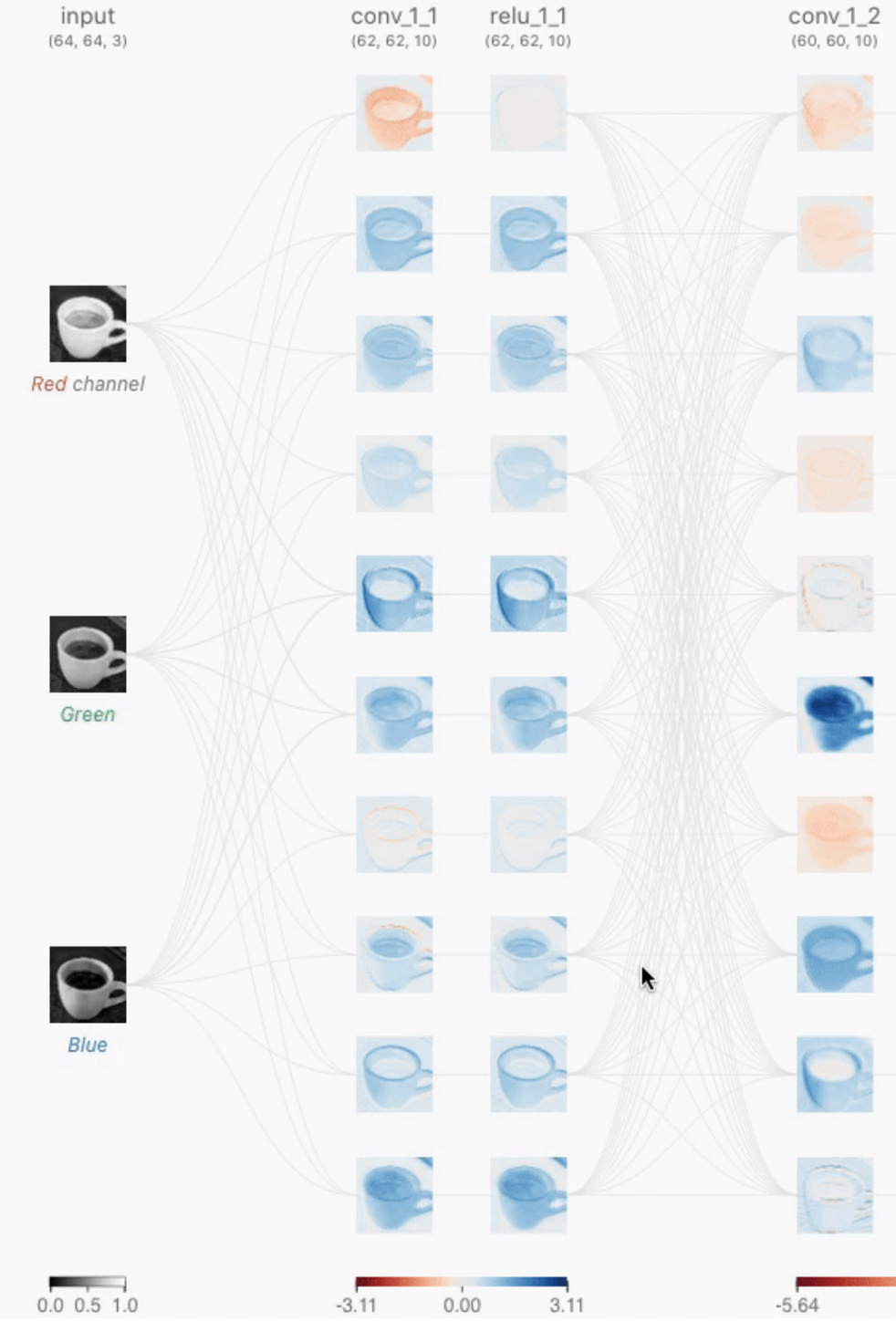


卷积层可视化

以交互图中的 Tiny VGG 架构为例。它的第一个卷积层有 10 个神经元，其前一层有 3 个神经元。

如果将鼠标悬停在第一个卷积层的某个激活图上，就可看到此处应用了 3 个卷积核来得到此激活图。点击此激活图，可以看到每个卷积核都进行了卷积运算。

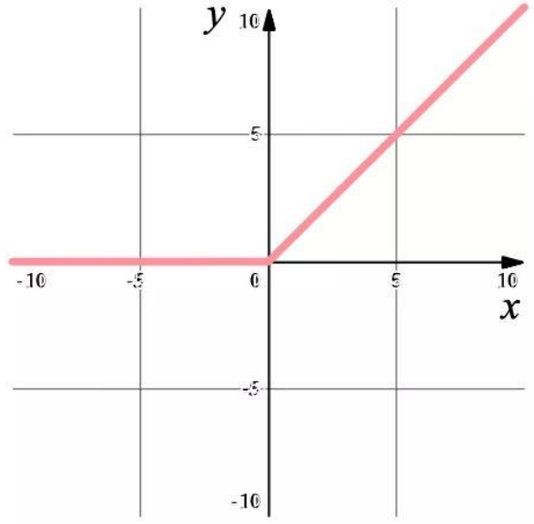


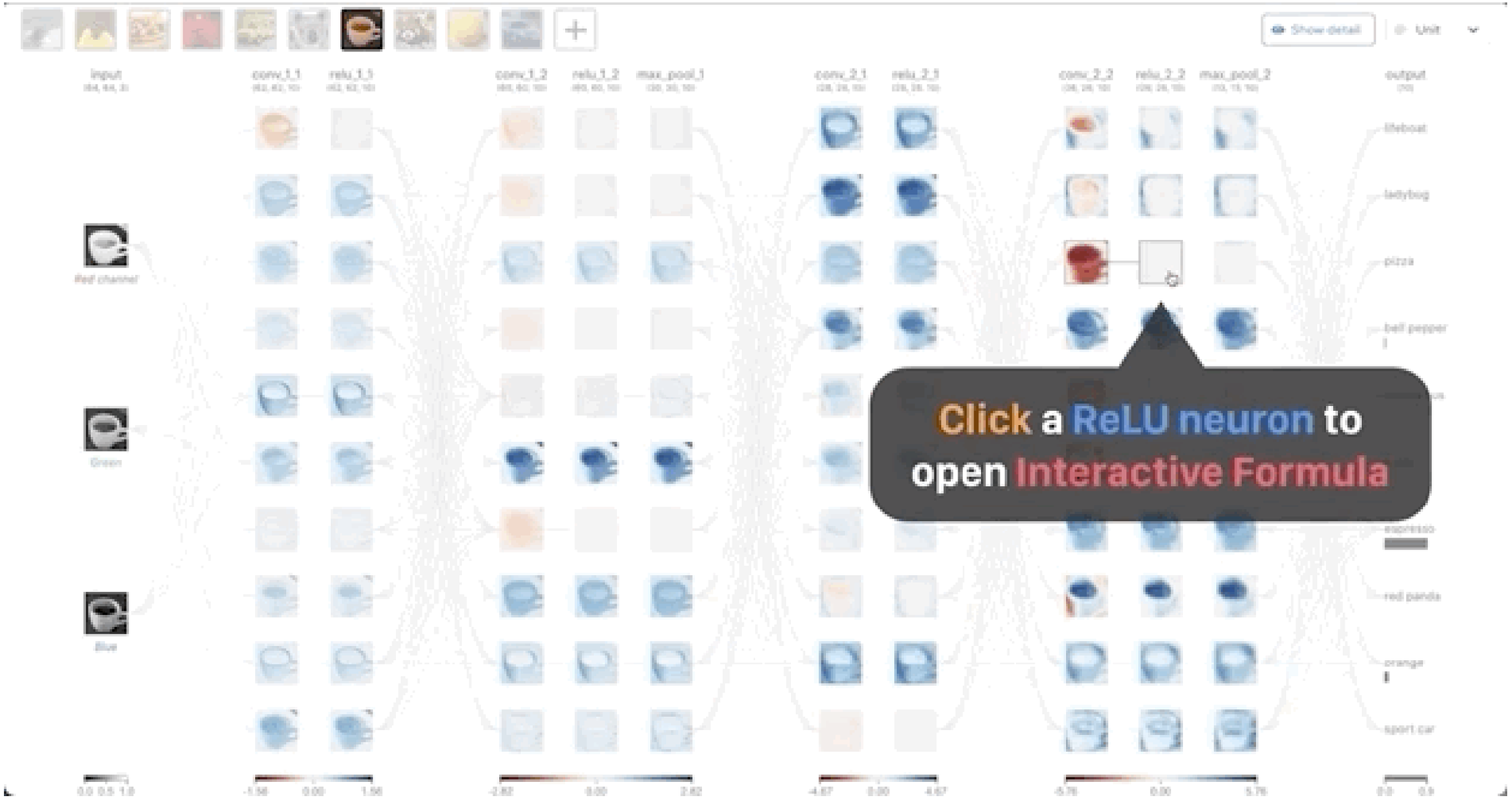


激活函数ReLU可视化

点击交互图中的 ReLU 神经元就能观察到这个激活函数是如何工作的。

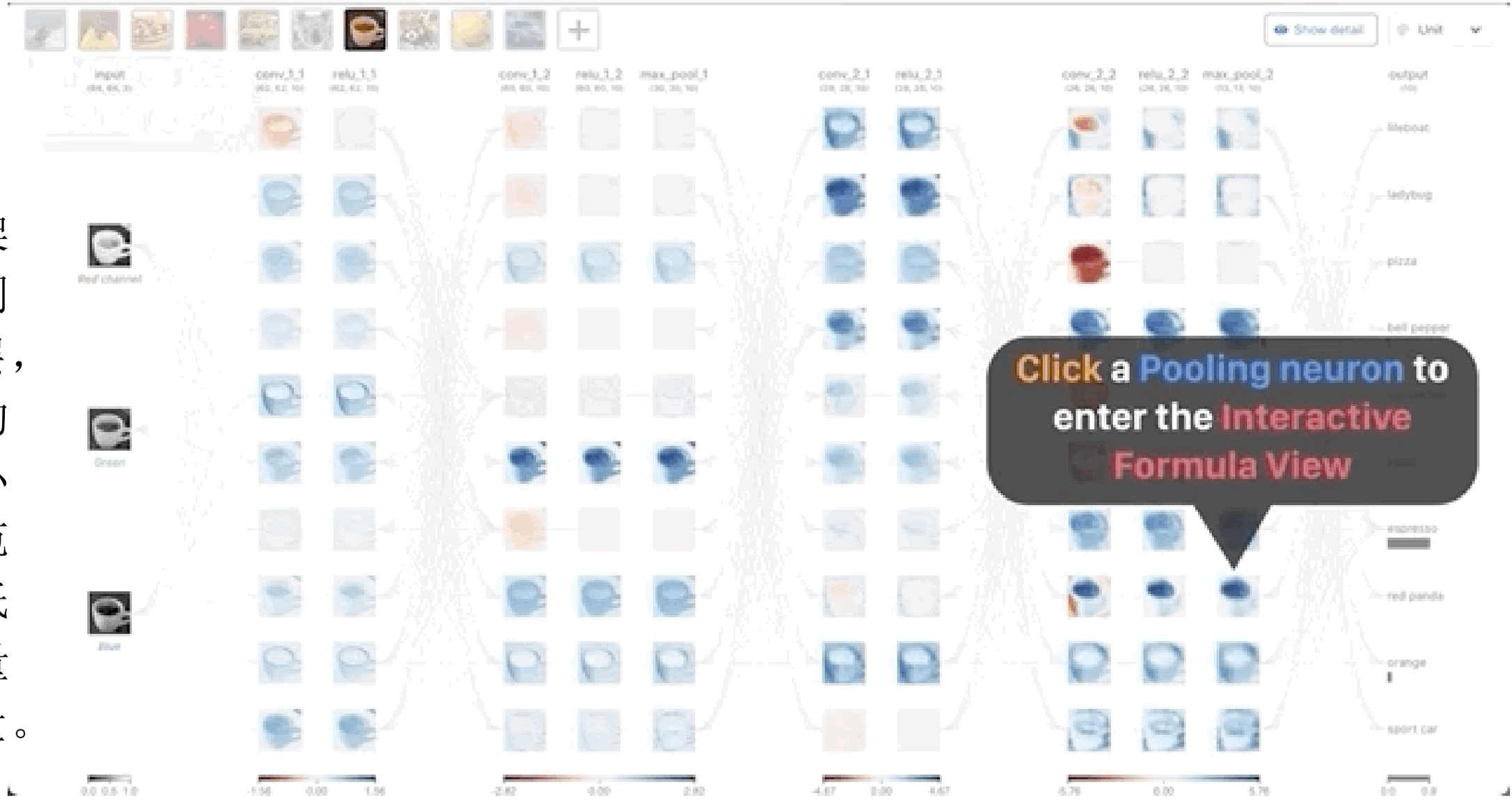
$$\mathrm{ReLU}(x) = \max(0, x)$$





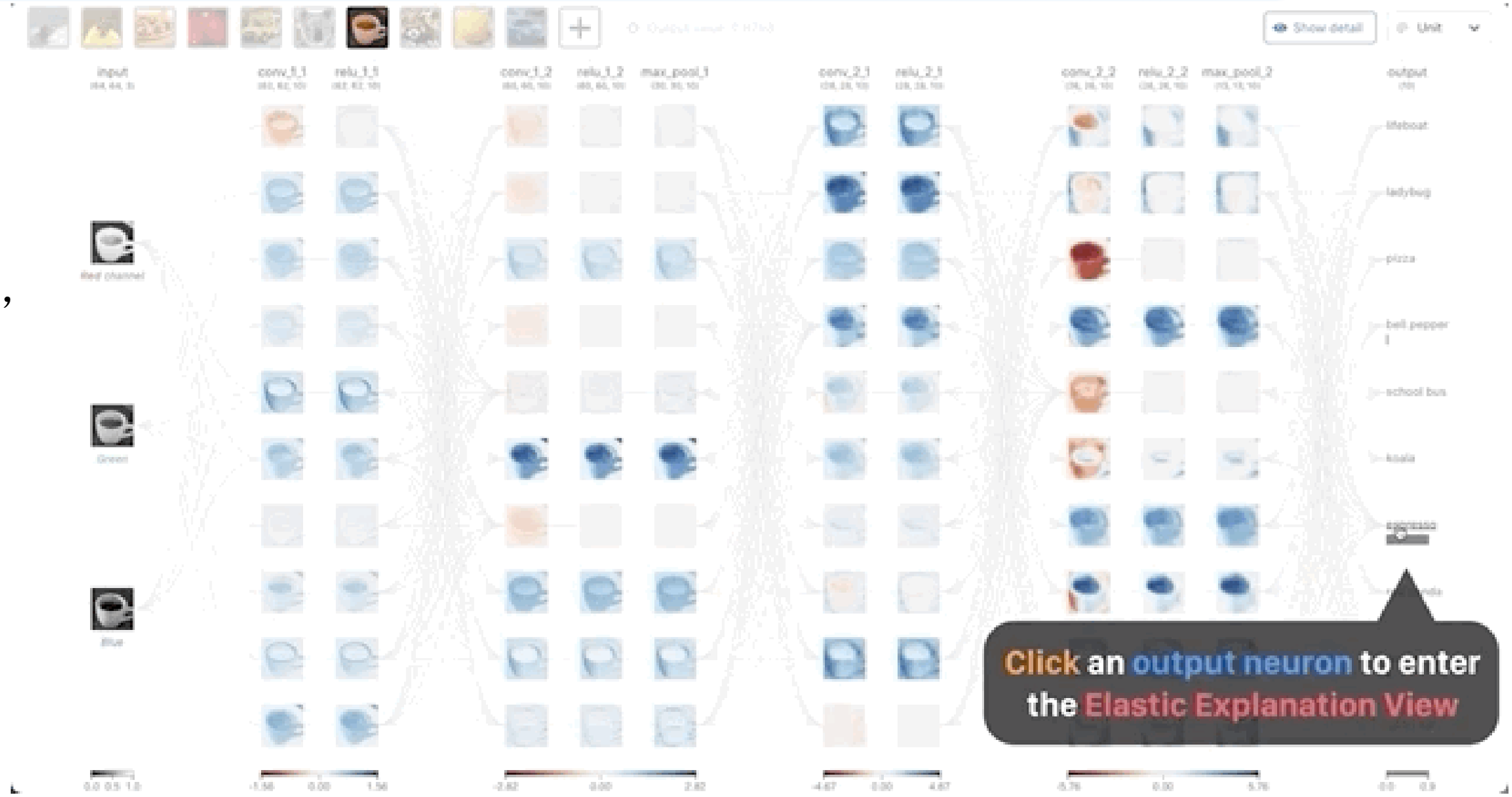
Maxpooling可视化

不同的 CNN 架构有很多不同类型的池化层，但它们的目的都是逐渐缩小网络的空间范围，从而降低网络的参数量和整体计算量。



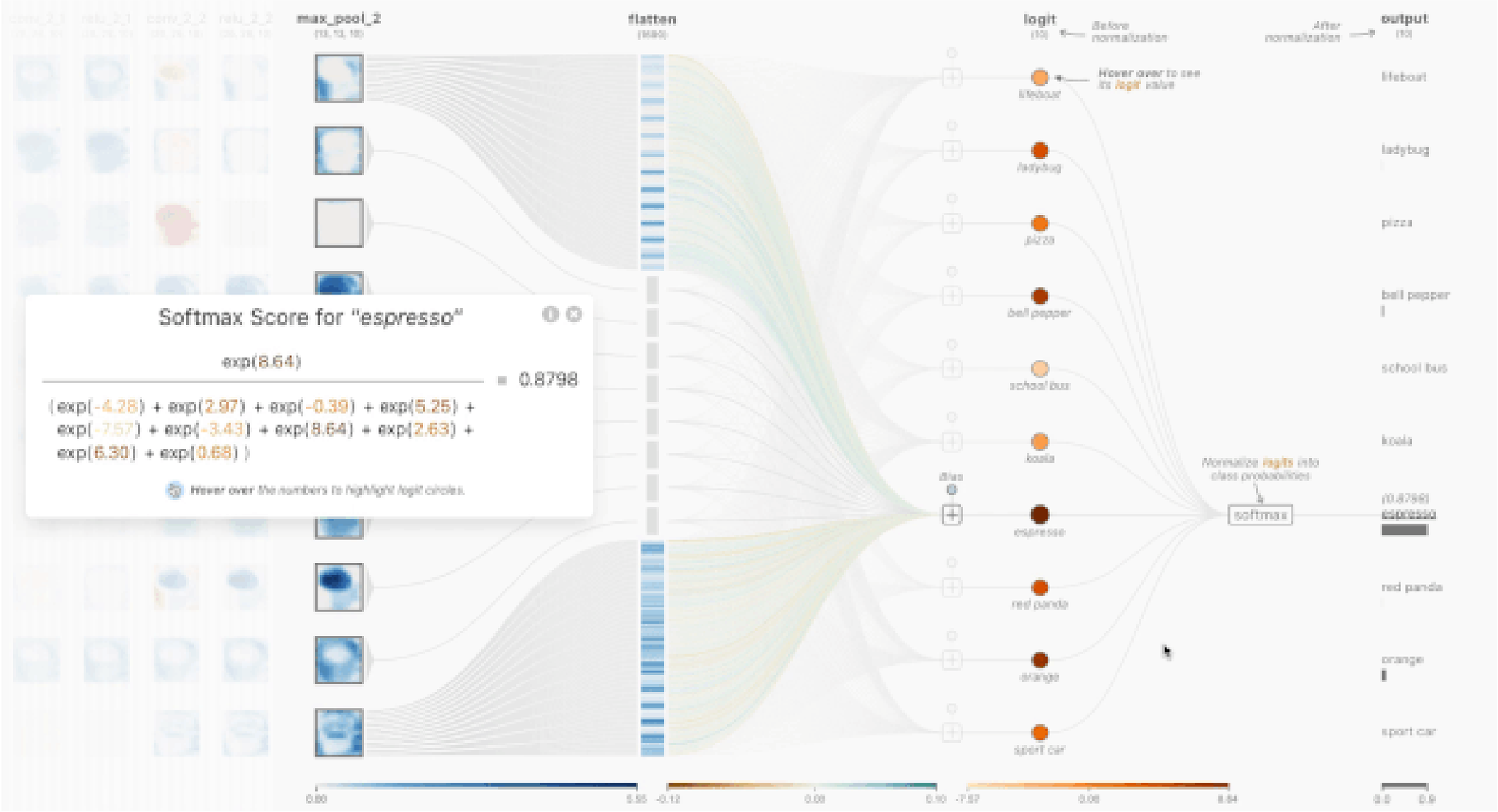
Flatten 层可视化

将三维层转为一维向量，并输入到全连接层用于分类。（此处不包括 batch 维）。



Softmax可视化

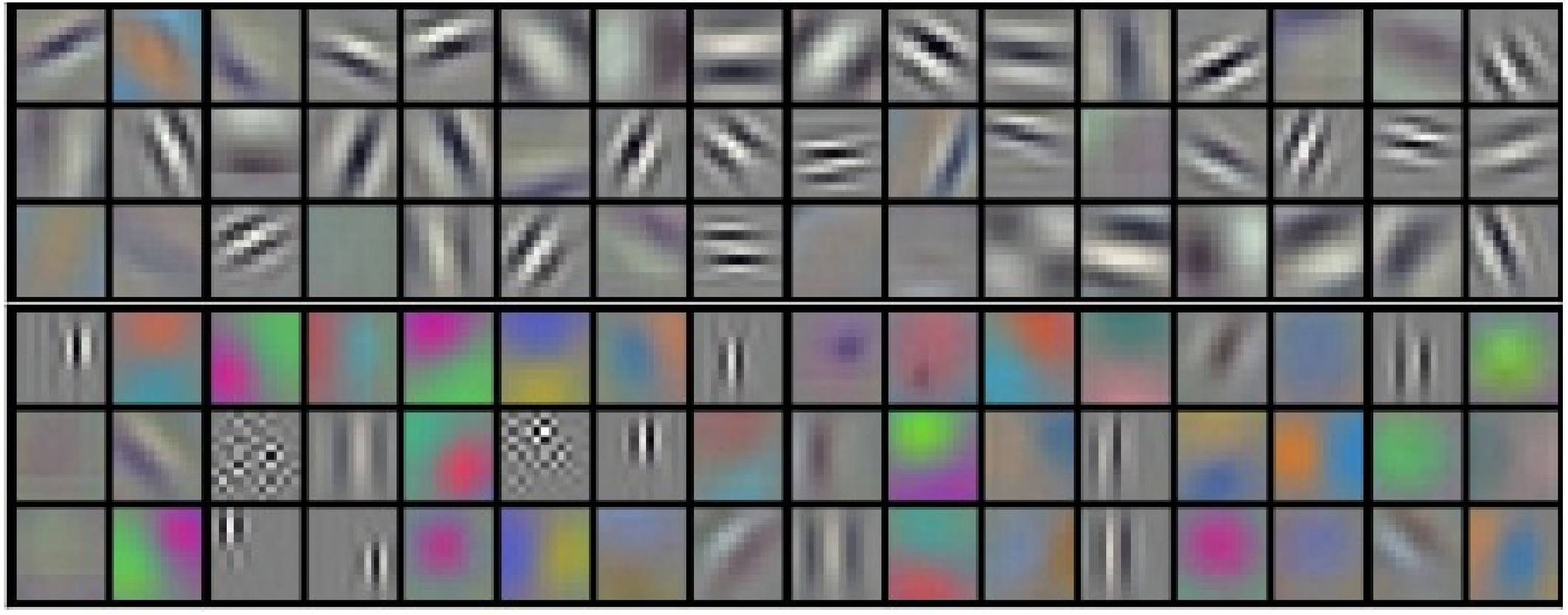
在卷积神经网络中，Softmax函数通常用于分类模型输出。在CNN解释器里，点击最后一层，即可显示网络中的Softmax运算过程。



What to learn?

Feature Extraction with Convolution

AlexNet中的滤波器（96 filters [11x11x3]）



What to learn?

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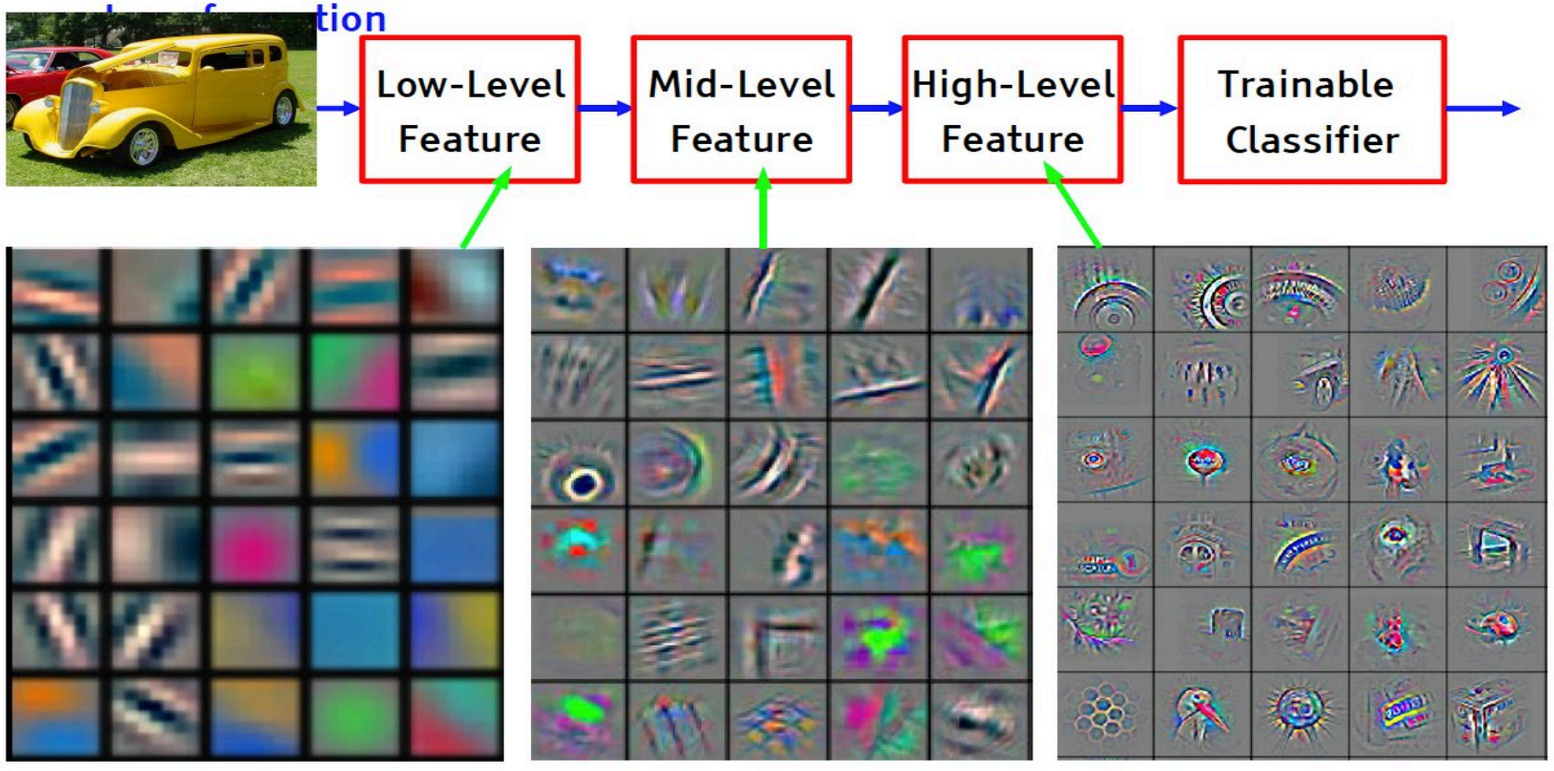


Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

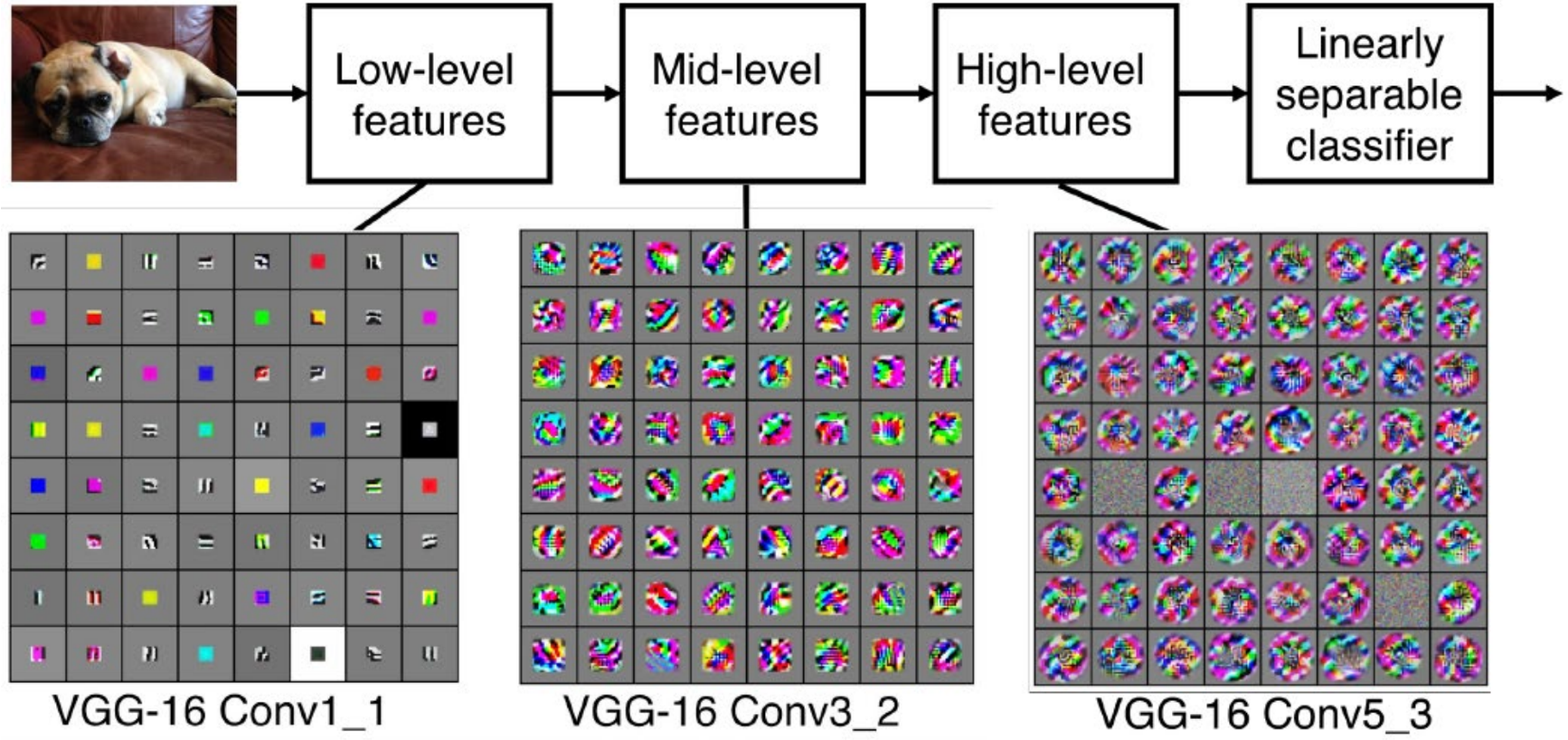
Deep Learning = Learning Feature

Hierarchical Representations

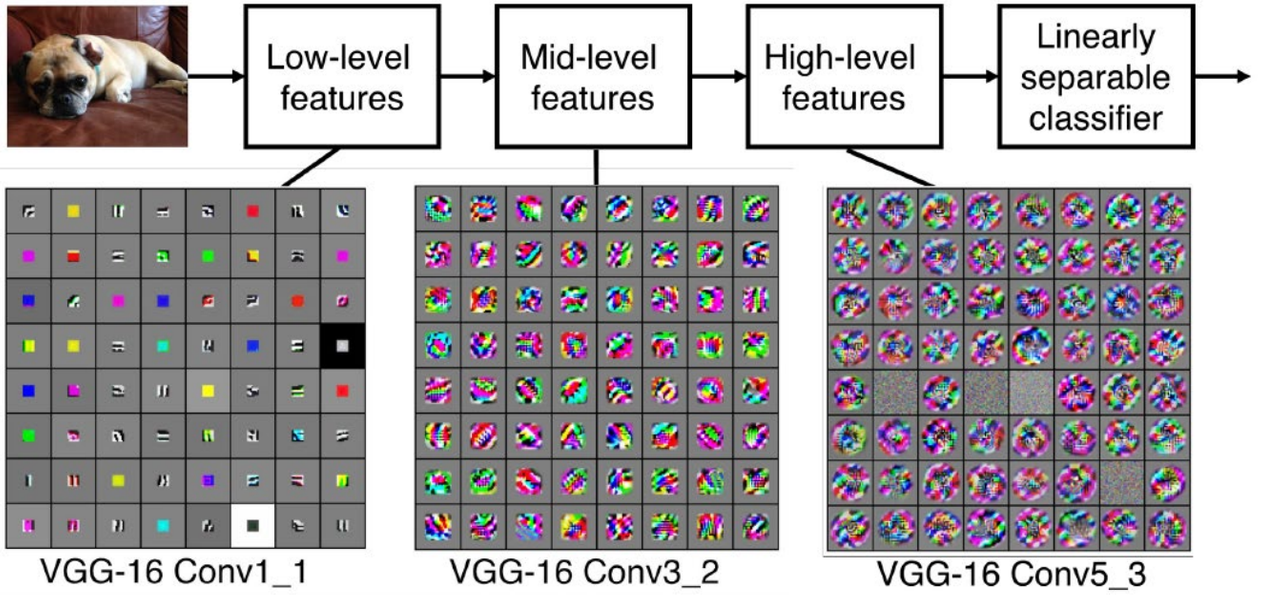
What to learn?

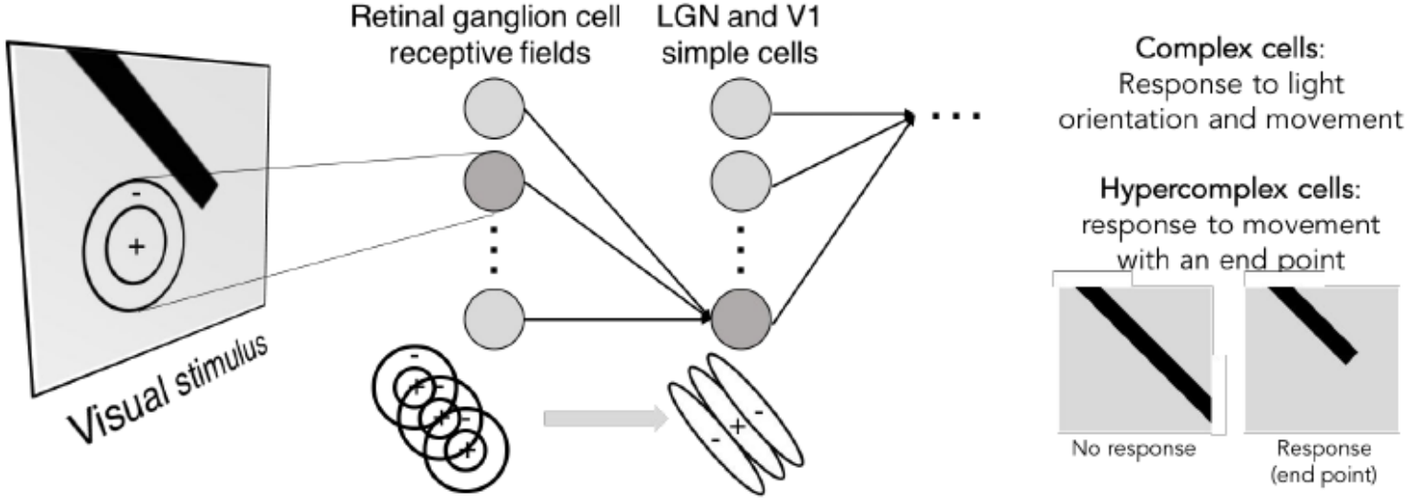
[Zeiler and Fergus 2013]
Visualization of VGG-16 by Lane Mcintosh.
VGG-16 architecture from [Simonyan and Zisserman 2014]

Feature Extraction with Convolution



What to learn?

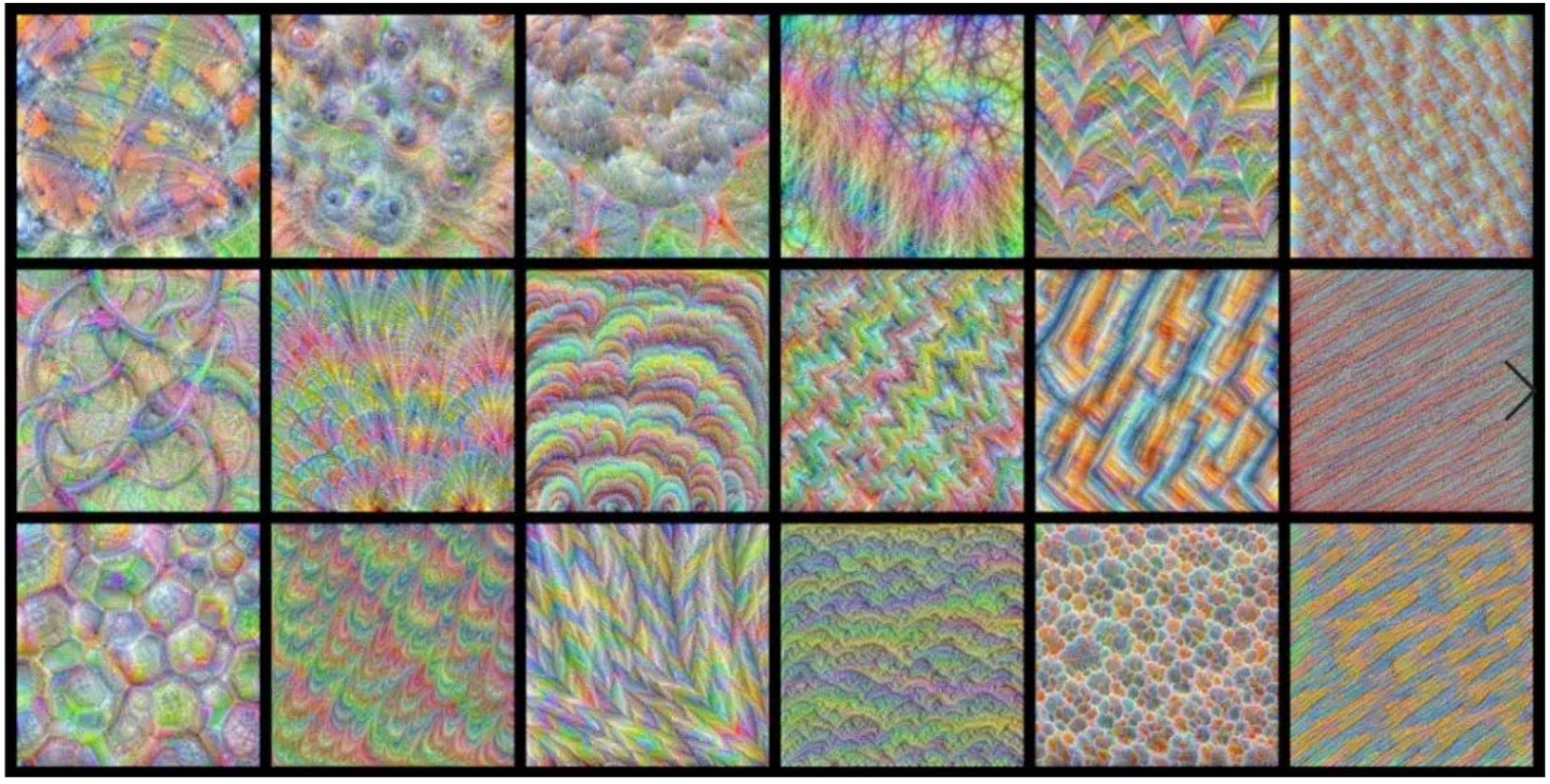




What to learn?

Feature Extraction with Convolution

https://www.jiqizhixin.com/articles/2019-01-31-13



机器之心：40行Python代码，实现卷积特征可视化。

为什么用卷积？

Feature Extraction with Convolution

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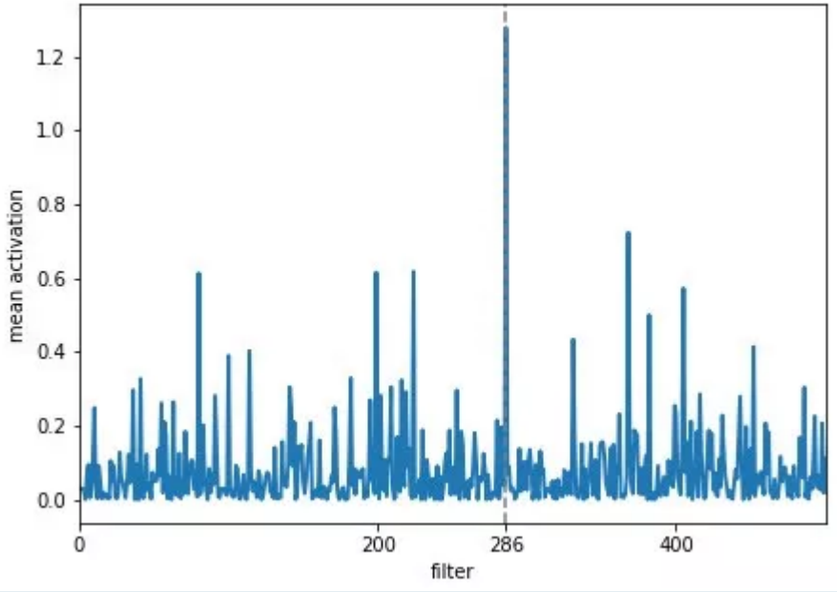
第 40 层第 286 个滤波器



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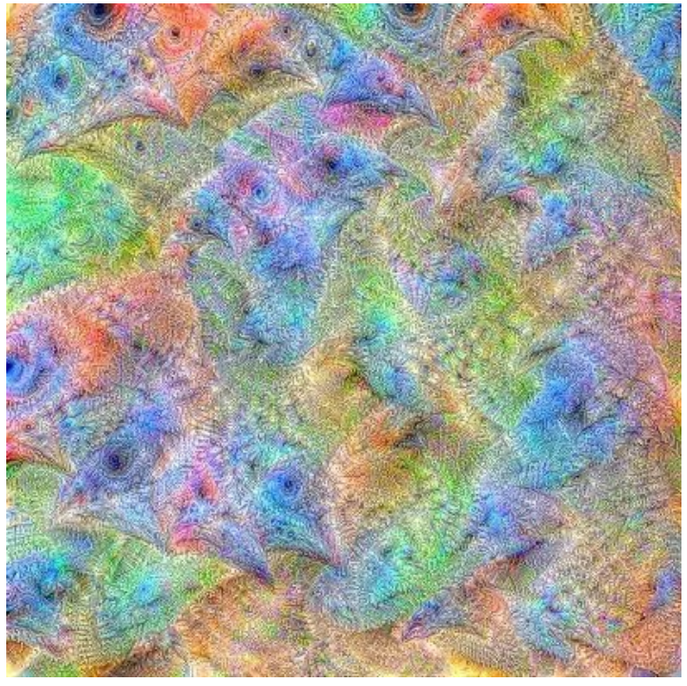
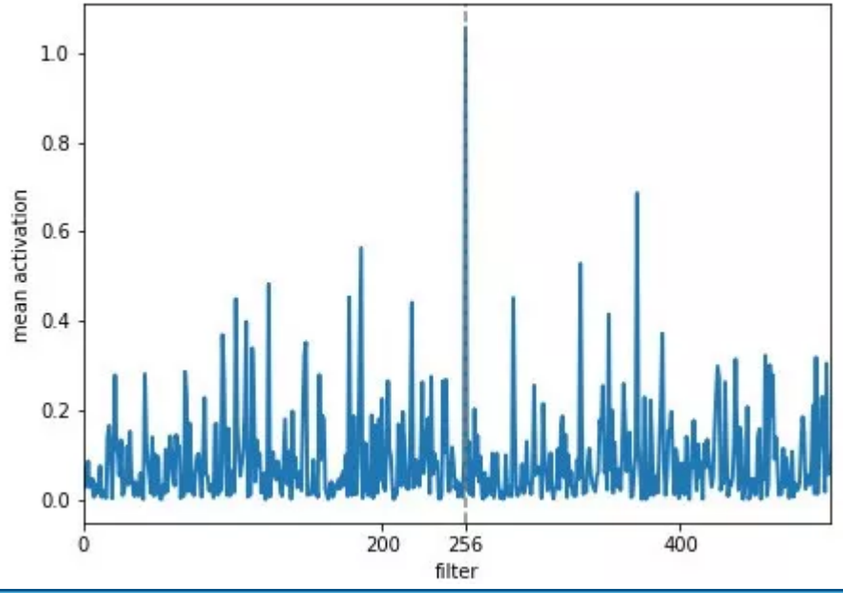


第 40 层第 256 个滤波器



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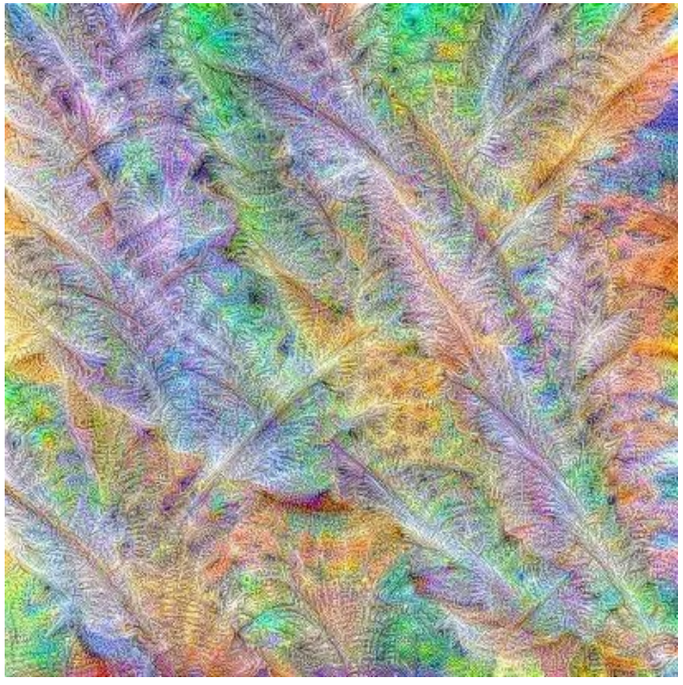
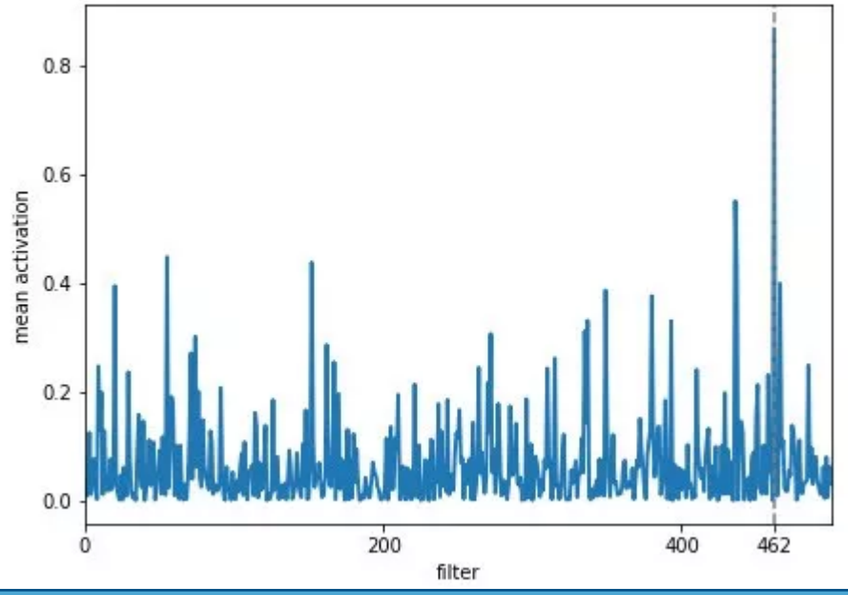


第 40 层第 462 个滤波器



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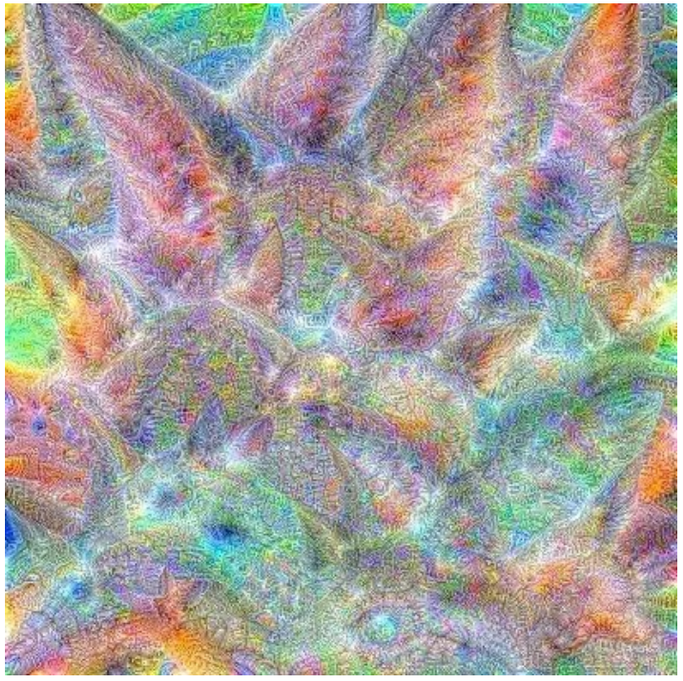
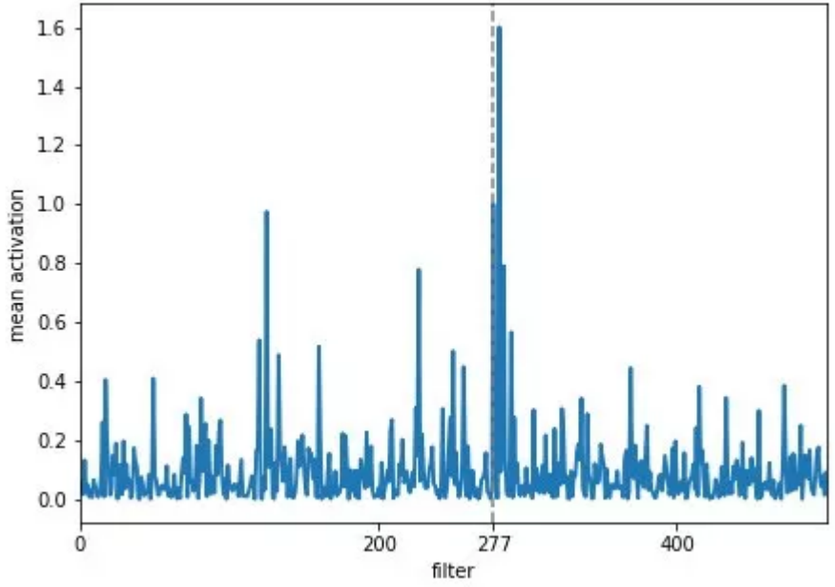


第 40 层第 277 个滤波器



Any Questions?