Convolutional Neural Networks (CNNs)

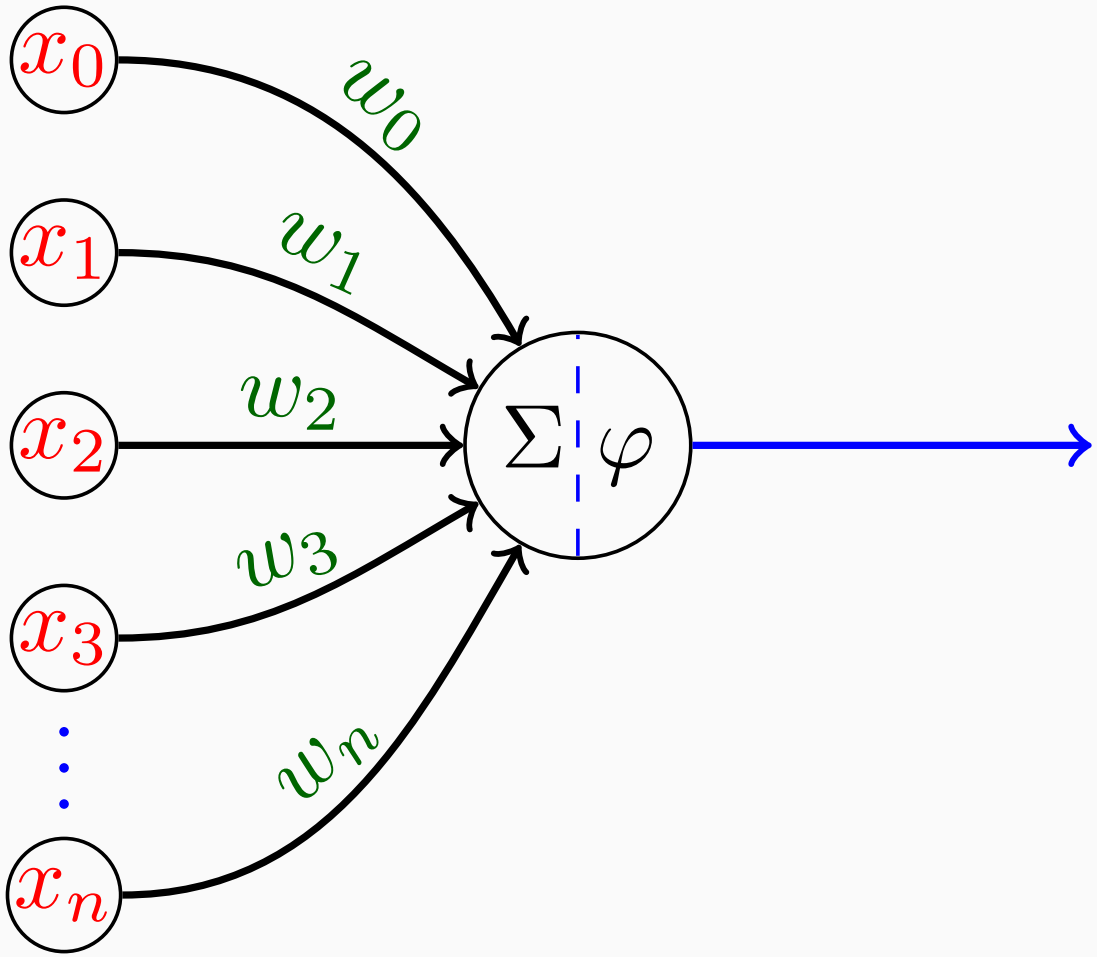
Theory and Applications

Martin Thoma – tinyurl.com/CNN-Intro

22. February 2019

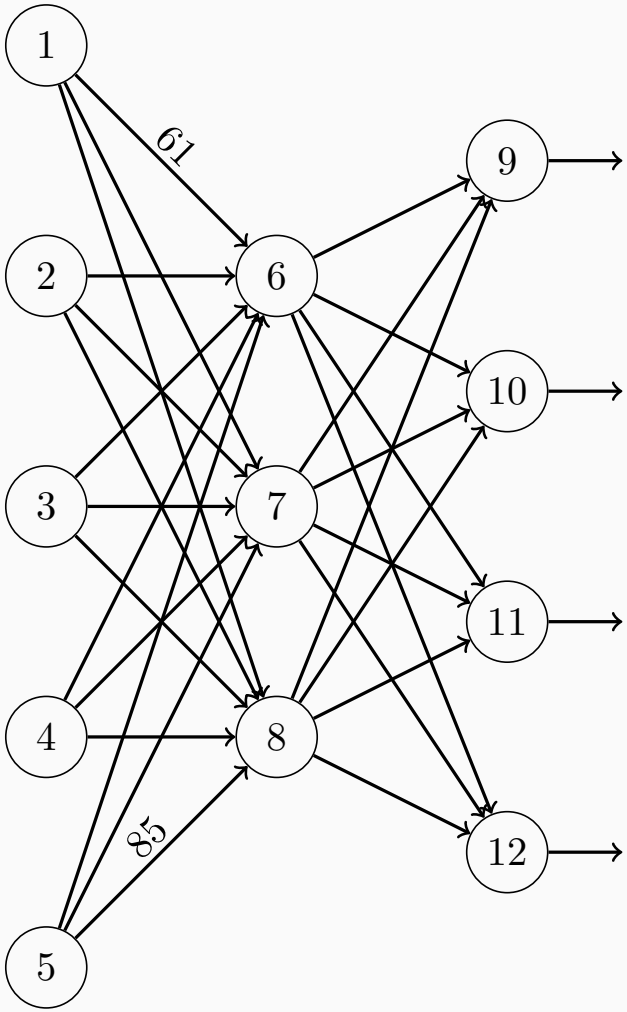
Artificial Neuron (Perceptron)

$$f : \mathbb{R}^n \to \mathbb{R}$$



Multi-Layer Perceptron (MLP)

$$f : \mathbb{R}^n \to \mathbb{R}^m$$



- Predict housing prices: (bed rooms, size, age) $\rightarrow$ Price

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- Product categorization: (weight, volume, price) $\rightarrow$ {shoe, handbag, shirt}

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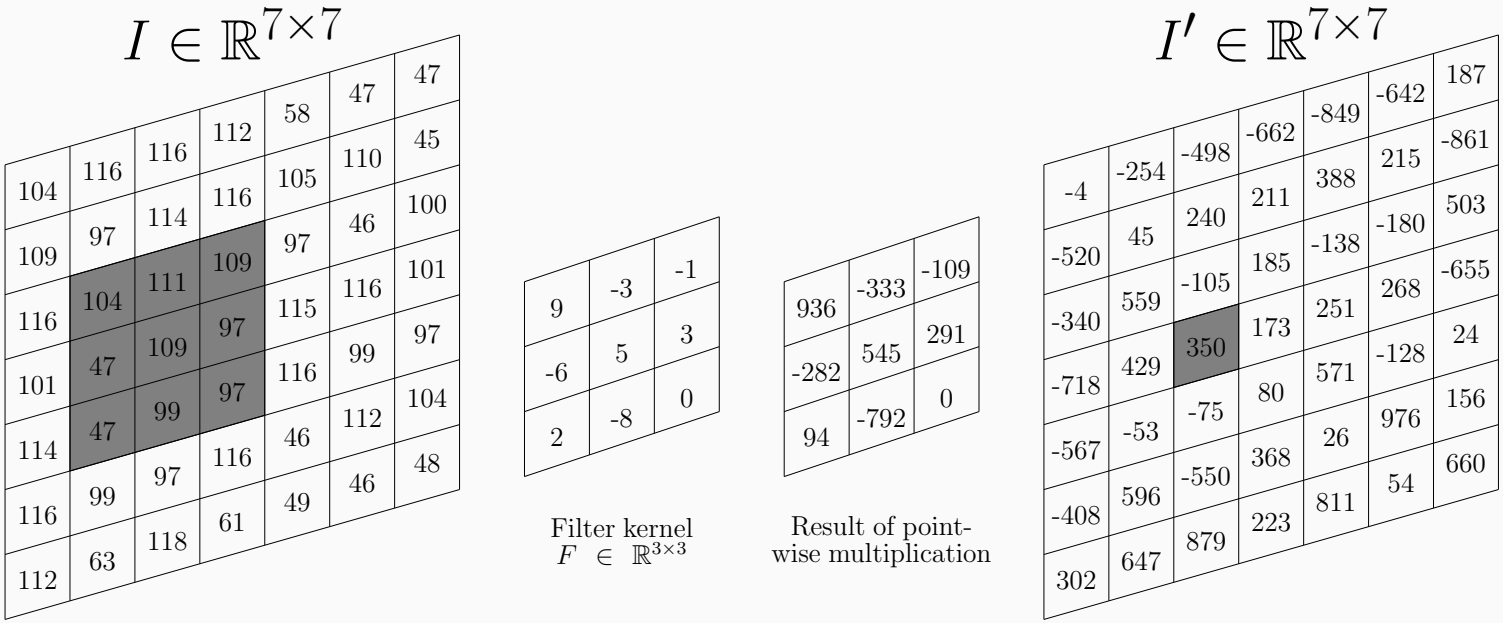
- Image classification: List of pixel colors $\rightarrow$ {cat, dog}

Data

Necessary Data

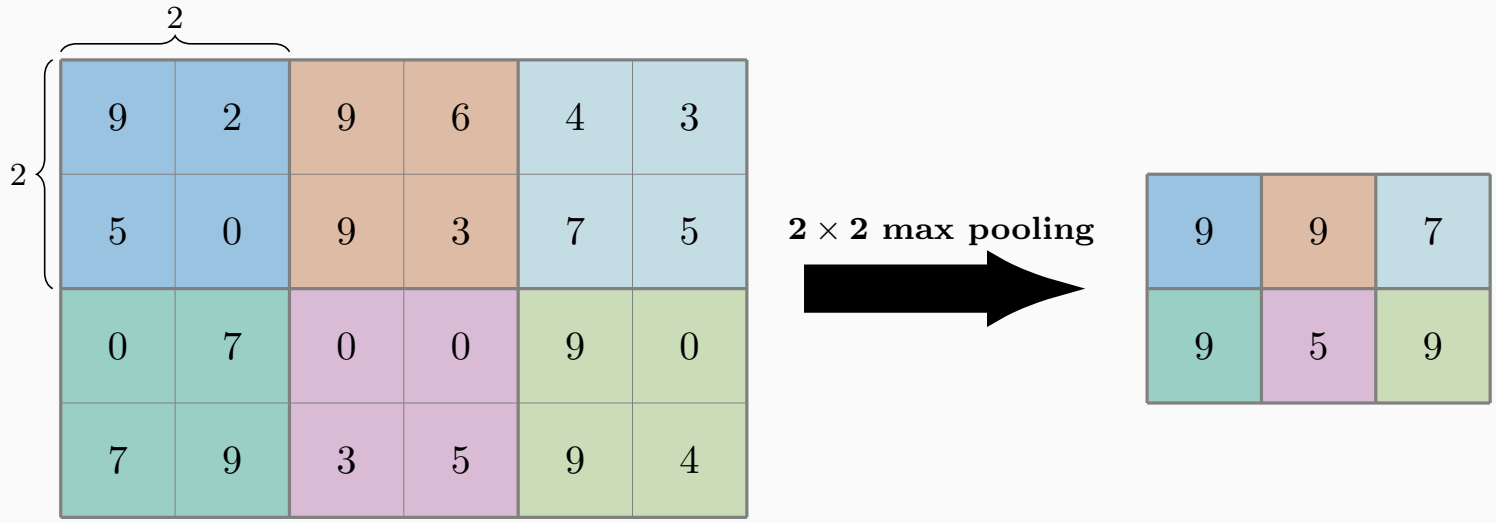
- $f(x) = w_0$
- $f(x) = w_1 \cdot x + w_0$
- $f(x) = w_2^2 \cdot x^2 + w_1^2 \cdot x + w_0$
- sin, cos, tan, ...

Convolution

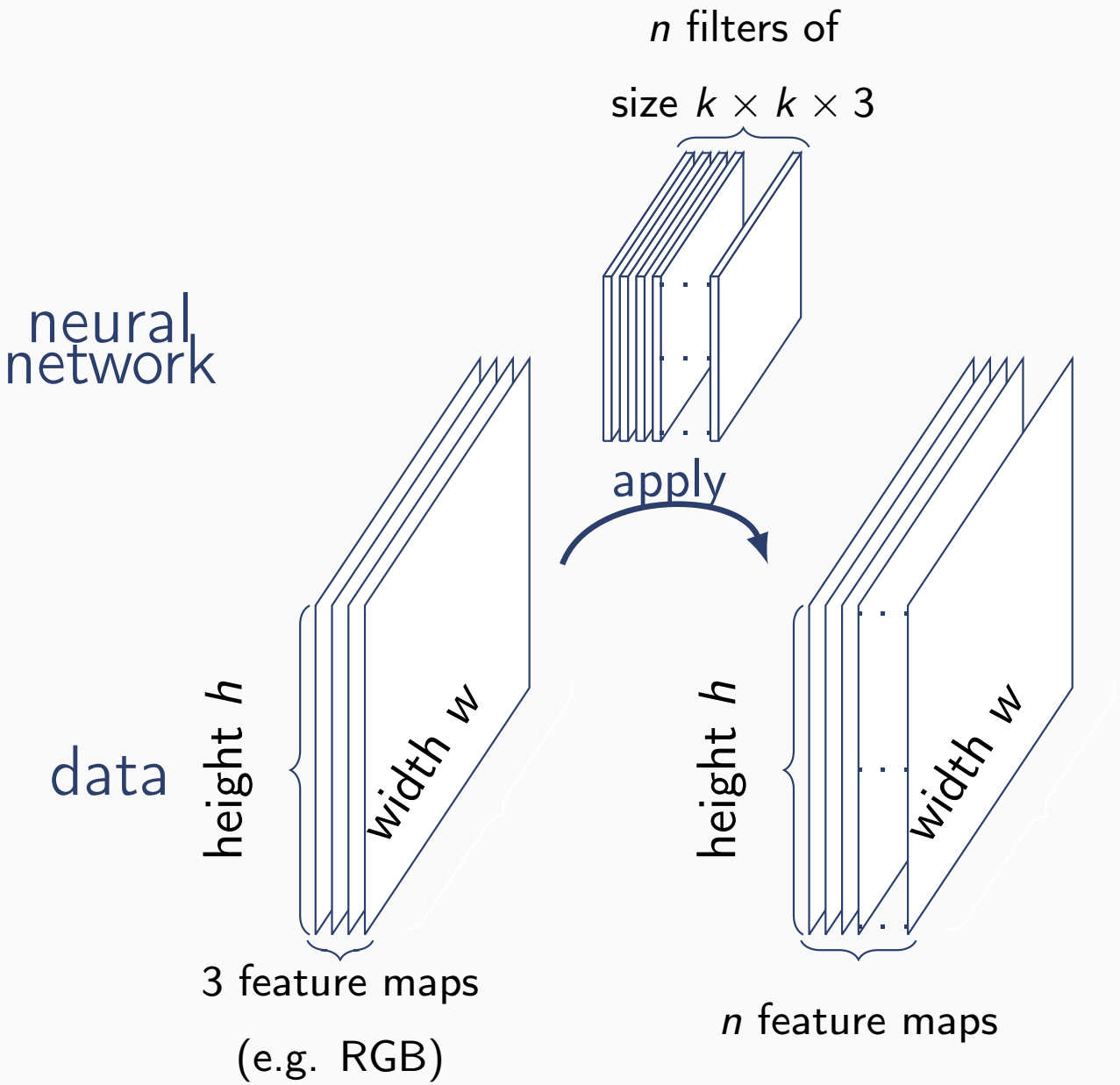


martin-thoma.com/graphic-filters

Max Pooling

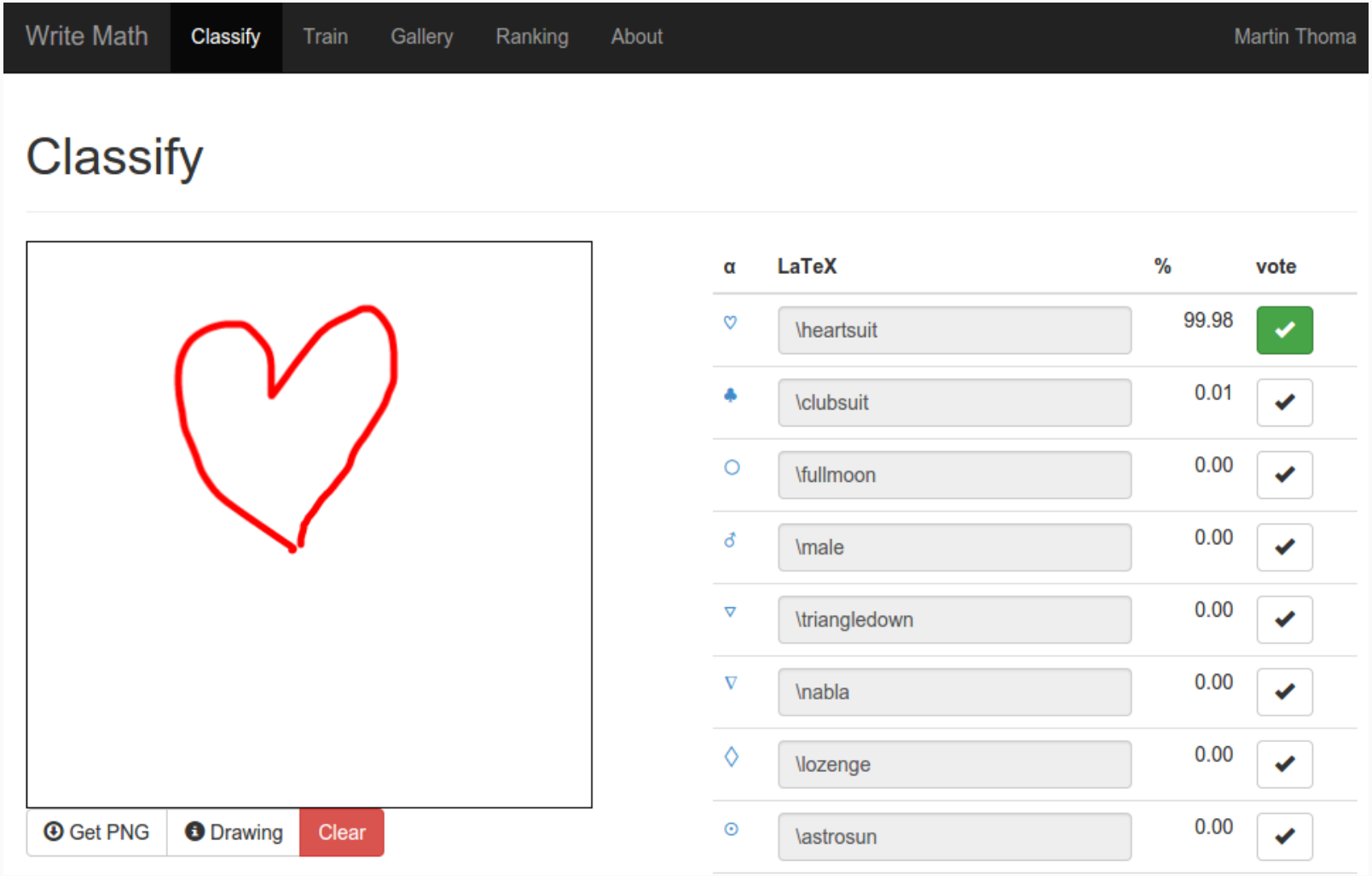


Convolutional Layer



Applications

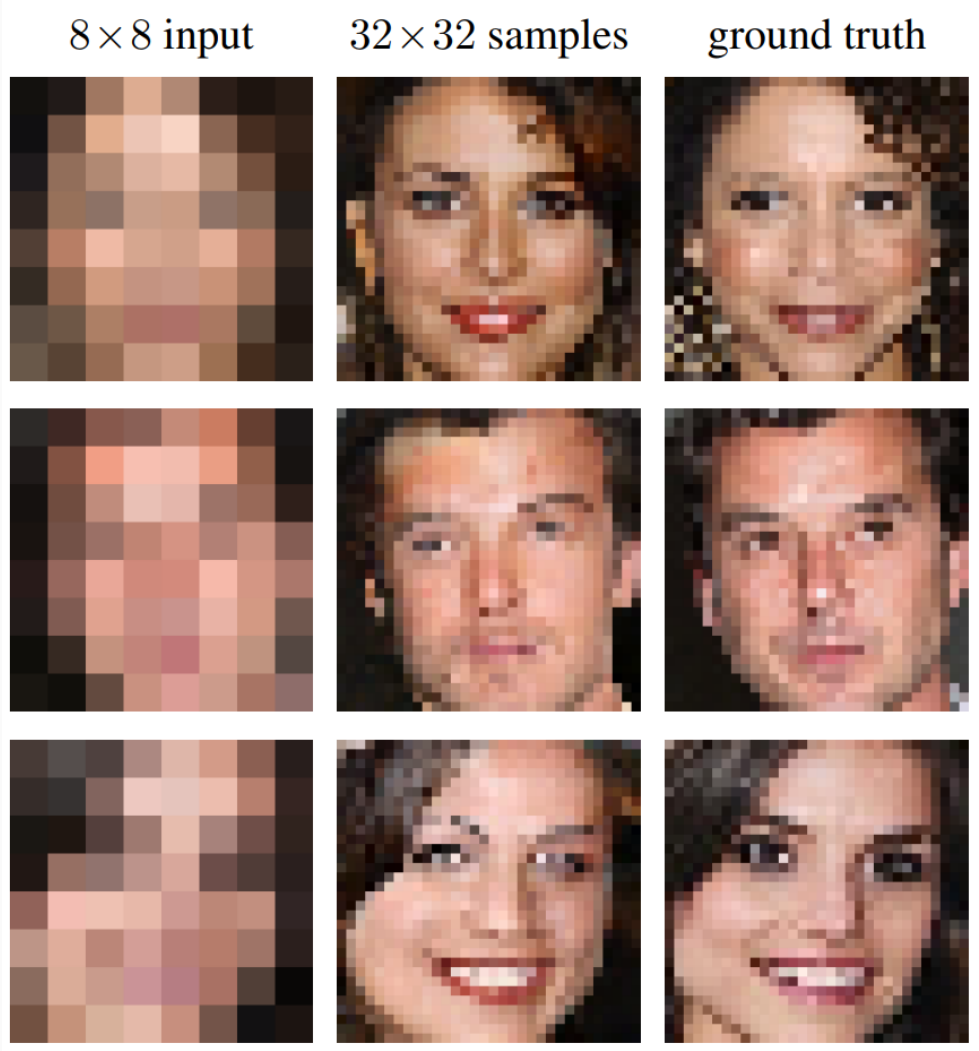
Symbol recognizer



write-math.com

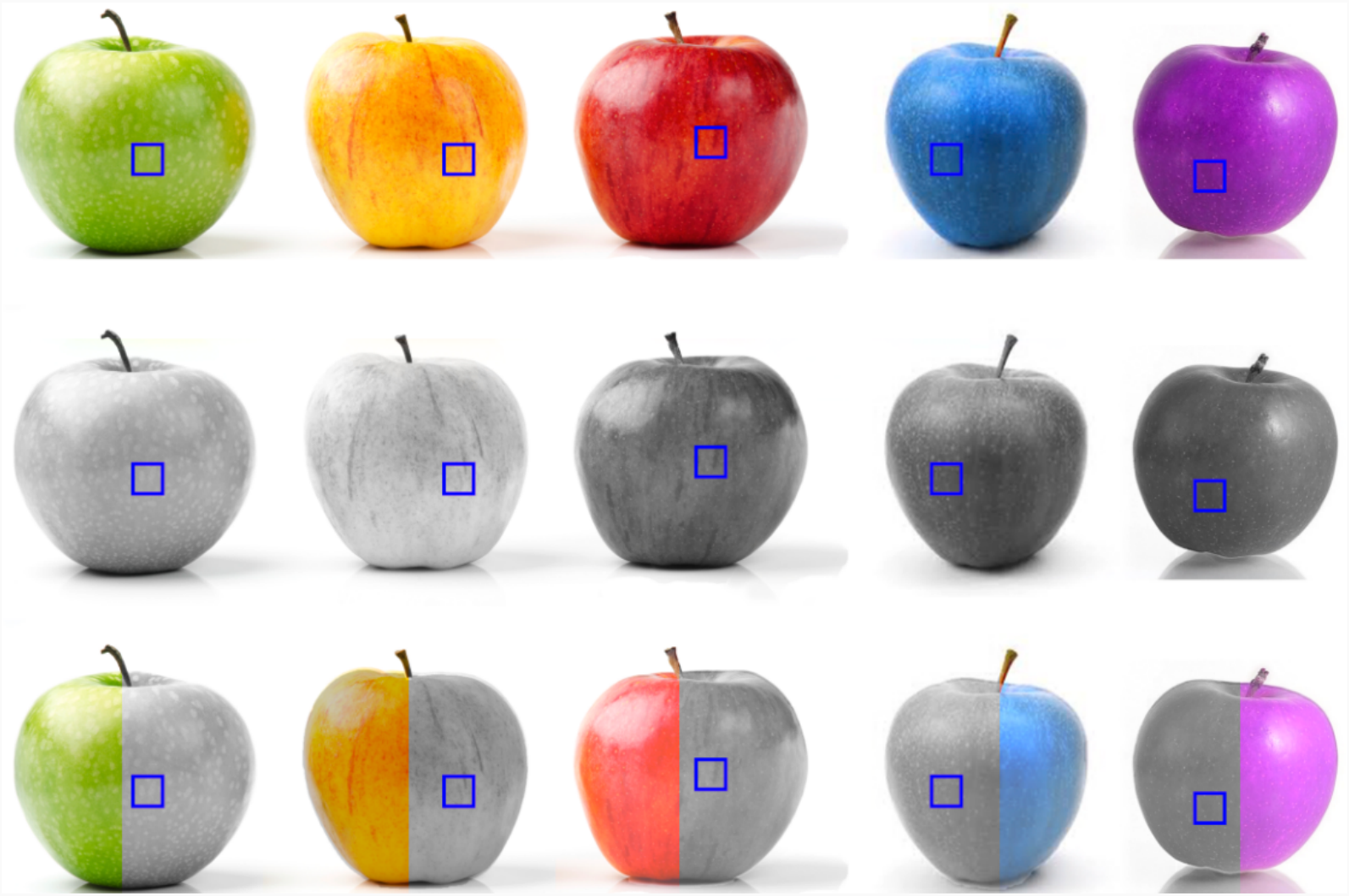
```
import data

from keras.layers import Dense, Flatten, Conv2D, MaxPooling2D
from keras.models import Sequential, load_model

model = Sequential()
model.add(Conv2D(16, (3, 3)))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Conv2D(16, (3, 3)))
model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dense(data.n_classes, activation='softmax'))

model.compile(loss='categorical_crossentropy', optimizer='adam')
model.fit(data.x_train, data.y_train)

model.save('model.h5')
model = load_model('model.h5')
y_predicted = model.predict(data.x_test)
```

Super Resolution



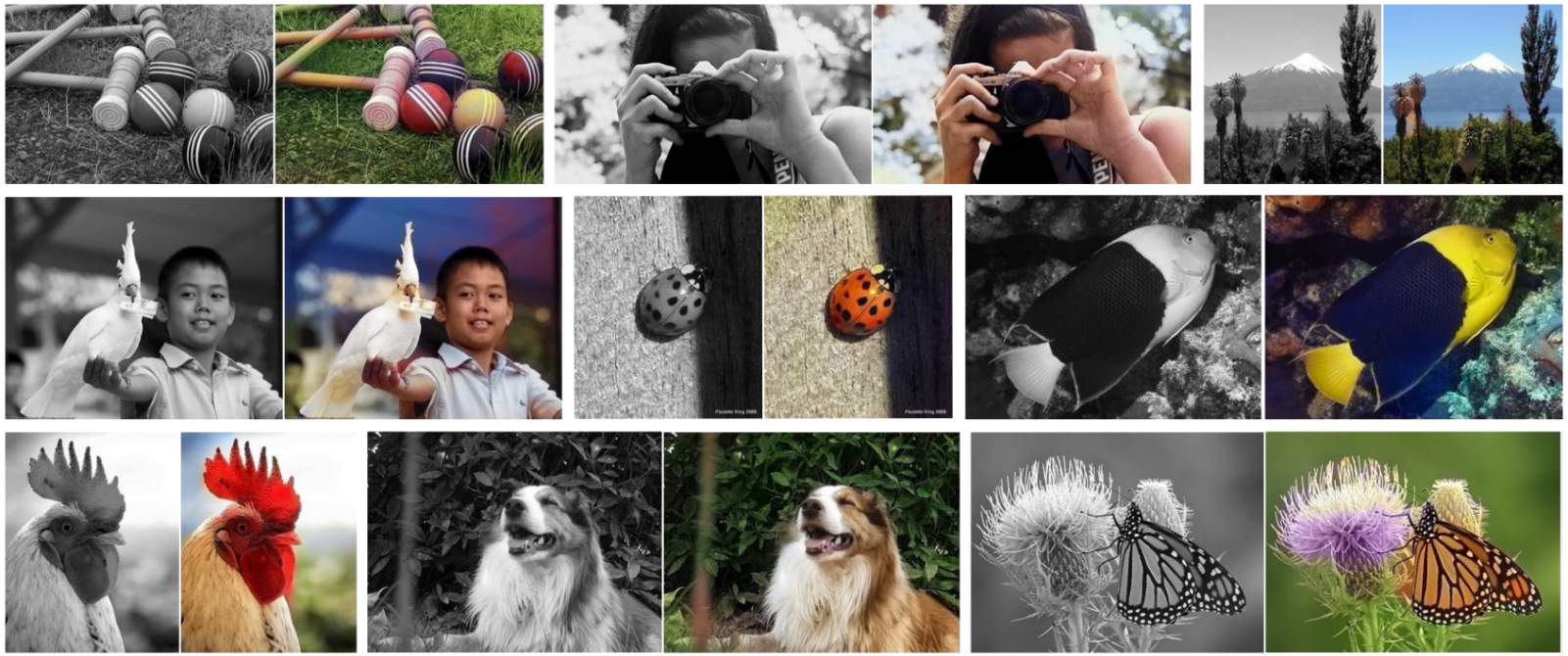
Dahl, Norouzi, Shlens: Pixel recursive super resolution (2017)

Colorization: The Problem



Cinarel: Automatic Colorization of Webtoons Using Deep Convolutional Neural Networks (2018)

Colorization - Photographs

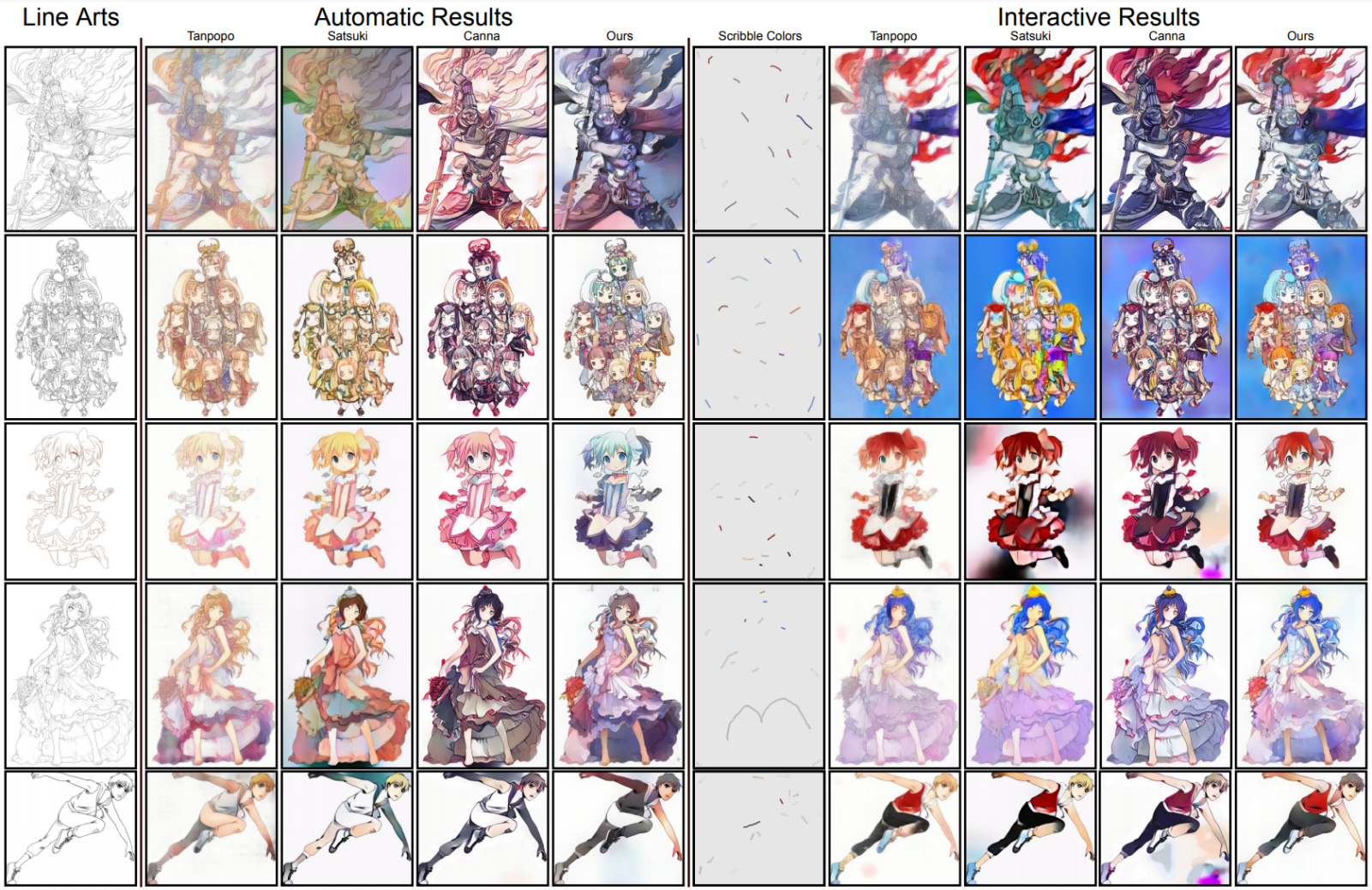


Zhang, Isola, Efros: Colorful Image Colorization (2016)

Interactive Demo: richzhang.github.io/colorization

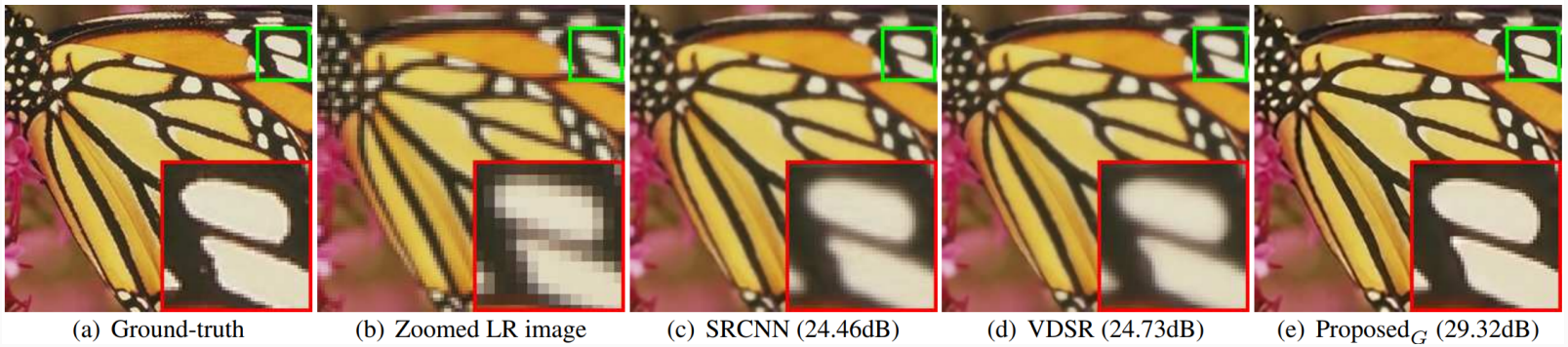
Model Lab: github.com/MartinThoma/model-lab

Colorization - Comic



Ci, Ma, Wang, Li, Luo: User-Guided Deep Anime Line Art Colorization with Conditional Adversarial Networks (2018)

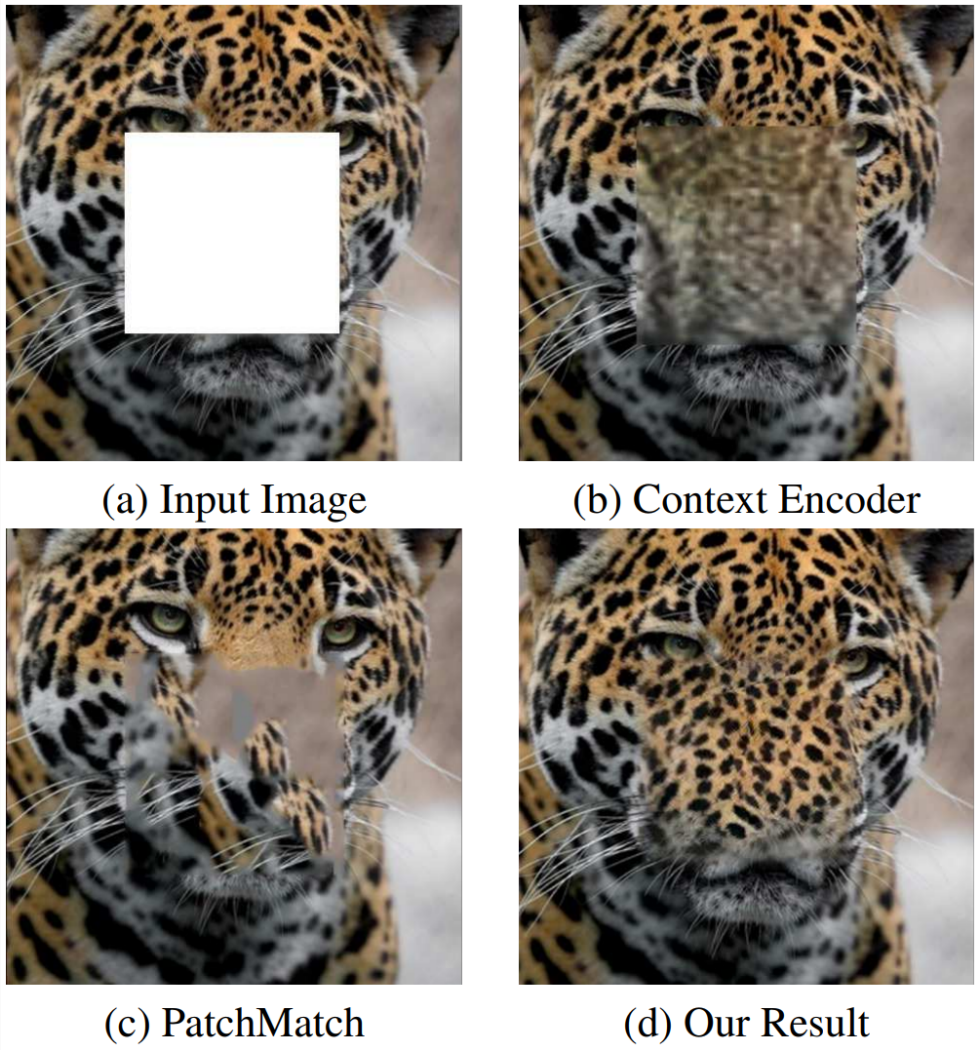
Denoising



(a) Ground-truth (b) Zoomed LR image (c) SRCNN (24.46dB) (d) VDSR (24.73dB) (e) Proposed$_G$ (29.32dB)

Zhang, Zuo, Gu, Zhang: Learning Deep CNN Denoiser Prior for Image Restoration (2017)

Image Inpainting (Watermark removal)

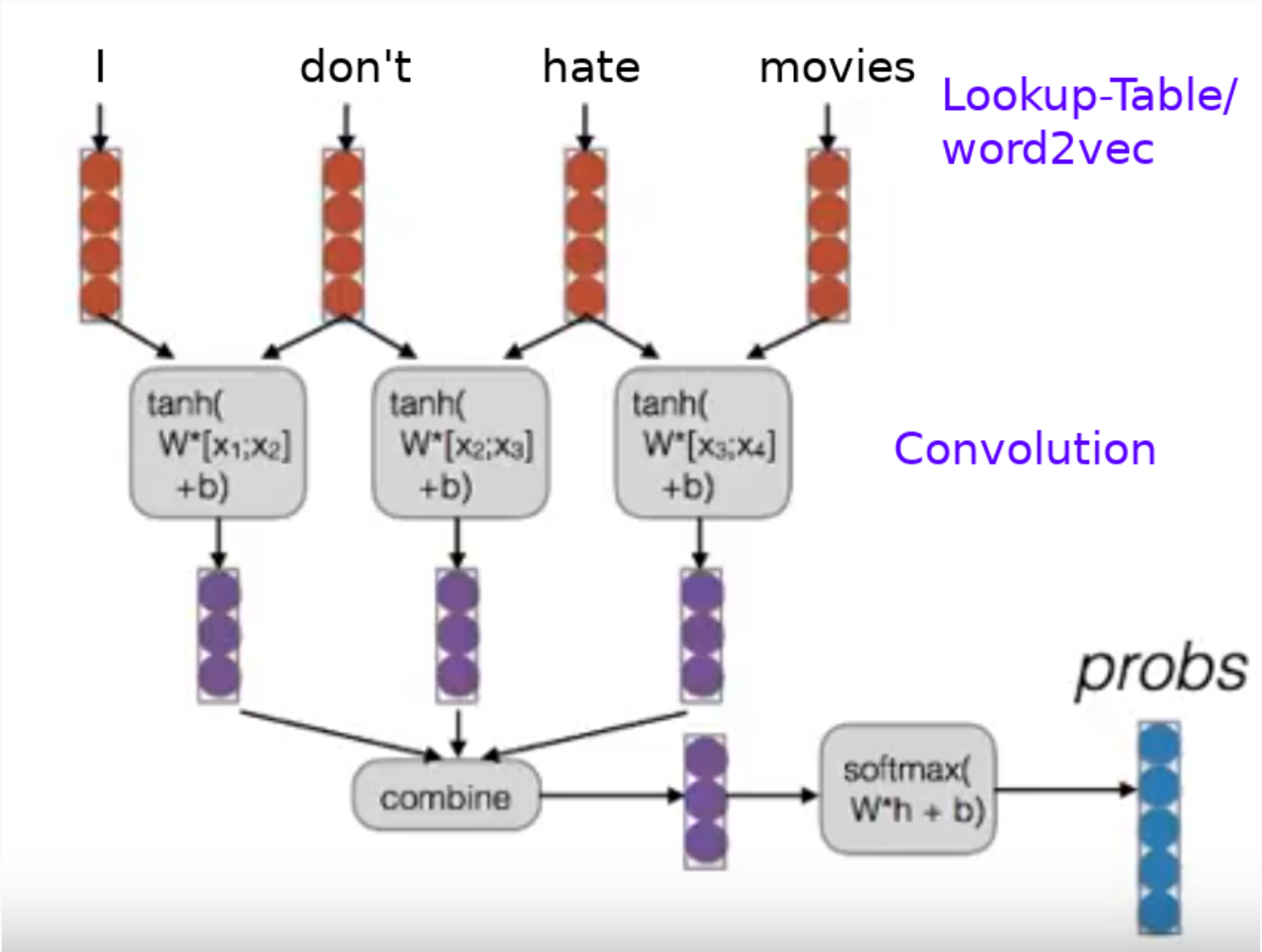


(a) Input Image (b) Context Encoder

(c) PatchMatch (d) Our Result

Yang, Lu, Lin, Shechtman, Wang, Li: High-Resolution Image Inpainting using Multi-Scale Neural Patch Synthesis (2017)

CNNs in NLP



Collobert, Weston, Bottou, Karlen, Kavukcuoglu, Kuksa: Natural Language Processing (almost) from Scratch (2011)