

Deep Learning Cheat Sheet

Evaluation Metrics

$$\begin{aligned} \text{Accuracy} &= \frac{TP + TN}{TP + TN + FP + FN} \\ \text{Error Rate} &= 1 - \text{accuracy} \\ \text{Precision} &= \frac{TP}{TP + FP} \\ \text{TPR} &= \frac{TP}{TP + FN} & \text{FPR} &= \frac{FP}{FP + TN} \\ \text{TNR} &= \frac{TN}{TN + FP} & \text{FNR} &= \frac{FN}{FN + TP} \\ \text{F1-score} &= \frac{2 \cdot \text{Precision} \cdot \text{TPR}}{\text{Precision} + \text{TPR}} \\ \text{Specificity} &= \frac{TP}{TN + FP} \\ \text{AUC} &= \int_0^1 \text{TPR} \cdot d\text{FPR} \\ \text{Macro Average} &= \frac{1}{n} \sum_{i=1}^n \text{avg}_i \\ \text{Micro Average} &= \frac{\sum_{i=1}^n TP_i}{\sum_{i=1}^n TP_i + \sum_{i=1}^n FP_i} \end{aligned}$$

Bias & Variance

$$\begin{aligned} \text{Bias}(h_\theta) &= \mathbb{E}[h_\theta, D] - f \\ \text{Var}(h_\theta) &= \mathbb{E}[(h_\theta, D - \mathbb{E}[h_\theta, D])^2] \\ \text{MSE} &= \text{Bias}(h_\theta)^2 + \text{Var}(h_\theta) + \sigma^2 \end{aligned}$$

Underfitting
high bias, low variance
Overfitting
low bias, high variance

Data Preparation

Min-max [0,1] : $x' = \frac{(x - x_{\min})}{(x_{\max} - x_{\min})}$

Min-max [-1,1] : $x' = 2 \cdot \min_max(x) - 1$
min-max doesn't handle outliers.

Z-norm : $x' = \frac{(x - \mu)}{\sigma}$

Scaling & Centering
Scaling improves the numerical stability, the convergence speed and accuracy of the learning algorithms. Centering improves the robustness of the learning algorithms

Activation Functions

—— Sigmoid ——

$$\sigma(z) = \frac{1}{1+e^{-z}} \text{ — Smooth and differentiable. Used in output layers for binary classification.}$$

—— Hyperbolic Tangent (tanh) ——

$$f(z) = \tanh(z) \text{ — Smooth, differentiable, output centered around 0. Used in LSTM.}$$

—— Rectified Linear Unit (ReLU) ——

$$f(z) = \max(0, z) \text{ — Non-linear, used as a standard, but has dying units problem for } z < 0.$$

—— Leaky ReLU ——

$$f(z) = \begin{cases} z & \text{if } z \geq 0 \\ \alpha z & \text{if } z < 0 \end{cases} \text{ — Addresses dying units problem with a small } \alpha \text{ (typical } \alpha = 0.01).$$

—— Exponential Linear Unit (ELU) ——

$$f(z) = \begin{cases} z & \text{if } z \geq 0 \\ \alpha(e^z - 1) & \text{if } z < 0 \end{cases} \text{ — Similar to Leaky ReLU but more computationally expensive.}$$

—— Softmax ——

$$f(z_i) = \frac{e^{z_i}}{\sum_{j=0}^{K-1} e^{z_j}} \text{ — Used in the last layer for multi-class classification, outputs a probability distribution.}$$

Universal Approximation Theorem

A feedforward network with a linear output layer and at least one hidden layer with a non-linear activation function (e.g. sigmoid) can approximate a large class of functions $f: \mathbb{R}^n \rightarrow \mathbb{R}^m$ with arbitrary accuracy, provided that the network is given enough hidden units.

Curse of Dimensionality

when the dimensionality increases, the volume of the space increases so fast that the available data become sparse. This sparsity is problematic for any method that requires statistical significance. In order to obtain a statistically sound and reliable result, the amount of data needed to support the result often grows exponentially with the dimensionality

Gradient Descent

- 1: Initialize parameter vector θ_0
- 2: **repeat**
- 3: Compute the gradient of the cost function at current position θ_t : $\nabla_{\theta} J(\theta_t)$
- 4: Update the parameter vector by moving against the gradient : $\theta_{t+1} = \theta_t - \alpha \cdot \nabla_{\theta} J(\theta_t)$
- 5: where α is the learning rate.
- 6: **until** change in θ is small

MSE

$$J_{MSE}(\theta) = \frac{1}{2m} \sum_{i=1}^m (\hat{y}(i) - y(i))^2$$

where :

- $\hat{y}(i) = h_{\theta}(x(i))$ is the prediction of the model,
- $y(i)$ is the true outcome,
- m is the number of training examples.

$$\nabla_w J_{MSE}(w, b) =$$

$$\frac{1}{m} \sum_{i=1}^m \hat{y}(i) \cdot (1 - \hat{y}(i)) \cdot (\hat{y}(i) - y(i)) \cdot x(i)$$

$$\nabla_b J_{MSE}(w, b) =$$

$$\frac{1}{m} \sum_{i=1}^m \hat{y}(i) \cdot (1 - \hat{y}(i)) \cdot (\hat{y}(i) - y(i))$$

Cross Entropy

$$J_{CE}(\theta) = - \sum_{i=1}^m y(i) \cdot \log h_{\theta}(x(i)) + (1 - y(i)) \cdot \log(1 - h_{\theta}(x(i)))$$

where :

- $p_{\theta}(y(i) | x(i))$ is the probability model parameterized by θ , predicting the probability of the true class $y(i)$ given the input $x(i)$,
- m is the number of observations or data points in the dataset.

$$\begin{aligned} \nabla_w J_{CE}(w, b) &= \frac{1}{m} \sum_{i=1}^m (\hat{y}(i) - y(i)) \cdot x(i) \\ \nabla_b J_{CE}(w, b) &= \frac{1}{m} \sum_{i=1}^m (\hat{y}(i) - y(i)) \end{aligned}$$

Gradient Descent Variants

BGD

Smooth, not wiggling, strictly decreasing cost, many epochs needed, choose larger learning rate, no out-of-core support - all data in RAM (m), easy to parallelise.

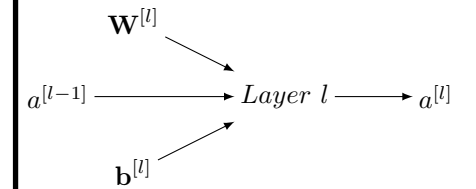
SGD

Wiggling, needs smoothing, wiggles around minimum, not necessarily decreasing cost, few epochs needed, choose smaller learning rate, out-of-core support - not all data to be kept in RAM of a single machine, not easy to parallelise.

MBGD

Slightly wiggling, wiggles around minimum, typically decreasing cost, less epochs than BGD, more than SGD needed, choose medium learning rate (dependent on model), out-of-core support - not all data to be kept in RAM of a single machine, easy to parallelise.

Compute Graph



$$\begin{aligned} \mathbf{W}^{[l]} &= \begin{pmatrix} w_{11} & \cdots & w_{1n^{[l-1]}} \\ \vdots & \ddots & \vdots \\ w_{n^{[l]}1} & \cdots & w_{n^{[l]}n^{[l-1]}} \end{pmatrix} \\ \mathbf{a}^{[l]} &= \begin{pmatrix} a_1 \\ \vdots \\ a_{n^{[l]}} \end{pmatrix} \\ \mathbf{b}^{[l]} &= \begin{pmatrix} b_1 \\ \vdots \\ b_{n^{[l]}} \end{pmatrix} \end{aligned}$$

$$\begin{aligned} \mathbf{a}^{[l]} &= \sigma^{[l]}(\mathbf{z}^{[l]}) \\ \mathbf{z}^{[l]} &= \mathbf{W}^{[l]} \cdot \mathbf{a}^{[l-1]} + \mathbf{b}^{[l]} \quad \text{with } \mathbf{a}^{[0]} = \mathbf{x} \end{aligned}$$

Backpropagation

Matrix Notation

$$\begin{aligned}\frac{\partial L}{\partial \mathbf{z}^{[l]}} &= \frac{\partial L}{\partial \mathbf{a}^{[l]}} * \frac{d\sigma^{[l]}(\mathbf{z}^{[l]})}{dz} \\ \frac{\partial L}{\partial \mathbf{W}^{[l]}} &= \frac{\partial L}{\partial \mathbf{z}^{[l]}} \cdot \left(\mathbf{a}^{[l-1]}\right)^T \\ \frac{\partial L}{\partial \mathbf{b}^{[l]}} &= \frac{\partial L}{\partial \mathbf{z}^{[l]}} \\ \frac{\partial L}{\partial \mathbf{a}^{[l-1]}} &= \left(\mathbf{W}^{[l]}\right)^T \cdot \frac{\partial L}{\partial \mathbf{z}^{[l]}} \\ \frac{\partial L}{\partial \mathbf{z}^{[l]}} &= \hat{\mathbf{y}} - \mathbf{y}\end{aligned}$$

Full Batch

$$\begin{aligned}\frac{\partial L}{\partial \mathbf{Z}^{[l]}} &= \frac{\partial L}{\partial \mathbf{A}^{[l]}} * \frac{d\sigma^{[l]}(\mathbf{Z}^{[l]})}{dz} \\ \frac{\partial L}{\partial \mathbf{W}^{[l]}} &= \frac{\partial L}{\partial \mathbf{Z}^{[l]}} \cdot \left(\mathbf{A}^{[l-1]}\right)^T \\ \frac{\partial L}{\partial \mathbf{b}^{[l]}} &= \frac{1}{m} \cdot \frac{\partial L}{\partial \mathbf{Z}^{[l]}} \cdot \begin{pmatrix} \cdot \\ \cdot \\ 1 \\ \cdot \\ \cdot \end{pmatrix} \\ \frac{\partial L}{\partial \mathbf{A}^{[l-1]}} &= \left(\mathbf{W}^{[l]}\right)^T \cdot \frac{\partial L}{\partial \mathbf{Z}^{[l]}} \\ \frac{\partial L}{\partial \mathbf{Z}^{[l]}} &= \hat{\mathbf{Y}} - \mathbf{Y}\end{aligned}$$

Batch Normalization

$$\begin{aligned}\frac{\partial L}{\partial \gamma} &= \frac{1}{m} \cdot \sum_{i=1}^m \frac{\partial L}{\partial \hat{a}^{(i)}} \cdot \frac{\partial \hat{a}^{(i)}}{\partial \gamma} \\ &= \frac{1}{m} \cdot \sum_{i=1}^m \frac{\partial L}{\partial \hat{a}^{(i)}} \cdot \hat{a}^{(i)} \\ \frac{\partial L}{\partial \beta} &= \sum_{i=1}^m \frac{\partial L}{\partial \hat{a}^{(i)}} \cdot \frac{\partial \hat{a}^{(i)}}{\partial \beta} \\ &= \sum_{i=1}^m \frac{\partial L}{\partial \hat{a}^{(i)}}\end{aligned}$$

Vanishing Exploding Gradient

Xavier & Heu Initialization

Sets the initial weights of a layer to values drawn from a uniform distribution with a range that depends on the number of input and output units in the layer. Specifically, the range is set to $[-r, r]$, where $r = \sqrt{\frac{6}{n_{in} + n_{out}}}$, and n_{in} is the number of input units and n_{out} is the number of output units. This range was chosen because it ensures that the variance of the outputs of each layer remains constant, which helps to prevent the vanishing or exploding gradient problem.

Batch Normalization

We calculate the average μ_r and standard deviation σ_r over the m column vectors z_r of the mini-batch according to :

$$\begin{aligned}\mu_r &= \frac{1}{m} \sum_{i=1}^m z_r^{[l](i)} \\ \sigma_r &= \sqrt{\frac{1}{m} \sum_{i=1}^m (z_r^{[l](i)} - \mu_r)^2}\end{aligned}$$

Now, the actual normalization of the logit matrix is as follows :

$$\hat{Z}_r^{[l]} = \frac{Z_r^{[l]} - \mu_r}{\sigma_r + \epsilon}$$

Finally, two addition parameter vectors are introduced that rescale the logits according to :

$$\tilde{Z}_r^{[l]} = \gamma^{[l]} \cdot \hat{Z}_r^{[l]} + \beta^{[l]}$$

Non Saturating Activation Function

To alleviate the saturation of sigmoid and tanh, we can use the ReLU activation function. It still suffer from dying units problem (when the input is negative, the gradient is 0).

Gradient Clipping

If gradients values exceed a certain threshold, they are "clipped" or rescaled to a smaller value. This prevents the gradients from becoming too large and helps to stabilize the training process.

Optimizers

Momentum

Uses a running average of gradients to smooth the optimization path.

$$\begin{aligned}m_t &\leftarrow \beta m_{t-1} + \alpha \nabla_{\theta} J(\theta) \\ \theta_t &\leftarrow \theta_{t-1} - m_t\end{aligned}$$

Nesterov variant :

$$\begin{aligned}m_t &\leftarrow \beta m_{t-1} + \alpha \nabla_{\theta} J(\theta_{t-1} - \beta m_{t-1}) \\ \theta_t &\leftarrow \theta_{t-1} - m_t\end{aligned}$$

AdaGrad

Scaling down the gradient vector along the steepest dimensions.

$$\begin{aligned}s_t &\leftarrow s_{t-1} + \nabla_{\theta} J(\theta_{t-1}) \cdot \nabla_{\theta} J(\theta_{t-1}) \\ \theta_t &\leftarrow \theta_{t-1} - \frac{\alpha}{\sqrt{s_t} + \epsilon} \cdot \nabla_{\theta} J(\theta_{t-1})\end{aligned}$$

RMS Prop

A variant of AdaGrad using an exponentially decaying average of squared gradients.

$$\begin{aligned}s_t &\leftarrow \beta s_{t-1} + (1 - \beta) \nabla_{\theta} J(\theta_{t-1}) \cdot \nabla_{\theta} J(\theta_{t-1}) \\ \theta_t &\leftarrow \theta_{t-1} - \frac{\alpha}{\sqrt{s_t} + \epsilon} \cdot \nabla_{\theta} J(\theta_{t-1})\end{aligned}$$

Adam

Combines momentum and RMSProp to adapt the learning rate for each parameter.

$$\begin{aligned}m_t &\leftarrow \beta_1 m_{t-1} + (1 - \beta_1) \nabla_{\theta} J(\theta_{t-1}) \\ s_t &\leftarrow \beta_2 s_{t-1} + (1 - \beta_2) \nabla_{\theta} J(\theta_{t-1}) \cdot \nabla_{\theta} J(\theta_{t-1}) \\ \hat{m}_t &\leftarrow \frac{m_t}{1 - \beta_1^t} \\ \hat{s}_t &\leftarrow \frac{s_t}{1 - \beta_2^t} \\ \theta_t &\leftarrow \theta_{t-1} - \frac{\alpha}{\sqrt{\hat{s}_t} + \epsilon} \cdot \hat{m}_t\end{aligned}$$

Scheduler

Strategies to adjust the learning rate during training : **Performance scheduling**

Exponential scheduling : $\alpha(t) = \alpha_0 \cdot 10^{-t/T}$

Power scheduling : $\alpha(t) = \alpha_0 \cdot \left(1 + \frac{t}{T}\right)^{-c}$, where c is typically set to 1.

Regularization

Weight Penalty

Modify the loss function to include a penalty to big weights :

$$J(\theta) = J_0(\theta) + \lambda \cdot \Omega(W)$$

where $\Omega(W)$ is the penalty term :

$$\begin{aligned}- \text{L1} : \Omega(W) &= \|\mathbf{W}\|_1 = \sum |W_{ji}| \\ - \text{L2} : \Omega(W) &= \frac{1}{2} \|\mathbf{W}\|_2^2 = \frac{1}{2} \sum (W_{ji}^2)\end{aligned}$$

Dropout

Randomly drop neurons during training :

- Each neuron has probability p of being dropped.
- Typical p : 50
- During testing, scale weights by $1 - p$.

Early Stopping

Stop training when validation error increases :

- Track validation error during training.
- Save model parameters when validation error improves.
- Stop if no improvement for a set number of steps.

Autoencoder

1. Data Compression / Dimensionality Reduction

- Train on input data, transmit encoded values instead of original.
- Related to PCA with linear activations.

2. Feature Extraction

- Train on unlabeled data, use encoder output as features for classifiers.

3. De-noising

- Train with noisy data to predict clean data, useful for feature robustness.

4. Image In-painting

- Restore lost information in images, active research field.

5. Pre-training for Supervised Learning

- Unsupervised pre-training, followed by supervised fine-tuning improves deep networks.

Convolutional Neural Networks

Features

colors, terrain texture, size, presence of straight lines, border

1. Extracting localized low-level features
2. Incrementally allowing the system to appropriately bind together features and their relationships
3. Gradually building up overall spatial invariance

Pooling layer

Maxpooling after a convolution layer eliminates non-maximal values : it is a form of non-linear down-sampling that reduces computation for upper layers and provides a "summary" of the statistics of features in lower layers.

Convolution layer

Different kernel sizes (3x3, 5x5, 7x7, etc.) allow the identification of features at different scales. Multiple layers of 3x3 kernels can implement other kernel sizes.

The CONV layer's parameters consist of a set of learnable filters. Every filter is small spatially (along width and height) but extends through the full depth of the input volume.

We can compute the spatial size of the output volume as a function of the input volume size (W), the receptive field size of the Conv Layer neurons (F), the stride with which they are applied (S), and the amount of zero padding used (P) on the border.

Input Volume

Size : $W_1 \times H_1 \times D_1$

Hyperparameters

K : Number of conv filters

F : Filter size (spatial extent)

S : Stride

P : The amount of zero padding

Output Volume

W2 : $\left\lfloor \frac{W_1 - F + 2P}{S} \right\rfloor + 1$

H2 : $\left\lfloor \frac{H_1 - F + 2P}{S} \right\rfloor + 1$

Size : $W_2 \times H_2 \times K$

Parameters

It introduces $(F \times F \times D_1) \times K$ weights plus K biases.

DeepCNN

LeNet5

- Premier CNN utilisé avec succès pour la reconnaissance des chiffres manuscrits (MNIST).

- Utilisation de couches de convolution suivies de couches de sous-échantillonnage (pooling).

AlexNet

- Introduction des CNN profonds avec huit couches apprises.

- Utilisation de ReLU

- Utilisation de Dropout

- Utilisation de Data Augmentation

VGGnet

- Profondeur accrue avec 16 à 19 couches.

- Introduction de l'utilisation de petits filtres 3x3 dans toutes les couches de convolution.

GoogleNet

- Introduction des Inceptions Modules : plusieurs tailles de filtres dans chaque couche.

- Réduction des paramètres grâce à des couches 1x1 convolutions (depth projection)

- injection of gradient at early stages

ResNet

- Introduction des residual connections pour assurer la rétropropagation du gradient (gradient highway)

- Résolution du problème de gradient vanishing dans les réseaux très profonds.

- Batch Normalization

- Xavier He Initialization

- Bottleneck layers 1x1x64

Pattern

- [Ajouter ici une brève description de l'innovation ou du concept clé lié au réseau "Pattern"].

Data Augmentation

Strategies

pre-Augmentation, online augmentation

Methods

shear, zoom, color, rotation, flip, translation

Transfer Learning

Principle

using knowledge learned from tasks for which a lot of labelled data is available in settings where only little labelled data is available.

Keras Code

MobileNet

Strategies

Keras CNN

Model

```
def build_model():
    visible = Input(shape=(32, 32, 3))
    # first feature extractor
    conv1 = Conv2D(32, kernel_size=3, activation='relu')(visible)
    drop1 = Dropout(0.2)(conv1)
    pool1 = MaxPooling2D(pool_size=(2, 2))(drop1)
    flat1 = Flatten()(pool1)
    # second feature extractor
    conv2 = Conv2D(32, kernel_size=6, activation='relu')(visible)
    drop2 = Dropout(0.2)(conv2)
    pool2 = MaxPooling2D(pool_size=(2, 2))(drop2)
    flat2 = Flatten()(pool2)
    # merge feature extractors
    merge = concatenate([flat1, flat2])
    # interpretation layer
    hidden1 = Dense(100, activation='relu')(merge)
    # prediction output
    output = Dense(n_classes, activation='softmax')(hidden1)
    model = Model(inputs=visible, outputs=output, name='exp2_functional')
    return model
```

```
clf = build_model()
clf.compile(loss='categorical_crossentropy',
            optimizer='adam', metrics=['accuracy'])
```

Data Augmentation

```
datagen = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    horizontal_flip=True,
    shear_range=0.2,
    zoom_range=0.2,
    fill_mode='nearest')

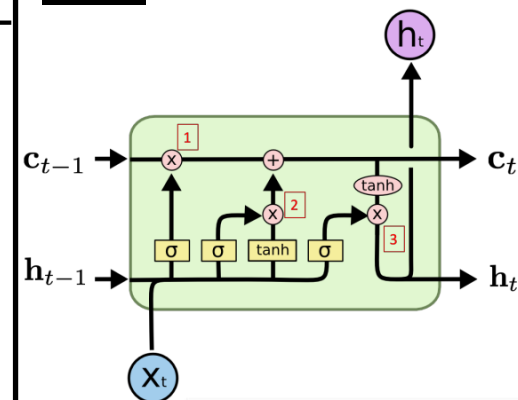
train_generator = datagen.flow(
    X_train, Y_train, batch_size=128)
test_generator = datagen.flow(X_test,
    Y_test, batch_size=128)

checkpoint_filepath = clf.name + '.keras'
```

Training

```
history = clf.fit(
    train_generator,
    steps_per_epoch=100,
    epochs=15,
    validation_data=test_generator,
    validation_steps=10,
    callbacks=[ModelCheckpoint(
        checkpoint_filepath,
        save_best_only=True)])
```

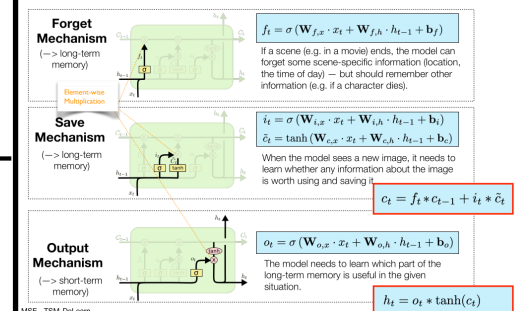
LSTM



Key Components :

- (1) Forget Gate
- (2) Input Gate
- (3) output State
- Cell state for storing long-term information.
- Hidden state for short-term information.

Functioning



Super-Highway for Backprop

(+) Better at capturing long-range dependencies than standard RNNs, More effective in learning from large sequences of data.

(-) More complex and computationally intensive to train than standard RNNs, May require more data to train effectively.

Number of Weights

$4x(N_{inputs} + N_{LSTMblocks} + bias)xN_{LSTMblocks}$

Weights for 32 LSTM units and 2-dim inputs : $4 \times (2 + 32 + 1) \times 32 = 4480$

Vanishing Gradient

Vanishing/Exploding Gradients problem and the usual remedies in the context of RNNs (parameter initialisation, batchnorm, grad clipping)

RNN

Use Cases

- Sentiment Classification
- Speech Recognition
- Machine Translation
- Captioning/Subtitling
- Named Entity Recognition (NER)
- Time Series Modelling, Prediction
- Chatbots
- Question/Answering
- Sequence Generation

Model Categories

One-to-Many

- Image Captioning : Image -> Sequence of Words

Many-to-One

- Sentiment Classification : Sequence of Words -> Sentiment

Many-to-Many (1 :1)

- Named Entity Recognition : Sequence of Words -> Sequence of Entity Classes

Many-to-Many (n :m)

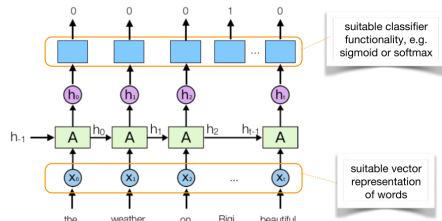
- Machine Translation : Sequence of Words -> Sequence of Words
- Speech Recognition : Sequence of Audio -> Sequence of Words
- Chatbots : Sequence of Words -> Sequence of Words

Recurrent Cells

$$h_t = f(h_{t-1}, x_t)$$

$$z_t = W_x x_t + W_h h_{t-1} + b_h$$

Many-to-Many Example



- Name classification with sequence lengths of up to 18 characters works well with SimpleRNN.

- Activity recognition with sequence lengths of up to 128 steps has not worked well with SimpleRNN. Probably too long!

RNN Keras

Name Classification

```
# Model with multiple layers
model_multi_rnn = Sequential()
model_multi_rnn.add(SimpleRNN(units=64, input_shape=(maxlen, len_alphabet), return_sequences=True))
model_multi_rnn.add(SimpleRNN(units=32, return_sequences=False))
model_multi_rnn.add(Dense(len(languages), activation='softmax'))

model_multi_rnn.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
model_multi_rnn.summary()

# Train the model
log_multi_rnn = model_multi_rnn.fit(
    x=X_train,
    y=Y_train,
    batch_size=batch_size,
    epochs=nepochs,
    validation_data=(X_test, Y_test))
```

Activity Recognition (TS Classification)

```
def build_RNN(input_shape, num_classes):
    model = Sequential()
    model.add(InputLayer(shape=input_shape))
    model.add(SimpleRNN(units=64, return_sequences=True))
    model.add(SimpleRNN(units=32))
    model.add(Dense(num_classes, activation='softmax'))
    model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
    return model
```

```
model = build_RNN(input_shape=(128, 9), num_classes=6)
model.fit(X_train, y_train, batch_size=128, epochs=50)
```

Word Embedding

Word
Mapping of vocabulary of words into a n-dim vector space; $n \ll v$ where v the size of the vocabulary.

Encodes meaning of words so that words close in vector space are expected to have similar meanings

Sentiment Classification

Data preparation

Remove html tags Replace punctuation with a space Remove single characters Remove multiple spaces

Splitting

Shuffle and apply split ratio

Tokenization

Mapping the words to integers by using a vocabulary of the most frequent words. Words not in most frequent words are skipped. Select parameter to specify 'most frequent words'

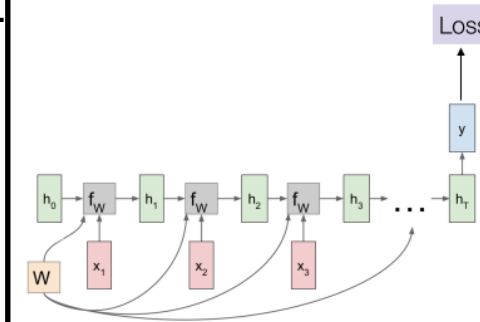
Cut and Pad

Cut and pad to fixed length. Select parameter with the sequence length.

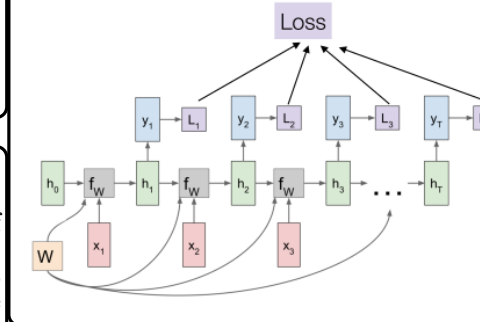
GenRNN

System able to generate new consistent data from a seed. By consistent, we mean respecting temporal or spatial "structures" that have been learned from the input space.

Many to One



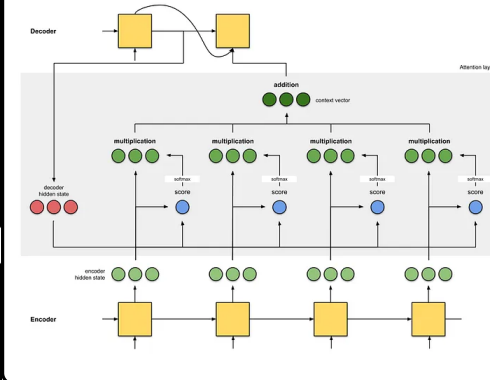
Many to Many



Attention

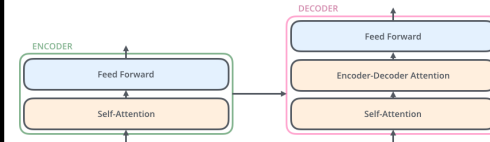
Sequence to Sequence

A Seq2Seq model is learning to map sequences of different length in situations where the entire input sequence is required in order to start predicting the target sequence. **Attention**



Transformer

High-Level Architecture

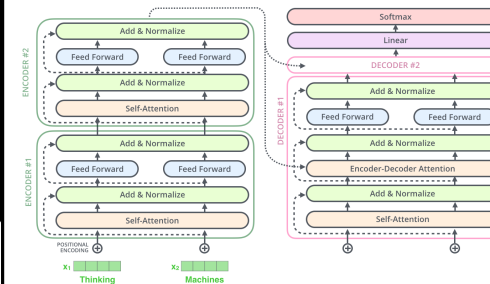


Self-Attention

A self attention layer implements an attention mechanism by looking at adjacent inputs to provide an enhanced representation of a current input.

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

Full Architecture



Bayes

$$P(C_k|x) = \frac{P(x|C_k) \cdot P(C_k)}{P(x)}$$

où

- C_k : Classe ciblée
- x : Évidence
- $P(C_k)$: Probabilité a priori de la classe C_k
- $P(x|C_k)$: probability of observing x given class j
- $P(C_k|x)$: Probabilité a posteriori de la classe C_k après observation de x
- $P(x)$: Probabilité de l'évidence x

avec

$$P(x) = \sum_{\text{toutes classes } C_k} P(x|C_k) \cdot P(C_k)$$

Classifier H/F:

- $P(C_f) = \frac{4}{70}, P(C_g) = \frac{66}{70}$
- $p(x|C_g) = 0.8, p(x|C_f) = 0.2$
- Calcul de $p(x)$:

$$p(x) = 0.2 \times \frac{4}{70} + 0.8 \times \frac{66}{70}$$

- Calcul de $P(C_f|x)$ et $P(C_g|x)$:
$$P(C_f|x) = \frac{0.2 \times \frac{4}{70}}{p(x)}, \quad P(C_g|x) = \frac{0.8 \times \frac{66}{70}}{p(x)}$$

(+)Can deal with imbalanced dataset, prior can be changed