## Autoencoder (Encode-Decode) - Overview

This example shows an autoencoder that encodes and reconstructs the input. After training the reduction from p -> k dimensions, the model decodes back to p. The better the training, the closer the reconstruction is to the original (low reconstruction error).

Prerequisites - Reticulate configured and Python with PyTorch installed - R packages: daltoolbox, tspredit, daltoolboxdp, ggplot2

Steps 1) Build time-series windows 2) Normalize data 3) Split into train and test 4) Train the AE (5 -> 3) and track losses 5) Reconstruct and compute metrics (R2, MAPE)

# Vanilla autoencoder transformation (encode-decode)  
  
# Considering a dataset with $p$ numerical attributes.  
  
# The goal of the autoencoder is to reduce the dimension of $p$ to $k$, such that these $k$ attributes are enough to recompose the original $p$ attributes. However from the $k$ dimensions the data is returned back to $p$ dimensions. The higher the autoencoder quality, the more similar is the output to the input.  
  
# Installing packages  
#install.packages("tspredit")  
#install.packages("daltoolboxdp")

# Loading packages  
library(daltoolbox)  
library(tspredit)  
library(daltoolboxdp)  
library(ggplot2)

# Example dataset (series -> windows)  
data(tsd)  
  
sw\_size <- 5  
ts <- ts\_data(tsd$y, sw\_size)  
  
ts\_head(ts)

## t4 t3 t2 t1 t0  
## [1,] 0.0000000 0.2474040 0.4794255 0.6816388 0.8414710  
## [2,] 0.2474040 0.4794255 0.6816388 0.8414710 0.9489846  
## [3,] 0.4794255 0.6816388 0.8414710 0.9489846 0.9974950  
## [4,] 0.6816388 0.8414710 0.9489846 0.9974950 0.9839859  
## [5,] 0.8414710 0.9489846 0.9974950 0.9839859 0.9092974  
## [6,] 0.9489846 0.9974950 0.9839859 0.9092974 0.7780732

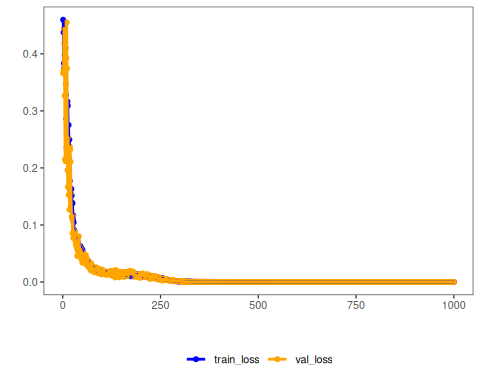
# Normalization (min-max by group)  
preproc <- ts\_norm\_gminmax()  
preproc <- fit(preproc, ts)  
ts <- transform(preproc, ts)  
  
ts\_head(ts)

## t4 t3 t2 t1 t0  
## [1,] 0.5004502 0.6243512 0.7405486 0.8418178 0.9218625  
## [2,] 0.6243512 0.7405486 0.8418178 0.9218625 0.9757058  
## [3,] 0.7405486 0.8418178 0.9218625 0.9757058 1.0000000  
## [4,] 0.8418178 0.9218625 0.9757058 1.0000000 0.9932346  
## [5,] 0.9218625 0.9757058 1.0000000 0.9932346 0.9558303  
## [6,] 0.9757058 1.0000000 0.9932346 0.9558303 0.8901126

# Train / test split  
samp <- ts\_sample(ts, test\_size = 10)  
train <- as.data.frame(samp$train)  
test <- as.data.frame(samp$test)

# Training autoencoder (reduction 5 -> 3)  
auto <- autoenc\_ed(5, 3)  
auto <- fit(auto, train)

# Loss curves (train and validation)  
fit\_loss <- data.frame(x=1:length(auto$train\_loss), train\_loss=auto$train\_loss, val\_loss=auto$val\_loss)  
  
grf <- plot\_series(fit\_loss, colors=c('Blue','Orange'))  
plot(grf)



# Testing: reconstruction of the test set  
print(head(test))

## t4 t3 t2 t1 t0  
## 1 0.7258342 0.8294719 0.9126527 0.9702046 0.9985496  
## 2 0.8294719 0.9126527 0.9702046 0.9985496 0.9959251  
## 3 0.9126527 0.9702046 0.9985496 0.9959251 0.9624944  
## 4 0.9702046 0.9985496 0.9959251 0.9624944 0.9003360  
## 5 0.9985496 0.9959251 0.9624944 0.9003360 0.8133146  
## 6 0.9959251 0.9624944 0.9003360 0.8133146 0.7068409

result <- transform(auto, test)  
print(head(result))

## [,1] [,2] [,3] [,4] [,5]  
## [1,] 0.7269621 0.8296570 0.9120550 0.9724615 0.9985892  
## [2,] 0.8333948 0.9124585 0.9698439 0.9990059 0.9951831  
## [3,] 0.9194384 0.9709096 0.9995622 0.9941100 0.9601757  
## [4,] 0.9705135 0.9962037 0.9963565 0.9604343 0.9010125  
## [5,] 0.9934939 0.9937090 0.9607359 0.8994752 0.8147804  
## [6,] 0.9888072 0.9625454 0.8983132 0.8134072 0.7071778

# Evaluating reconstruction quality: R2 and MAPE per attribute  
result <- as.data.frame(result)  
names(result) <- names(test)  
r2 <- c()  
mape <- c()  
for (col in names(test)){  
 r2\_col <- cor(test[col], result[col])^2  
 r2 <- append(r2, r2\_col)  
 mape\_col <- mean((abs((result[col] - test[col]))/test[col])[[col]])  
 mape <- append(mape, mape\_col)  
 print(paste(col, 'R2 test:', r2\_col, 'MAPE:', mape\_col))  
}

## [1] "t4 R2 test: 0.99876993799842 MAPE: 0.00454560638952058"  
## [1] "t3 R2 test: 0.999730303032115 MAPE: 0.00235502369008514"  
## [1] "t2 R2 test: 0.999948741512537 MAPE: 0.00191139875262249"  
## [1] "t1 R2 test: 0.999919491869453 MAPE: 0.00317583286328251"  
## [1] "t0 R2 test: 0.999981843431408 MAPE: 0.00228308024152542"

print(paste('Means R2 test:', mean(r2), 'MAPE:', mean(mape)))

## [1] "Means R2 test: 0.999670063568787 MAPE: 0.00285418838740723"