## Variational Autoencoder (encode-decode)

The VAE uses an encoder to parameterize a latent distribution and a decoder to reconstruct inputs from latent samples. Training optimizes an evidence lower bound with reconstruction and KL divergence terms, shaping a smooth, regularized latent space.

This example uses a Variational Autoencoder (VAE) to encode windows of a time series (p -> k) and reconstruct them (k -> p). We evaluate reconstruction quality at the end.

Prerequisites - Python with PyTorch accessible via reticulate - R packages: daltoolbox, tspredit, daltoolboxdp, ggplot2

# Installing example dependencies (if needed)  
#install.packages("tspredit")  
#install.packages("daltoolboxdp")

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

# Example dataset (series -> windows)  
data(tsd)  
  
sw\_size <- 5 # sliding window size (p)  
ts <- ts\_data(tsd$y, sw\_size) # convert series into windows with p columns  
  
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

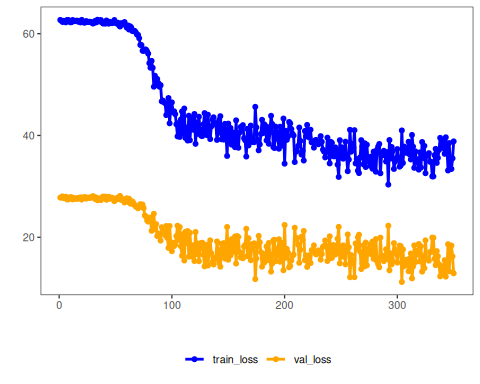
# Normalization (min-max by group)  
preproc <- ts\_norm\_gminmax()  
preproc <- fit(preproc, ts)  
ts <- transform(preproc, ts)  
  
ts\_head(ts)

## 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)

# Creating the VAE (encode-decode): 5 -> 3 -> 5 dimensions  
auto <- autoenc\_variational\_ed(5, 3, num\_epochs = 350)  
  
# Training the model  
auto <- fit(auto, train)

# Learning curves (total loss per epoch)  
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 the VAE (reconstruction)  
# Show samples from the test set and the reconstruction (p columns)  
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,] 0.7533972 0.8619918 0.9191276 0.9443331 0.9537569  
## [2,] 0.8909496 0.9401729 0.9616017 0.9683594 0.9671394  
## [3,] 0.9328234 0.9585398 0.9684950 0.9688181 0.9608278  
## [4,] 0.9491552 0.9606449 0.9621298 0.9535940 0.9298517  
## [5,] 0.9495365 0.9523126 0.9444267 0.9215984 0.8696570  
## [6,] 0.9537395 0.9427686 0.9148628 0.8562292 0.7377717

# Reconstruction metrics per column: R2 and MAPE  
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: 0.91550614863017 MAPE: 0.0312319884569728"  
## [1] "t3 R2 test: 0.967642441595765 MAPE: 0.0233391412946862"  
## [1] "t2 R2 test: 0.986357779963362 MAPE: 0.0236923571012776"  
## [1] "t1 R2 test: 0.986031499307736 MAPE: 0.0405009356717352"  
## [1] "t0 R2 test: 0.986768460590105 MAPE: 0.0539099894580779"

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

## [1] "Means R2 test: 0.968461266017428 MAPE: 0.0345348823965499"

References - Kingma, D. P., & Welling, M. (2014). Auto-Encoding Variational Bayes. ICLR.