variational autoencoder (VAE) (encode-decode): A variational autoencoder (VAE) learns a probabilistic latent space and reconstructs windows; high reconstruction error (and uncertainty) signals anomalies. Errors are summarized and thresholded using harutils().

Objectives: This Rmd demonstrates anomaly detection with a variational autoencoder (han\_autoencoder(..., autoenc\_variational\_ed, ...)). The VAE learns a probabilistic latent space; reconstruction error (and uncertainty) can indicate anomalies. Steps: load packages/data, visualize, define the architecture/epochs, fit, detect, evaluate, and plot.

# Load required packages  
library(daltoolbox)  
library(harbinger)   
library(daltoolboxdp)

# Load example datasets bundled with harbinger  
data(examples\_anomalies)

# Select a simple synthetic time series with labeled anomalies  
dataset <- examples\_anomalies$simple  
head(dataset)

## serie event  
## 1 1.0000000 FALSE  
## 2 0.9689124 FALSE  
## 3 0.8775826 FALSE  
## 4 0.7316889 FALSE  
## 5 0.5403023 FALSE  
## 6 0.3153224 FALSE

# Plot the time series  
har\_plot(harbinger(), dataset$serie)



# Define variational autoencoder-based detector (autoenc\_variational\_ed)  
 model <- han\_autoencoder(3, 2, autoenc\_variational\_ed, num\_epochs = 1500)

# Fit the model  
 model <- fit(model, dataset$serie)

# Detect anomalies (reconstruction error -> events)  
 detection <- detect(model, dataset$serie)

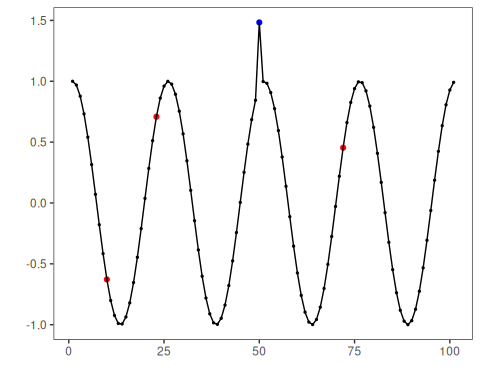
# Show only timestamps flagged as events  
 print(detection |> dplyr::filter(event==TRUE))

## idx event type  
## 1 10 TRUE anomaly  
## 2 23 TRUE anomaly  
## 3 72 TRUE anomaly

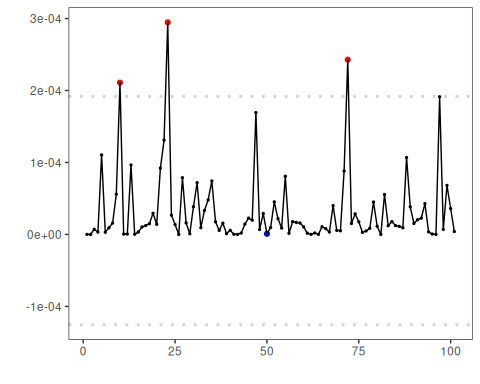
# Evaluate detections against ground-truth labels  
 evaluation <- evaluate(model, detection$event, dataset$event)  
 print(evaluation$confMatrix)

## event   
## detection TRUE FALSE  
## TRUE 0 3   
## FALSE 1 97

# Plot detections over the series  
 har\_plot(model, dataset$serie, detection, dataset$event)



# Plot residual scores and threshold  
 har\_plot(model, attr(detection, "res"), detection, dataset$event, yline = attr(detection, "threshold"))



References - Sakurada, M., Yairi, T. (2014). Anomaly Detection Using Autoencoders with Nonlinear Dimensionality Reduction. MLSDA 2014.