Surrogate Loss Learning for Dynamic Time Warping(DTW)

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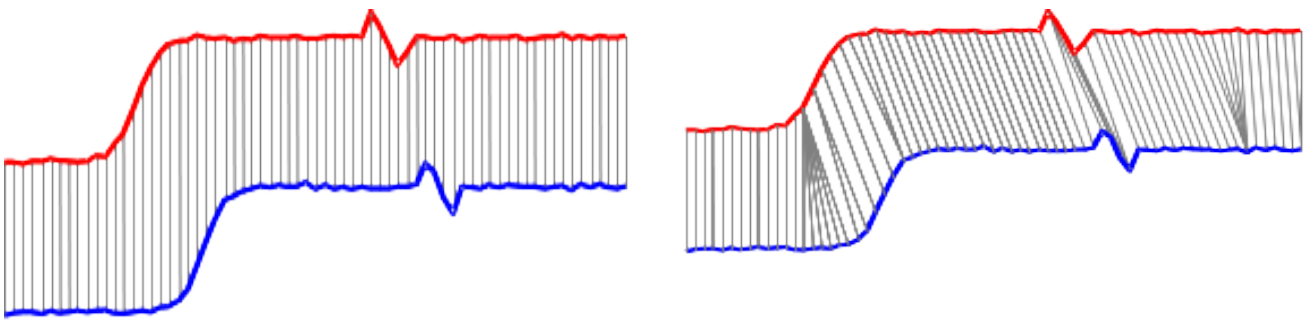
Agenda

Motivation



(a) Euclidean Distance (b) Dynamic Time Warping

- **Dynamic Time Warping(DTW)** is a technique used to quantify the similarity between two time sequences varying in speed and length.
- DTW is used as an evaluation metric in time series forecasting.
- Can be applied to irregular time series.

Motivation

DTW Method:

- Calculate for each point in the series an easy distance (e.g. Euclidean).
- Iterate back through the series and add also the distance to the nearest a adjacent point.

For any two time-series,

$$X = (x_1, x_2, ..., x_N)$$

and

$$Y = (y_1, y_2, ..., y_M)$$

we compute a distance(cost) matrix as:

$$c_{i,j} = d(x_i, y_i) + min\{c(i-1, j-1), c(i, j-1), c(i-1, j)\}$$

Motivation

Research has manifested that we can use a metric as a loss function.

Problem: *DTW is non-differentiable because of* ***'min'*** *operation.*
Solution: *Surrogate Losses are a superior option.*

Goal: Develop a surrogate model which depicts DTW loss function as a meta-level neural network.

- Surrogate Loss network will be trained before forecasting model.

Literature Review

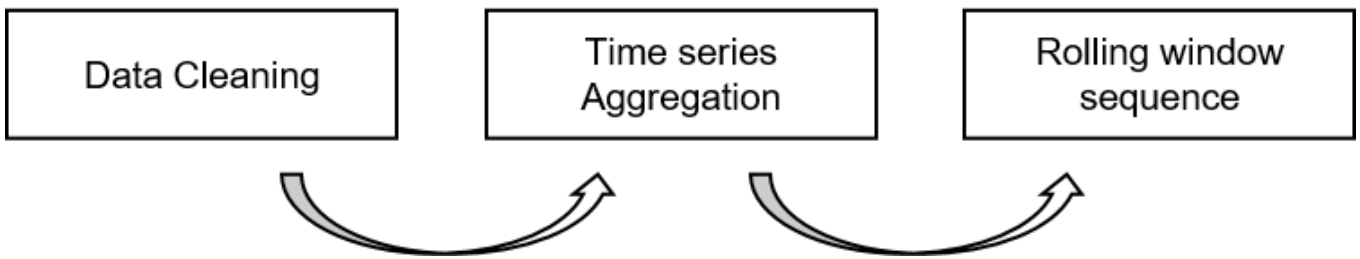
In time series forecasting following loss functions are used:

- MAE:
- MAPE
- MSE
- soft-DTW *

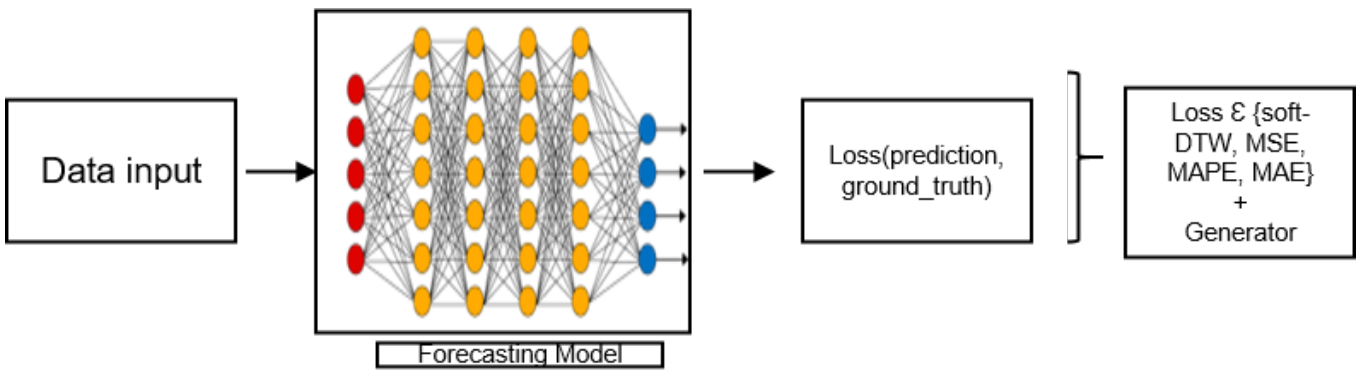
*soft-DTW: a differentiable loss function version of DTW which is highly depedent on hyperparameter λ.
Given as: $dtw_\gamma(x, y) := min_\gamma\{\langle A, \Delta(x, y)\rangle, A \epsilon A_{n,m}\}$.

Research Idea

Pre-processing

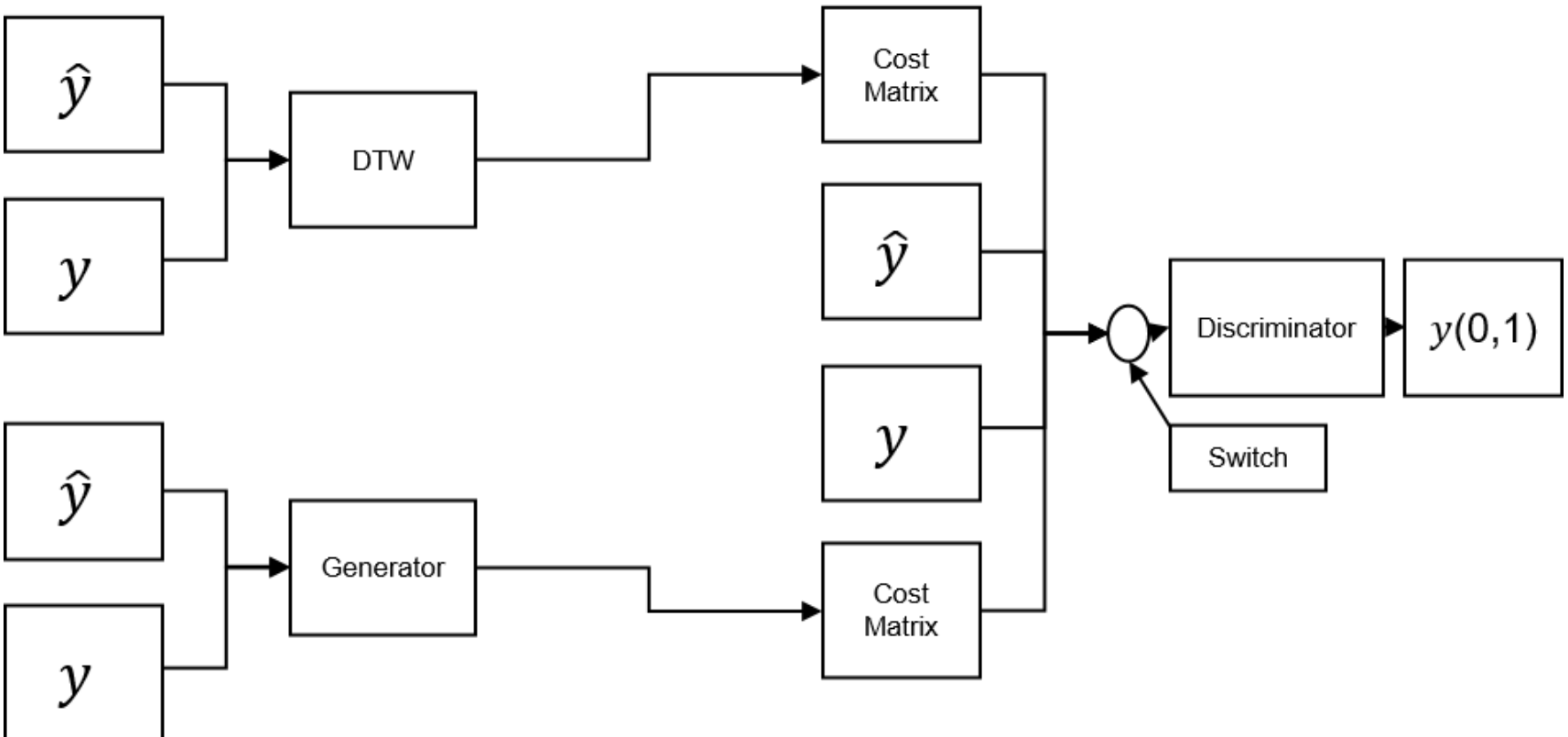


Baseline Idea



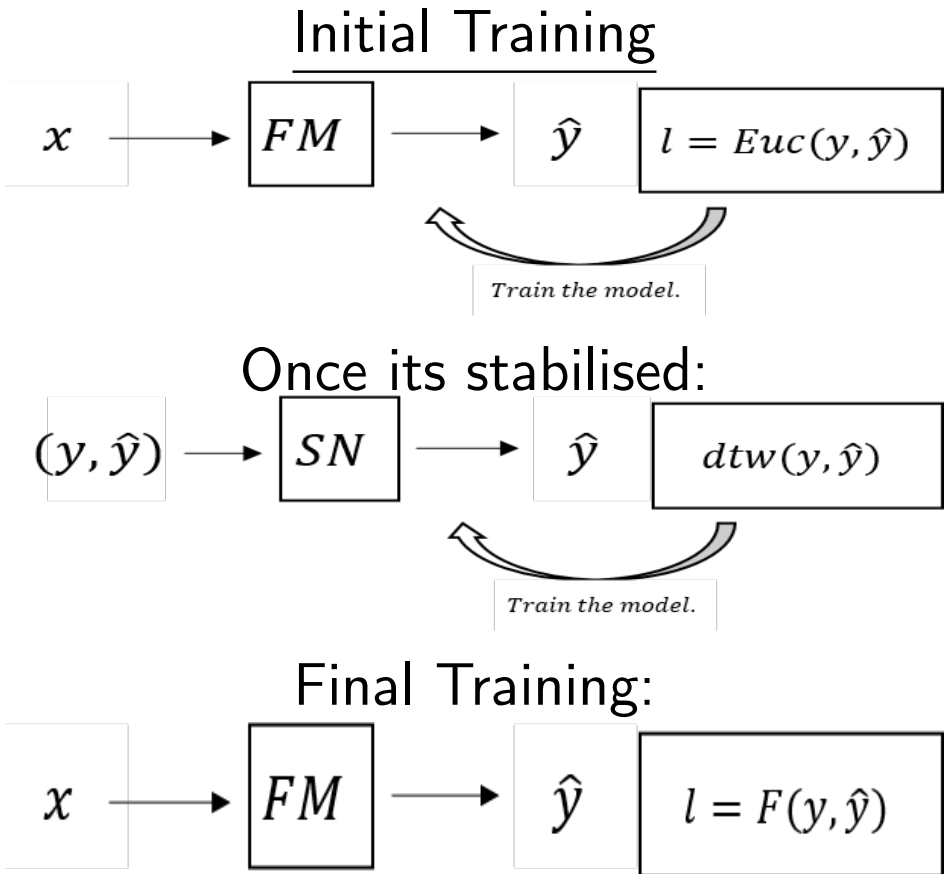
Research Idea

Proposed Model for Surrogate Loss Network- GAN:



Research Idea

Meta-data for training Surrogate Loss Network:
Forecasting Model → FM, Surrogate Function → SF,Input → X, Prediction → Y



Data Foundation

Public Data-sets:

- Traffic
- Electricity
- Retail

Private/ Company Data-set:
RBB Data-streams

Data Foundation

Dataset	Description	Prediction horizon	Properties	Pre-processing
Electricity Dataset	UCI Electricity Load Diagrams Dataset, containing electricity consumption of 370 customers	Use past week's data to forecast over the next 24 hours.	Target Type: R No. Of columns: 370 No. Of samples: 500k	Aggregate on hourly level.
RBB Data-streams	Time-related sensored data from production machinery.	Use past year's data to forecast over the next week.	Target Type: R No. Of columns: 165 No. Of samples: 17k	Aggregate on daily level.
Traffic Dataset	UCI PEM-SF Traffic Dataset which describes occupancy rate of 440 San Francisco Bay Area Freeways.	Use past week's data to forecast over the next 24 hours.	Target Type: $[0, 1]$ No. Of columns: 370 No. Of samples: 500k	Aggregate on hourly level.
Retail Dataset	Favorita Grocery Sales Dataset from the Kaggle competition is a metadata for different products and the stores sampled at the daily level.	Use 90 days of past data to forecast product sales of 30 days into the future.	Target Type: R No. Of columns: 130k No. Of samples: 500k	Use daily data.

Evaluation

Performance Evaluation:

- We evaluate the performances of proposed model, and compare it against above mentioned baselines.
- The results are evaluated using following metrics:
  1. DTW
  2. MSE

References

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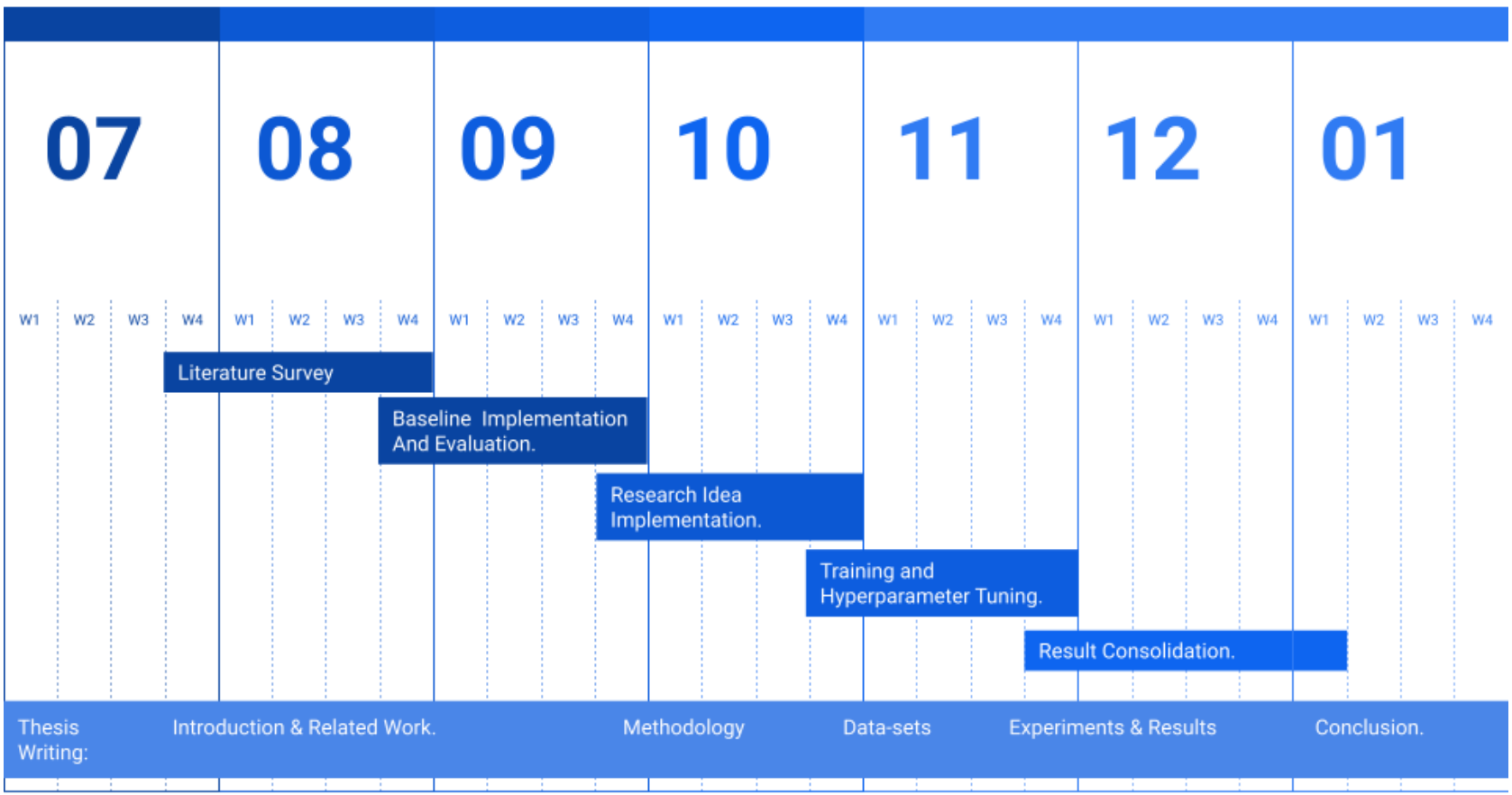
- Grabocka, Josif, Randolf Scholz, and Lars Schmidt-Thieme. Learning surrogate losses, arXiv:1905.10108 (2019).
- Lamb Alex et al, Professor Forcing: A New Algorithm for Training Recurrent Networks 2016(https://arxiv.org/abs/1610.09038)
- Electricity Data-set: https://archive.ics.uci.edu/ml/datasets/ElectricityLoadDiagrams20112014

References

- Traffic Data-set: http://pems.dot.ca.gov/
- Favorita Data-set: https://www.kaggle.com/c/favorita-grocery-sales-forecasting/data
- RBB-Dataset: MunichRE

Timeline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Literature Survey
Baseline Implementation And Evaluation.
Research Idea Implementation.
Training and Hyperparameter Tuning.
Result Consolidation.
Thesis Writing:
Introduction & Related Work.
Methodology
Data-sets
Experiments & Results
Conclusion.