FaultNet

A Deep Learning Framework for the Analysis of Status of Heath Data at the NDC

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T4.2-02

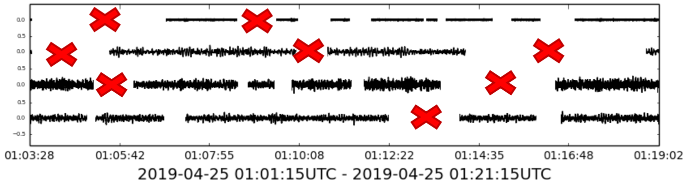
Overview

- Status of Health (SOH) Need
- SOH Foundation
- SOH Evolution
- Dataset Description
- Static Thresholds
- Project Objective
- FaultNet Framework
- Deep Learning Model
- Results
- Questions

SOH Need

Data gaps plague NDC's each year

- Often caused by equipment failures:



Power

_Voltage

Comm

_RSSI

Sensor

_Timeouts

Digitizer

_Latency

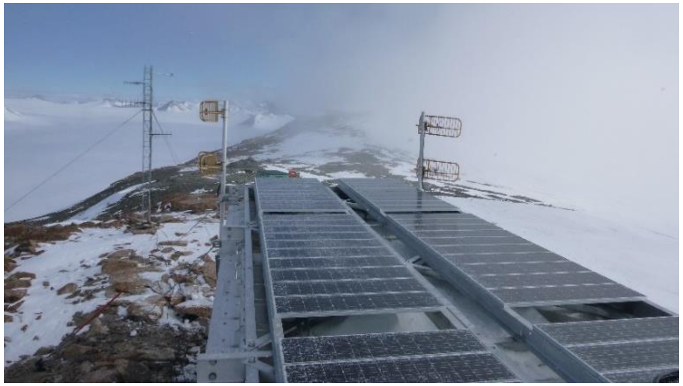
GPS

_PPS

Data loss must not be first indication of a problem!

SOH Foundation

- Enterprise communication upgrade
  - Enable battery backup capability
  - Current & future system interoperability
  - Worldwide remote communication
- Engineering shift “smart” IoT devices
  - Radios, charge controllers, micro controllers, monitoring devices…



Enable early detection of problems

SOH Evolution

- Exploratory – manual analysis on individual data sets
  - Input power outage
  - RF transmission degradation
  - Remote engineering studies
- Conditional-based – manual analysis on stacked data sets
  - Battery refreshment
  - Maintenance frequency (VSWR)
- Automated operation – automated analysis on stacked data sets
  - Alarm on threshold exceptions

Transforming data into information requires expert knowledge

SOH Dataset

- Dataset
  - 2+ years of SOH data
  - 13 SOH streams
  - 148 sensor sites
- Diverse Sources
  - Radios
  - Chargers
  - Digitizers
  - NDC Databases
- Using Nagios XI
  - 5 min resolution
  - 5700 service checks
  - 1900 host checks

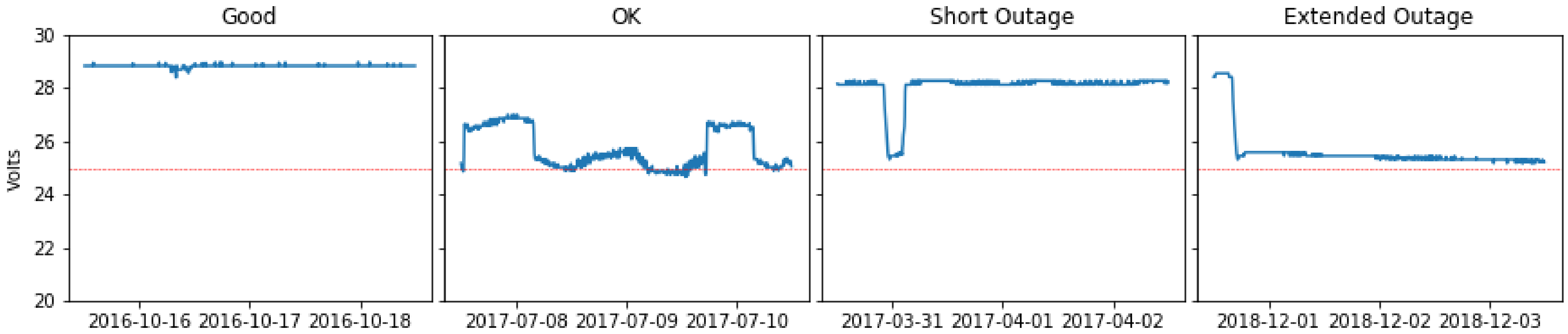
Name	Type	Description
Latency_to_IDC	FLOAT	Delay in seconds between data timestamp and arrival at the IDC
Data_Received	FLOAT	Seconds of data received at the IDC during the previous 5 minutes
CIM3_Timeouts	INT	Number of times the CIM3 had to re-request data from the digitizer
Latency_to_Station_Processor	FLOAT	Delay in seconds between data timestamp and arrival at the station processor
GPS_Antenna_Detected	BOOL	GPS antenna is connected to digitizer
GPS_PPS_Signal	BOOL	GPS is receiving valid pps
GPS_Set_Time	BOOL	GPS time is reset
Intrusion_Alarm_I0	FLOAT	Intrusion alarm zero is activated
CIM3_Receive_Rejects	INT	Number of times the station processor has to re-request data from the CIM3
Intrusion_Alarm_I1	BOOL	Intrusion alarm one is activated
Radio_RSSI	FLOAT	Radio receive signal strength indicator
Radio_Board_Temperature	FLOAT	Radio board temperature in degrees Celsius
Radio_Voltage	FLOAT	Radio voltage in volts

Here, we focus on the Battery Voltage at the Radio

Static Thresholds

AFTAC currently uses Static Threshold Alarms:

- Can not effectively account for location differences:
  - Good is what we want
  - OK is what we get, no actionable alerts
  - Short Outage goes undetected
  - Extended outage takes too long to alert



Static Thresholds don't work

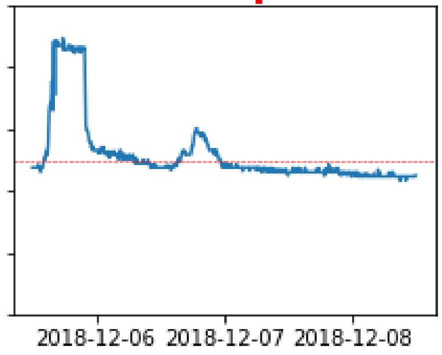
Objective

FaultNet Objectives:

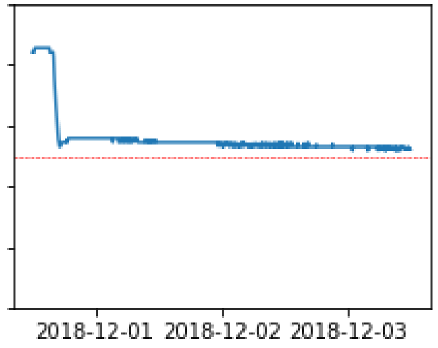
1. Build a Deep Learning (DL) framework for the analysis of SOH data at NDC
2. Build binary classifier for alarm conditions vs normal operation

Alarm Conditions for Battery Voltage:

Photovoltaic Power Outage Example



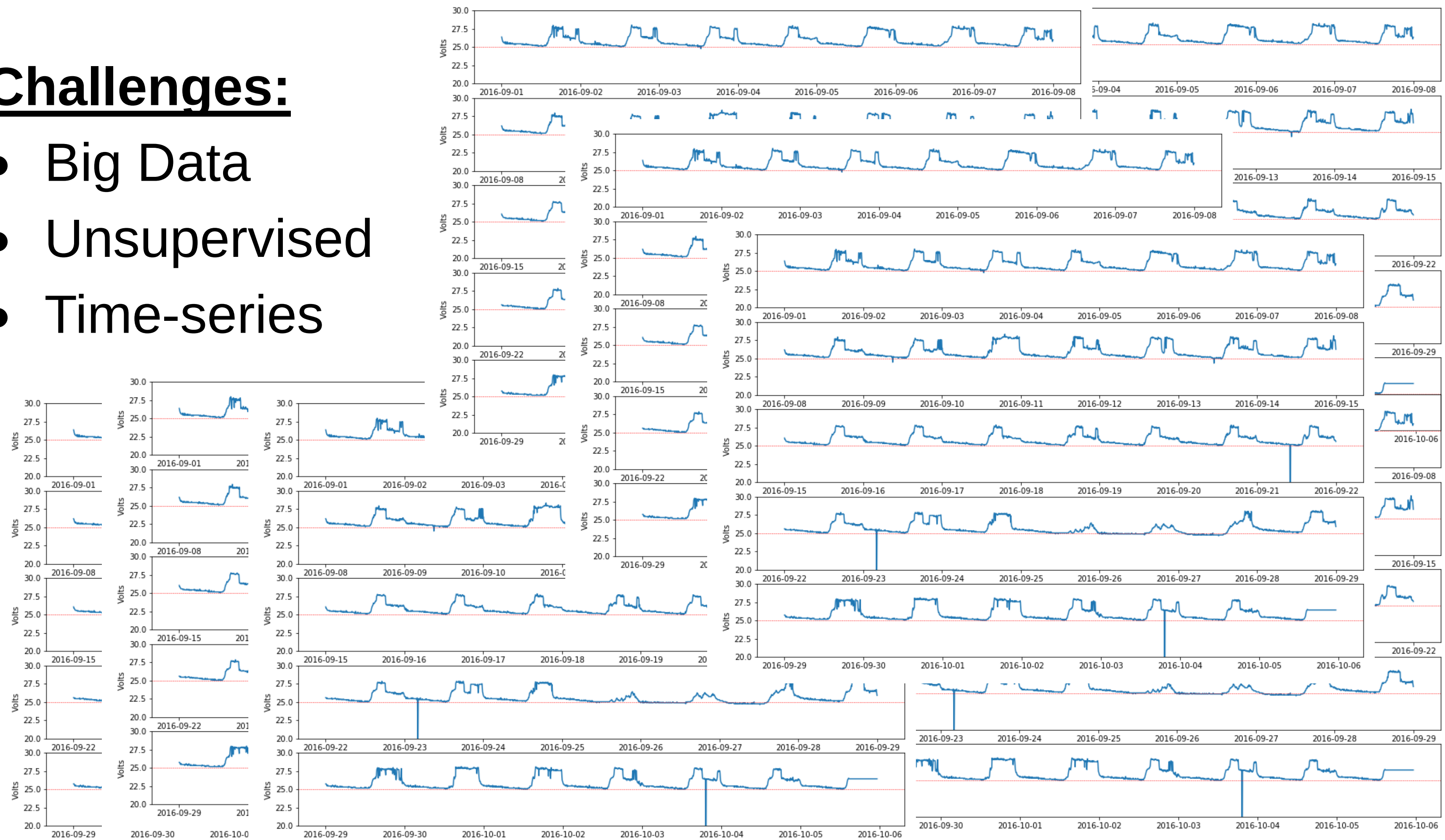
Commercial Power Outage Example



Real-Time SOH Diagnostics

Challenges:

- Big Data
- Unsupervised
- Time-series



Unsupervised ML for time-series is an active area of research with many challenges

FaultNet Framework

AI-centric toolkit for rapid exploration, clustering and classification

Raw Time-series

Feature-Rich Encodings

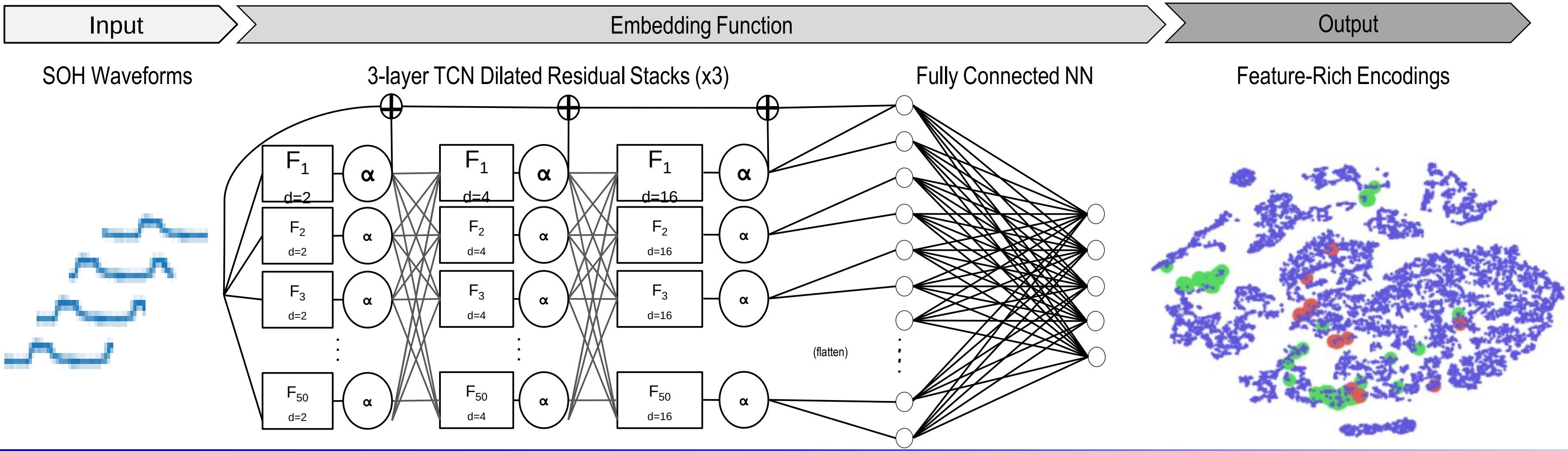
Siamese-Shift Encoder

Siamese-Shift Encoder:

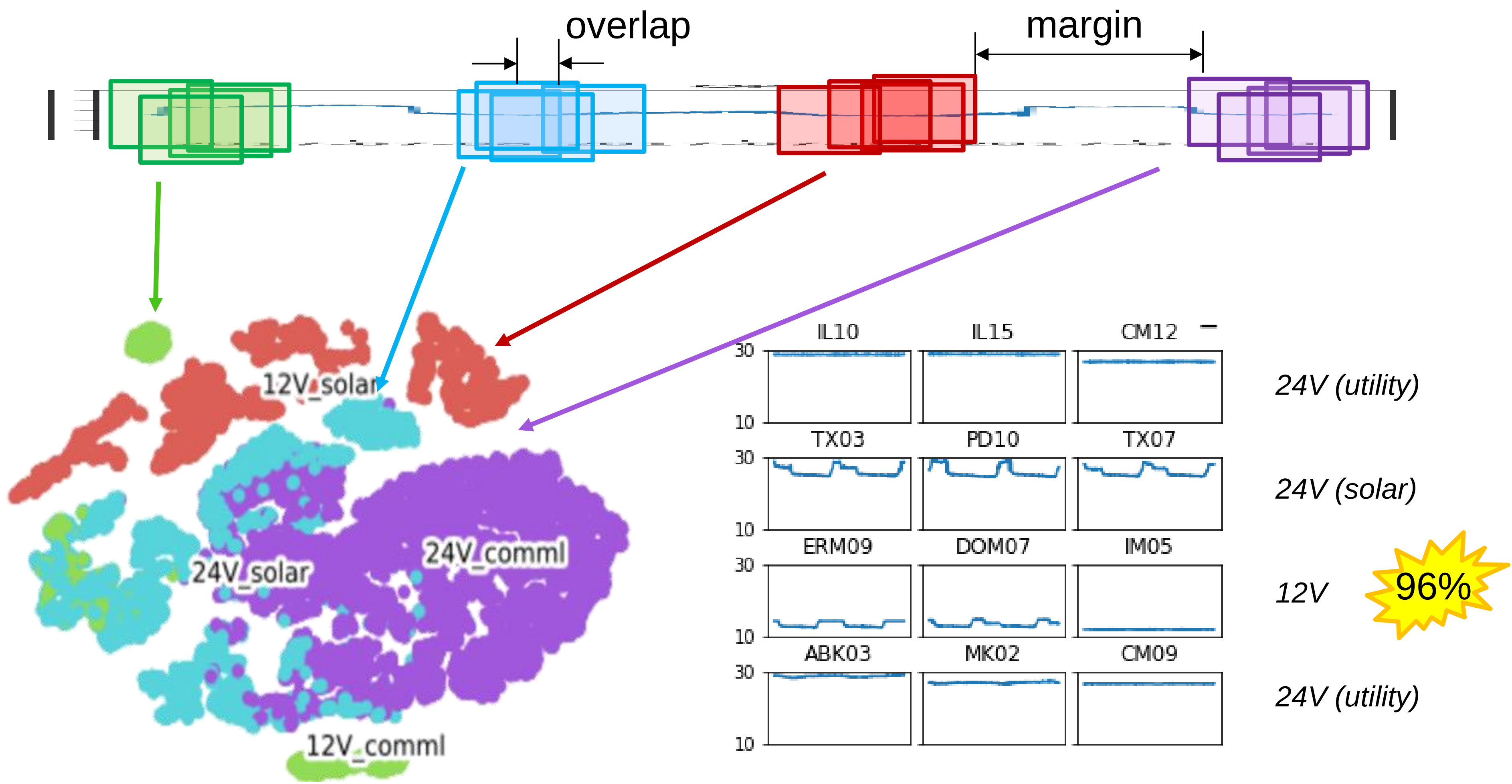
- Input: raw unlabeled time-series
- Output: feature-rich, low-dim, self-organized, Euclidean encoding space
- Encodings are optimized to be meaningful to the application

Deep Neural Network Architecture:

- WaveNet model from audio processing
- Residual and Skip connections from computer vision
- Siamese Architecture from Facial Recognition (Batch-Hard Loss)



Batch-hard Encoding



Machine-Encoded Clusters **Expert Assigned Labels**

Cluster Analysis

Shift-encoded Clusters

Visually Assigned Labels

12V PV (good)

24V AC (good)

24V PV (good)

24V PV (cloudy)

24V PV (cloudy)

24V PV (cloudy)

24V PV (outage)

24V AC (poor)

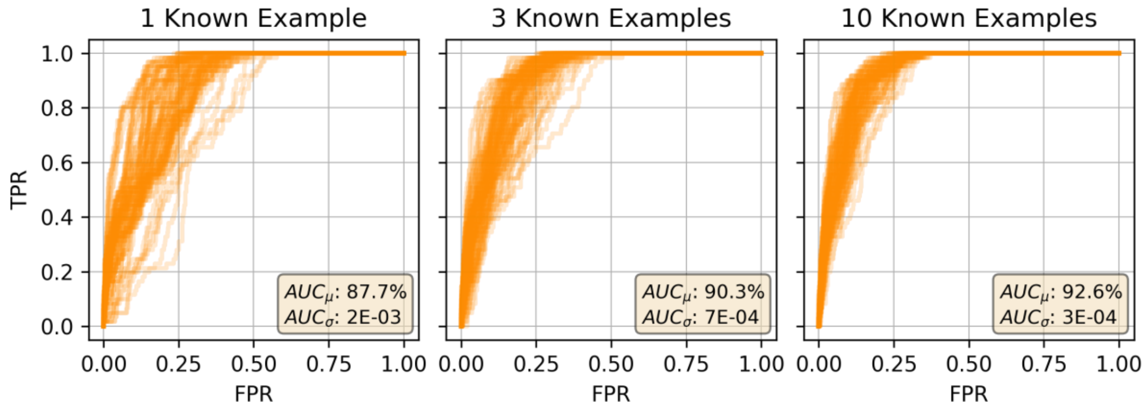
24V AC (outage)

Excellent intra-cluster homogeneity and inter-cluster distinction

Fault Detection Results

- **With 10 templates and**
- **0.05 Type-I error rate**

- **Acc: 93%**
- **Recall: 64%**
- **Precision: 43%**

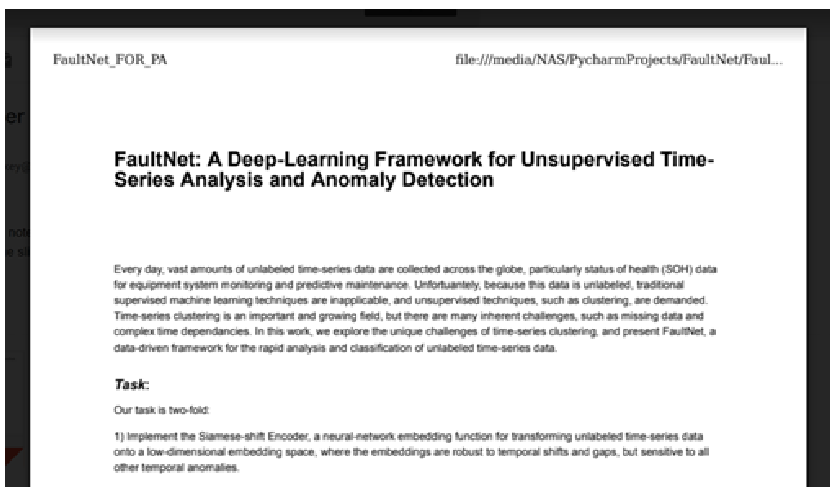


Effective Fault Detection with as few as 10 fault templates.

Code Availability

- **Full Code Made Available on Github:**
  - Jupyter Notebook w/ detailed exploration
  - Easily adaptable to ***your*** unlabeled data!

https://github.com/joshuadickey/FaultNet



FaultNet_FOR_PA file:///media/NAS/PycharmProjects/FaultNet/Faul...

FaultNet: A Deep-Learning Framework for Unsupervised Time-Series Analysis and Anomaly Detection

Every day, vast amounts of unlabeled time-series data are collected across the globe, particularly status of health (SOH) data for equipment system monitoring and predictive maintenance. Unfortuantely, because this data is unlabeled, traditional supervised machine learning techniques are inapplicable, and unsupervised techniques, such as clustering, are demanded. Time-series clustering is an important and growing field, but there are many inherent challenges, such as missing data and complex time dependancies. In this work, we explore the unique challenges of time-series clustering, and present FaultNet, a data-driven framework for the rapid analysis and classification of unlabeled time-series data.

Task:

Our task is two-fold:

1) Implement the Siamese-shift Encoder, a neural-network embedding function for transforming unlabeled time-series data onto a low-dimensional embedding space, where the embeddings are robust to temporal shifts and gaps, but sensitive to all other temporal anomalies.

Questions?

FaultNet
SnT 2019
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https://github.com/joshuadickey/FaultNet