Integrated Dimensionality Reduction and Sequence Prediction using LSTM

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Integrated Dimensionality Reduction and Sequence Prediction using LSTM

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Problem
- Most industrial or complex processes present temporal dependencies which stretch over a long time.
- The underlying patterns in these processes can be extremely non-linear.
- Use of linear predictive model (ARMA/ARIMA[1]) is not suitable.
- Hidden Markov Model[2] has prediction limitation when dealing with temporal dependencies that stretch over long durations.

Objectives
- Use of external and a proposed integrated dimensionality reduction LSTM predictive systems for predicting message logs from industrial machines.
- Conversion of nominal codes (raw codes) to other vectorial paradigms to obtain better correlated patterns.

Methods
- External Methods: Recurrent Neural Networks (RNN) [3-7]
- Proposed Method: Integrated Dimensionality-reduction LSTM

Results
- ID-LSTM Prediction on OHE codes during training and testing phases (left plot) and index predictions (right plot) over a duration of 10K time-counts.

Data Representations
- One-hot-Encoding Codes
- 3-DIM: Principal Component Analysis (PCA) Codes

Future Directions
- We suggest that it may be possible to combine the proposed model with an early anomaly detection algorithm.
- To allow continuous prediction of physical problems in the machines generating the message logs.
- Optimization of LSTM-based feature dimensionality reduction in a realistically large dataset.

Conclusion
- We have transformed nominal codes to other vectorial representations with the objective of identifying correlated patterns using one hot encoding (OHE) and principal component analysis (PCA).
- Nominal integer codes are not sensible to use in the RNN.
- A separate dimensionality reduction by PCA is not needed: the ID-LSTM uses 10 hidden dimensions in the bottleneck layer.
- The ID-LSTM on OHE codes yield the best result on a small sample dataset.
- The use of ID-LSTM also obtains good results on reduced dimension PCA vector codes (20-DIM-PCA).
- The ID-LSTM obtained < 5% error on the predicted OHE codes in a realistically large dataset.

References

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