Methods to Improve
Multi-Step Time Series Prediction

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Introduction

- A time series is an ordered set of data points indexed in time.
- Examples of time series data:
  - Sensor readings in manufacturing processes
  - Stock closing value
  - Temperature of a city
  - Traffic flow in a road
  - Video data

Time Series Prediction

Time-series prediction refers to the problem of predicting the future of sequential data based on some finite history.

$$x(t) \longrightarrow \boxed{\text{Predictor}} \longrightarrow x(t+1)$$
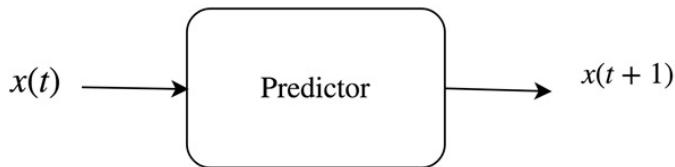
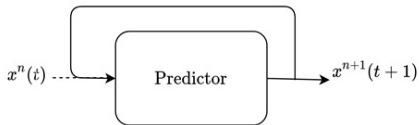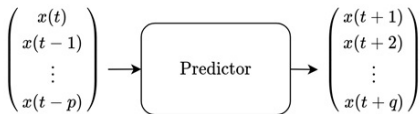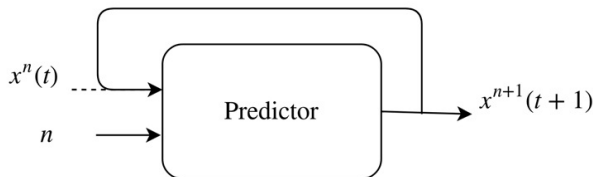# Multi-step Time Series Prediction

Figure 1: Recursive

Figure 2: Multi-output

Proposed Approaches: Conditional-DaD (C-DaD)

- An extension to Data as Demonstrator (DaD) algorithm [Venkatraman et al., 2015]
- We augment the data with with the current time-step in the recursive process
- The model learns to compensate for deviations based on forecasting time-step
- We call this extension Conditional-DaD (C-DaD)

Proposed Approaches: Conditional-GAN (C-GAN)

- Recently people have begun using generative adversarial networks (GAN) to augment training data with additional samples
- We propose to use a similar strategy in the context of multi-step time series prediction, generating paired history-future samples and aggregating them with the original dataset
- The generated data are conditioned on the future: we want to generate possible histories of a time series given a known future
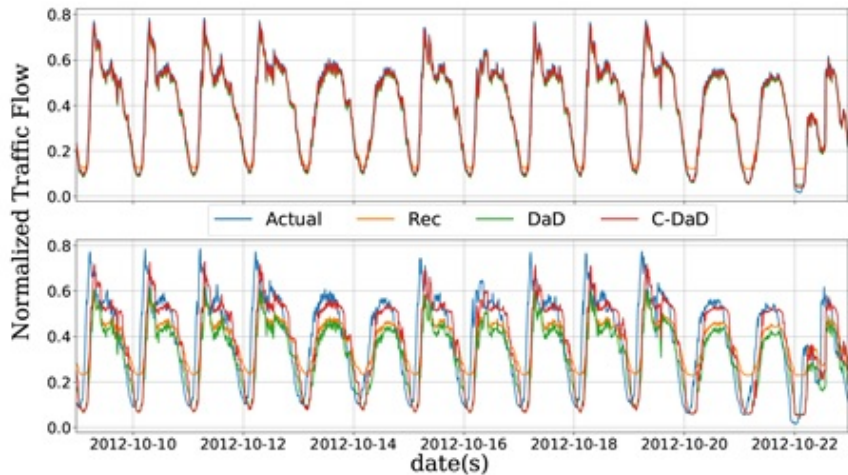- We call this approach conditional-GAN (C-GAN)
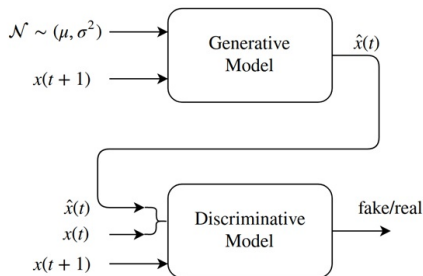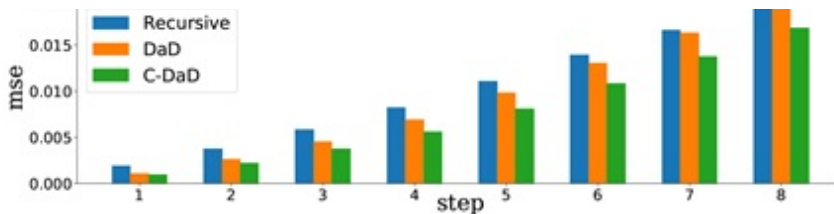
Experimental Results: Dataset

Traffic flow:

- District 4, Bay Area, San Francisco.
- Dataset covers the duration between January 1st 2011 -– December 31st 2012.
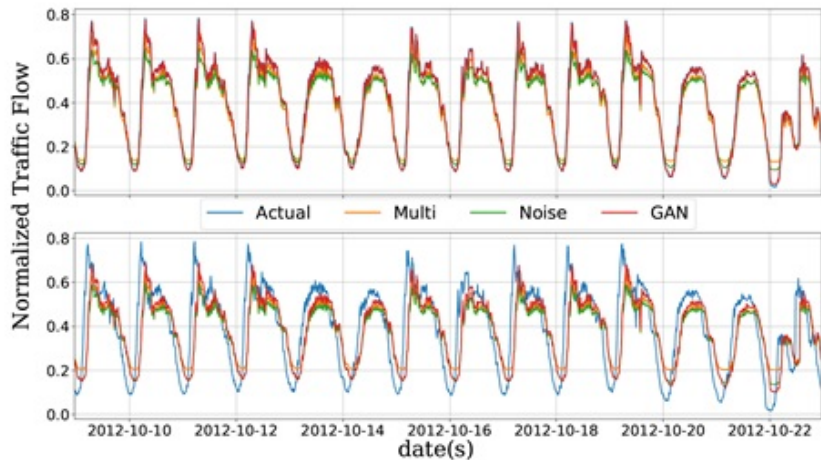
Experimental Results: Recursive Strategy
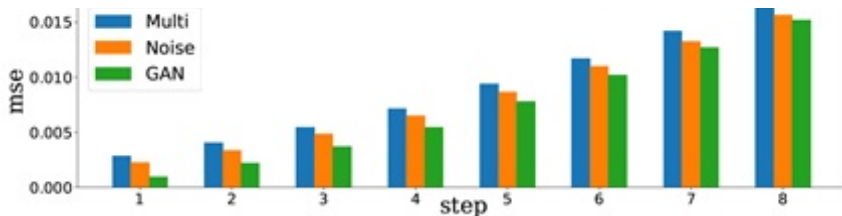
Experimental Results: Recursive Strategy

Perf. Models	MSE	% Improv.
Recursive	0.0101	-
DaD	0.0092	8.16
C-DaD	0.0078	22.92

Experimental Results: Multi-Output Strategy

Experimental Results: Multi-Output Strategy

Models	Perf. MSE	% Improv.
Multi	0.0089	-
Noise	0.0082	8.13
GAN	0.0072	18.47

Summary

- Introduced two approaches to improve multi-step time series prediction
- C-DaD was shown to improve recursive prediction models
- C-GAN was used to improve multi-output performance

References

Arun Venkatraman, Martial Hebert, and J. Andrew Bagnell. Improving multi-step prediction of learned time series models. In *Proceedings of the Twenty-Ninth AAAI Conference on Artificial Intelligence*, AAAI'15, pages 3024–3030. AAAI Press, 2015. ISBN 0-262-51129-0. URL http://dl.acm.org/citation.cfm?id=2888116.2888137.