Prediction and Inverse Problems in Dynamical Systems

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August 3, 2014

Introduction

Extracting information from unlabeled data remains the main challenge of unsupervised learning. In this work we consider semi-supervised learning, in which one observes the evolution of a dynamical system and attempts to learn through the underlying dynamics. The main strategy to understand the dynamics is by linearizing them through an appropriate non-linear representation.

This work considers the setting of speech and temporal video data. There are two main taks we are interested in: prediction and source separation/denoising. Other works on NLP have shown that training systems to perform prediction is a very effective surrogate that can be applied to other tasks, such as recognition. On the other hand, source separation is a major application of speech representations that requires exploiting the temporal coherence of different sources.

Dynamics can be learnt with a variety of models. The simplest are Kalman Filter and Hidden Markov Models, which learn dynamics in the form of linear equations, assuming Gaussian distributions in the former and discrete variables in the latter. On the other hand, recent works on speech and natural language processing have developed Recurrent Neural Networks (RNNs), which the capacity to learn more complex nonlinear dynamics.

Our objective is to develop a model which progressively moves from linear to RNNs, which keeps the interpretability but also handles non-linear dynamics. Since we are interested in inverse problems, models need to be generative.

1 General Model

2 Examples: Newton Dynamics, Jitter

3 Pooling and Scattering

4 Bilinear Model

5 Experimental Results

Important points:

- deformation operators are phase modulations
- proximal operators
- link with optical flow estimation
- cascade: we must show at least two layers of prediciton.
- scattering; link with commutation error.
- deep network performs gradient steps of a proximal operator: this ressembles LISTA.
- causal vs non-causal
- relationship with RNN
- Consider a model: jitter, local deformations. Can I prove things there? What is the optimum system?