Modern Machine Learning Algorithms: Applications in Nuclear Physics

by

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Thesis

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Abstract

In this thesis a novel filtering thechinque of AT-TPC noise events is presented using clustering techniques on the latent space produced by a Variational Autoencoder(VAE)

Chapter 1

Theory

1.1 Autoencoder

An Autoencoder is an attempt at learning a directed reconstruction model of some input. The simplest possible such model is a neural network composed of two parts; an encoder and a decoder. Where the encoder is in general a non linear map ψ

$$\psi : \mathcal{X} \to \mathcal{Z}$$

Where $\mathcal{X}$ and $\mathcal{Z}$ are arbitrary vector spaces with $\dim(\mathcal{X}) > \dim(\mathcal{Z})$. The second part of the network is the decoder that maps back to the original space.

$$\phi : \mathcal{Z} \to \mathcal{X}$$

The objective is then to find the configuration of the two maps ϕ and ψ that gives the best possible reconstruction, i.e the objective $\mathcal{O}$ is given as

$$\mathcal{O} = \arg\min_{\phi,\psi} ||X - \phi \circ \psi(X)||^2 \tag{1.1}$$

As the name implies the encoder creates a lower-dimensional "encoded" representation of the input. This representation can be useful for identifying the information-carrying variations in the data. This can be thought of as an analogue to Principal Component Analysis (PCA)Marsland (2009). More recently the Machine Learning community discovered that the decoder part of the network could be used for generating new samples form the sample distribution, dubbed "Variational Autoencoders" they are among the most useful generative algorithms in modern machine learning.

1.1.1 Variational Autoencoder

Originally presented by Kingma und Welling (2013) the variational autoencoder is a twist upon the traditional

Bibliography

[Kingma und Welling 2013] Kingma, Diederik P. ; Welling, Max: Auto-Encoding Variational Bayes. (2013), dec. – URL http://arxiv.org/abs/1312.6114

[Marsland 2009] Marsland, Stephen: *Machine Learning: An Algorithmic Perspective*. 2009