

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Technical Note	LIGO-T11XXXXX-vX	2017/06/19
Online Detector Characterization using Neural Networks		
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1 Introduction

The data obtained from LIGO has noise that comes from many sources. In order to be able to better distinguish a signal from the noise it is important to characterize the type of noise observed. Neural networks can be used to characterize the noise.

Neural networks can be used to find relationships between the inputted data using hidden layers of connections within the data. A diagram of a neural network is shown in Figure 1.

Recurrent neural networks are neural networks that use loops within them so that previous information can be retained. Long Short Term Memory (LSTM) networks are a type of recurrent neural network that can remember information for longer than a typical recurrent neural network. A diagram of a LSTM network is shown in Figure 2.

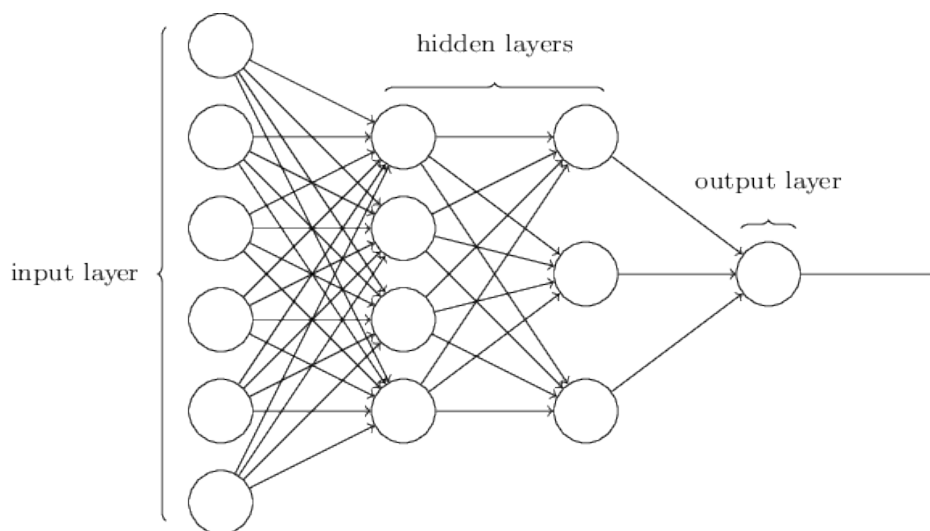


Figure 1: Diagram of Neural Network (from <http://neuralnetworksanddeeplearning.com/chap1.html>)

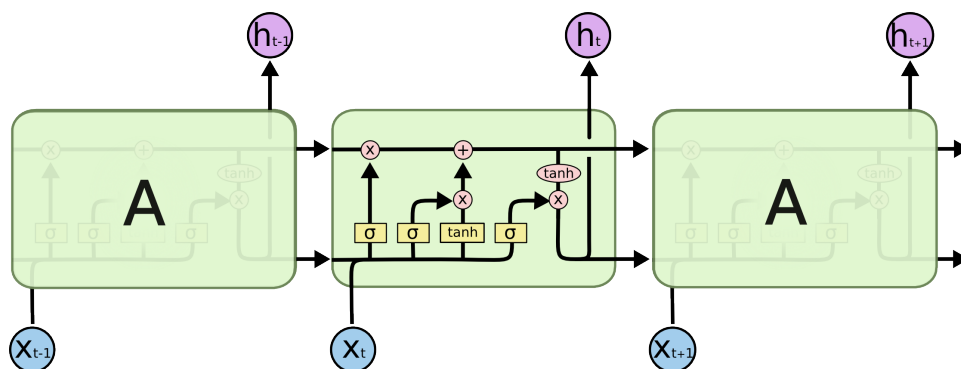


Figure 2: Diagram of LSTM (from <http://colah.github.io/posts/2015-08-Understanding-LSTMs>)

2 Classification vs. Clustering

In order to sort data two types of approaches are used: classification and clustering. Classification algorithms search the data and sort the data into already defined categories. Clustering algorithms look for relationships within the data to create categories into which the data is sorted. Classification algorithms are part of supervised learning since the computer determines the structure of the data from data that is already provided. Clustering algorithms are part of unsupervised learning since the computer determines the structure of the data without any previous information. Clustering algorithms can be used to characterize the noise by identifying common characteristics within the noise depending on its sources. Clustering algorithms can further help with classification. A summary of the differences between classification and clustering is shown in the table below.

Classification	Clustering
Supervised Learning	Unsupervised Learning
Classes are known	Classes are unknown
Used to classify data	Used to find relationships within data

An example of a clustering visualization code can be found at <https://www.mathworks.com/help/stats/visualize-high-dimensional-data-using-t-sne.html>.

3 Objectives

The interferometer's gravitational wave signal output is a time series. We will see whether to analyze the raw time series data or the intermediate data products such as spectrograms of the strain data or the band limited RMS of the channels. We will look into whether the data should be clustered according to its power spectral density or the phase of the signal. We will also look at the various environmental channels to recognize noise states.

4 Approach

We will use the keras python library to use neural networks and clustering algorithms.

5 Project Schedule

- Weeks 1-2: I will familiarize myself with the project
- Weeks 3-4: I will work on comparing the raw data to intermediate data products
- Weeks 5-6: I will cluster the data according to power spectral density or phase
- Weeks 7-8: I will look at the environmental channels
- Weeks 9-10: I will wrap up project and prepare the final report