Neural Networks Term Project

Ahmad Zaidan
Department of Computer Engineering
Eskişehr Osmangazi University
Eskişehir, Turkey
152120171076@ogrenci.ogu.edu.tr

Kumbukani Kamanga
Department of Computer Engineering
Eskişehir Osmangazi University
Eskişehir, Turkey
152120171097@ogrenci.ogu.edu.tr

***Abstract* — This paper seeks to look into the exploration of a special topic where Neural Networks algorithms are getting popular in the industry. Using a dataset from NASA simulated for a turbofan engine, this paper looks into the forecasting of the RUL (Remaining Useful Life) of an equipment.**

Keywords—deep learning, neural networks, prognostics.

I. Introduction

At the start of this project, a dataset simulated for a turbofan jet engine generated by NASA is provided. This dataset consists of 25 simulated sensor values collected from various locations on the jet engine (see Fig. 1 below). It also contains a column for the remaining number of cycles until a “system failure”. Given the dataset provided by NASA, the objective of this project is to estimate the number of cycles of the jet engine by utilizing neural network models and compare it to the actual dataset given values.

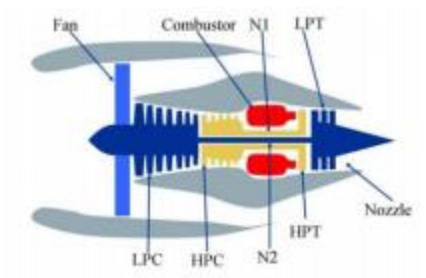

Fig. 1. Sensor locations on a turbofan jet engine

II. Methodology

Neural Networks and Architectures

Important to note is that there are several approaches that could be taken to tackle this kind of problem. Neural Network architectures vary in type and structure. Some examples, or rather the three most important types are ANNs (Artificial Neural Networks), CNNs (Convolution Neural Networks), and RNNs (Recurrent Neural Networks) [1]. For this project, we made use of a two types of RNN architecture known as LSTM *(*Long Short-Term Memory) and GNU (Gated Recurrent Units)

LTSM Neural Networks

Unlike standard feedforward neural networks, LSTM has feedback connections. It can not only process single data points, but also entire sequences of data [2]. LSTM networks are a type of RNN that uses special units in addition to standard units. LSTM units include a 'memory cell' that can maintain information in memory for long periods of time. A set of gates is used to control when information enters the memory, when it's output, and when it's forgotten. This architecture lets them learn longer-term dependencies [3].

Standard RNNs (Recurrent Neural Networks) suffer from vanishing and exploding gradient problems. LSTMs (Long Short Term Memory) deal with these problems by introducing new gates, such as input and forget gates, which allow for a better control over the gradient flow and enable better preservation of “long-range dependencies”. The long range dependency in RNN is resolved by increasing the number of repeating layer in LSTM.

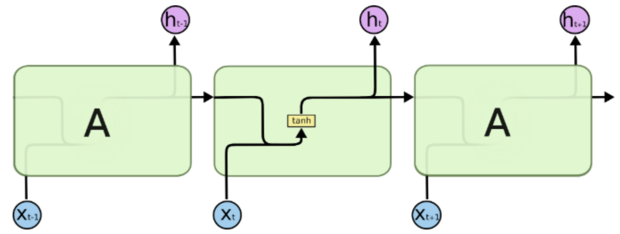

Fig. 2. The repeating module in a RNN contains a single layer

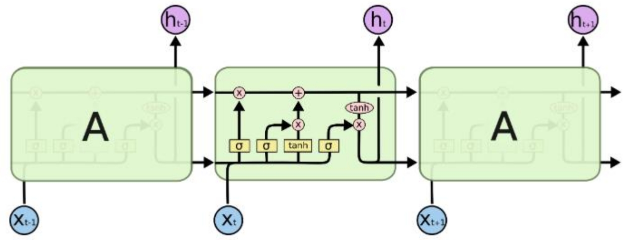

Fig. 3. The repeating module in an LSTM contains four interacting layers

GRU Neural Networks

A GRU, is a type of recurrent neural network. It is similar to an LSTM, but only has two gates - a reset gate and an update gate - and notably lacks an output gate. Fewer parameters means GRUs are generally easier/faster to train than their LSTM counterparts [4].

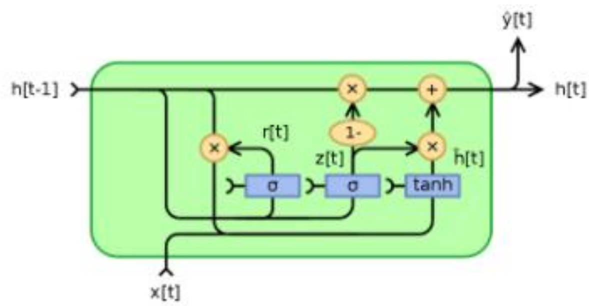

Fig. 4. Gradient Recurrent Unit

These gates can learn which data in a sequence is important to keep or throw away. By doing that, it can pass relevant information down the long chain of sequences to make predictions. Almost all state of the art results based on recurrent neural networks are achieved with these two networks [4]. LSTM's and GRU's can be found in speech recognition, speech synthesis, and text generation.

III. Results

After training our models several times and getting back data we came to a conclusion that both the GRU and LSTMS models had close results with their predictions. We can see here the difference between the mean average error between both models

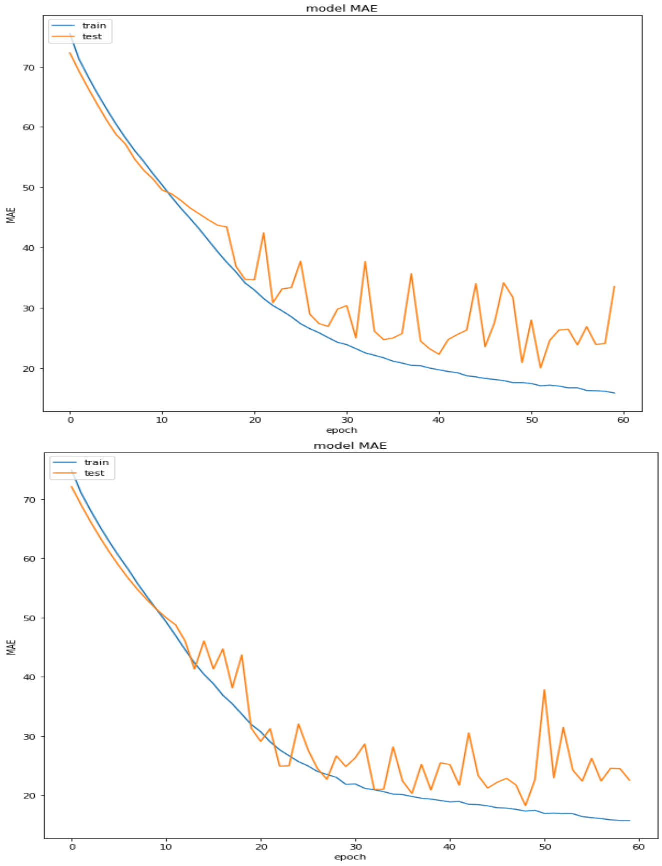

Fig. 5. LSTMS And GRU MAE

As in terms of the predicted values against the real values they both had really good results within a small error range

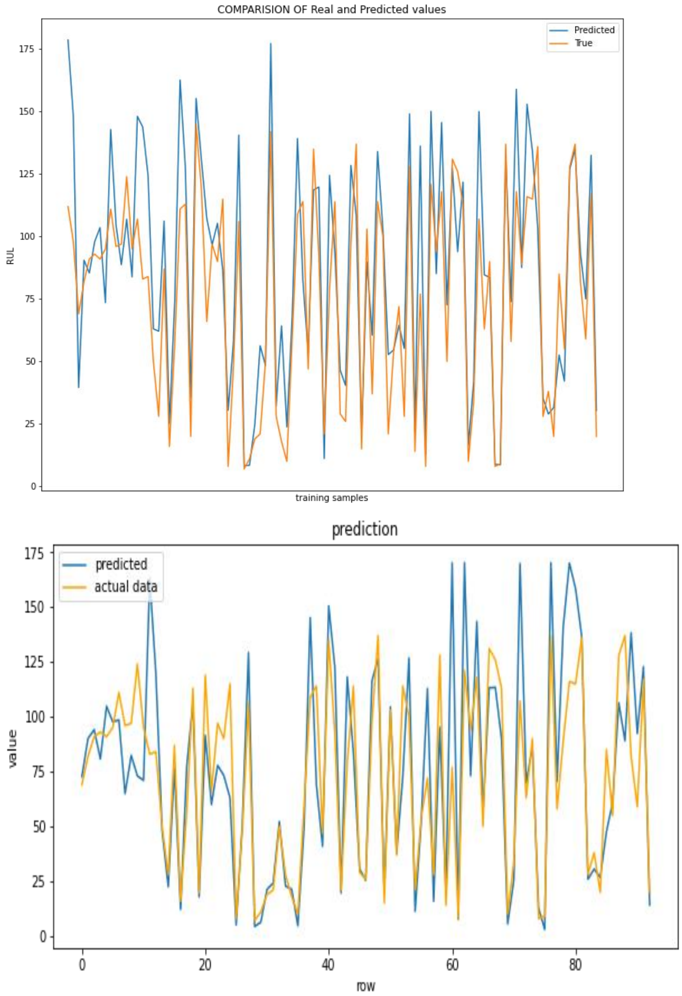

Fig. 6. LSTMS and GRU Predicted Values

Model	GRU	LSTMS
Mean absolute error	18.45	22.695
R^2 score	0.57	0.44

Fig. 7. MAE and R^2 of Models

So we were able to obtain really good results from our models and it shows how neural netwoks can be efficiently used in the future to predict a lot of things in a lot of fields in our lives.

References

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