University of Technology (Yatanarpon Cyber City)
Department of Information Science

IoT related Time Series Forecasting on Weather Data With LSTM

(PreDefense)

Supervised by:
Dr. Hnin Aye Thant

Presented by:
Thant Htet Myet
(2ME_IST_9)

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Outline

Abstract

- Weather information (temperature, humidity, rainfall, etc) play an important role for human.
- Internet of Things (IOT) based weather reporting system provides an efficient internet based weather reporting system for users.
- Weather predictions using deep neural network could be applied to enhance energy efficiency in social environments.
- The system presents a study of deep learning technique(Long Short-Term Memory) applied to time-series forecasting on indoor temperature and humidity.

Objective

- To study Long Short-Term Memory(LSTM) neural network and use it as a prediction theory
- To realize IoT and its usage in real application
- To apply IoT with LSTM in the area of indoor temperature forecasting system
- To make prediction for getting a positive impact on our lifestyle, energy conservation, transportation, and health

Introduction

- Several weather stations have employed Internet of Things (IoT) to monitor the condition of weather systems.
- The weather data from IoT based weather stations are useful for prediction and analyzing systems.
- For effective prediction on weather data, it is necessary to understand various factors that causes the weather changes.
- Accurate prediction is important because today's world is largely depend on the varying weather situations.
- Temperatures and energy consumption predictions using deep neural network could be applied to enhance energy efficiency in social environments.

Theoretical background

- Recurrent Neural Network(RNN) are a type of Neural Network where the output from previous step are fed as input to the current step.
- Recurrent neural networks are networks with loops in them, allowing information to persist.

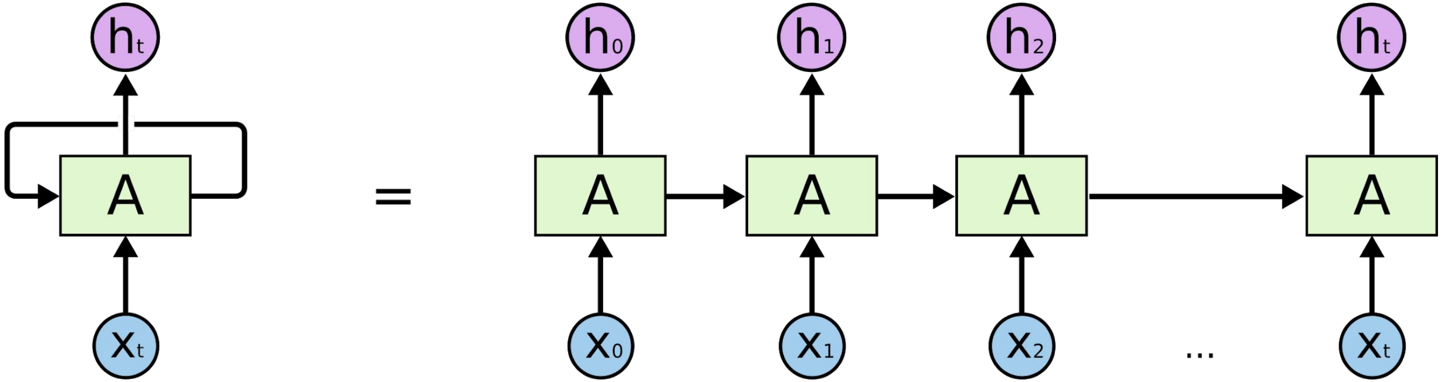

Fig: (a.)RNN with loop, (b.) Unrolled RNN

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- RNN have a “memory” which remembers most information about what has been calculated.
- The gap between the relevant information is small, RNNs can learn to use the past information.
- For example, prediction on the next word based on the previous ones, “the clouds are in the *sky*”.
- Recurrent Neural Networks suffer from short-term memory.
- If the gap between the relevant information is very large and as that gap grows, RNNs become unable to learn to connect the information.
- For example, predicting the last word in the text based on context of all words “I grew up in France… I speak fluent *French*.”

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- LSTMs are a special kind of RNN, capable of learning long-term dependencies.
- LSTMs are designed to avoid the long-term dependency problem.
- LSTMs have this chain like structure.

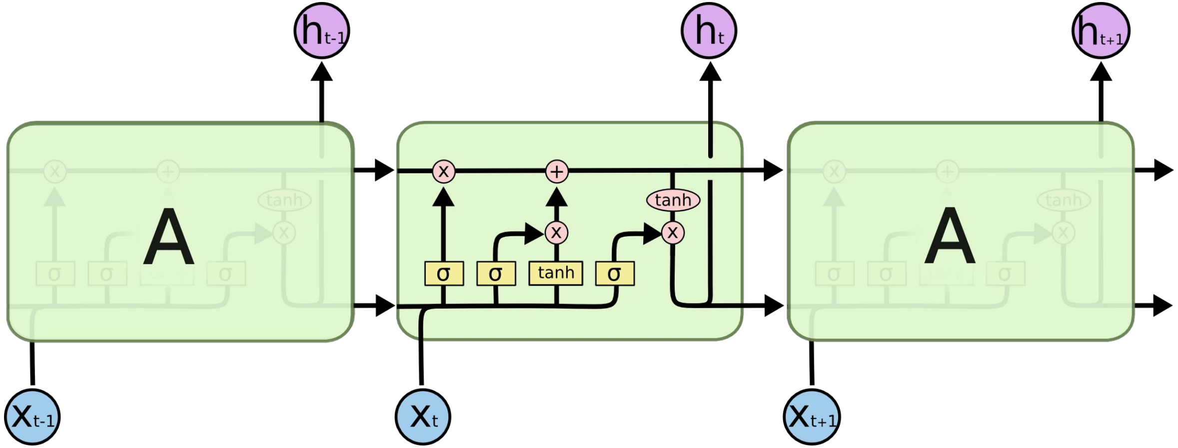

Fig. Long-short Term Memory (LSTM)

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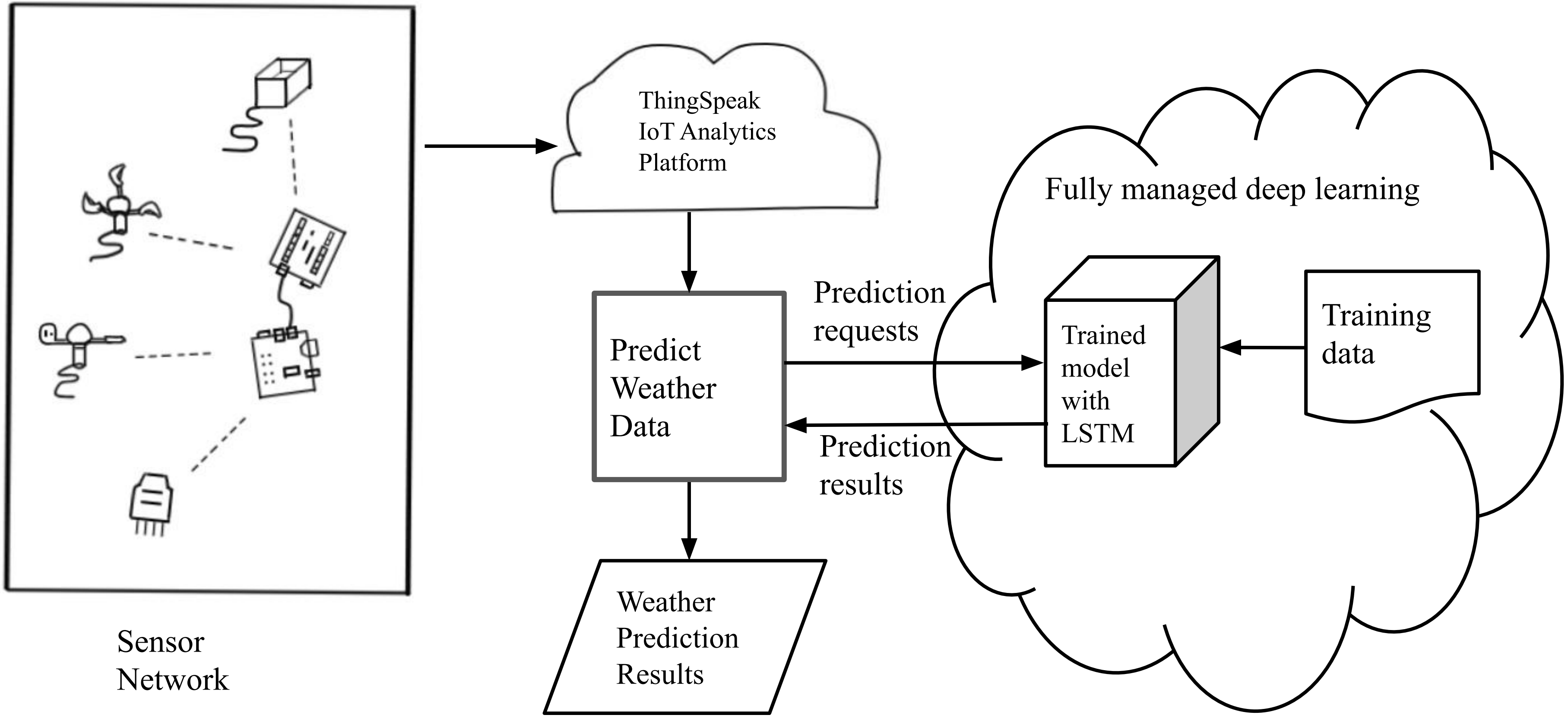
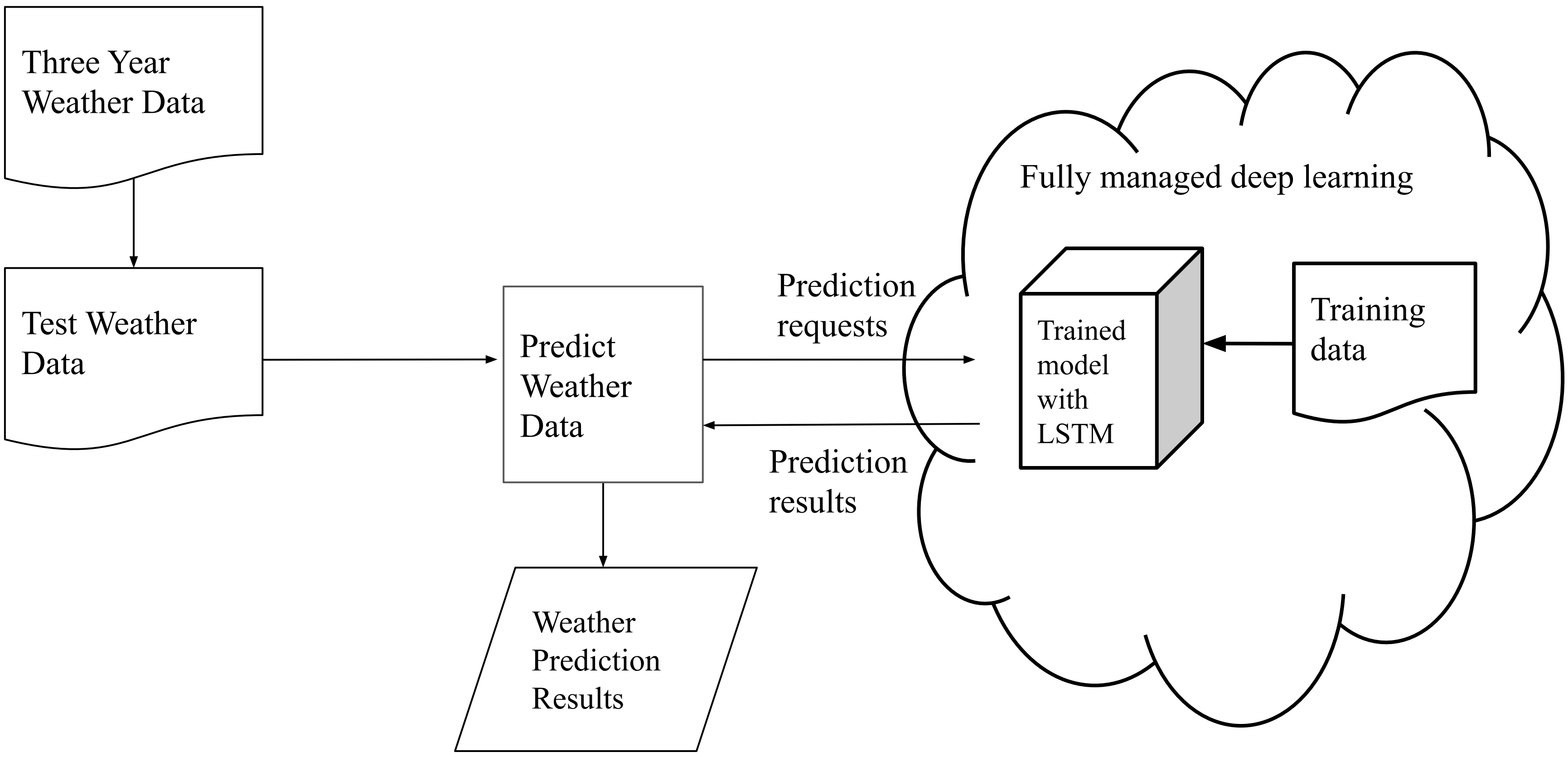
- In the case of LSTM architecture, the usual hidden layers are replaced with LSTM cells.
- The cells are composed of various gates that can control the input flow.
- An LSTM cell consists of input gate, cell state, forget gate, and output gate.
- It also consists of sigmoid layer, tanh layer and pointwise multiplication operation.

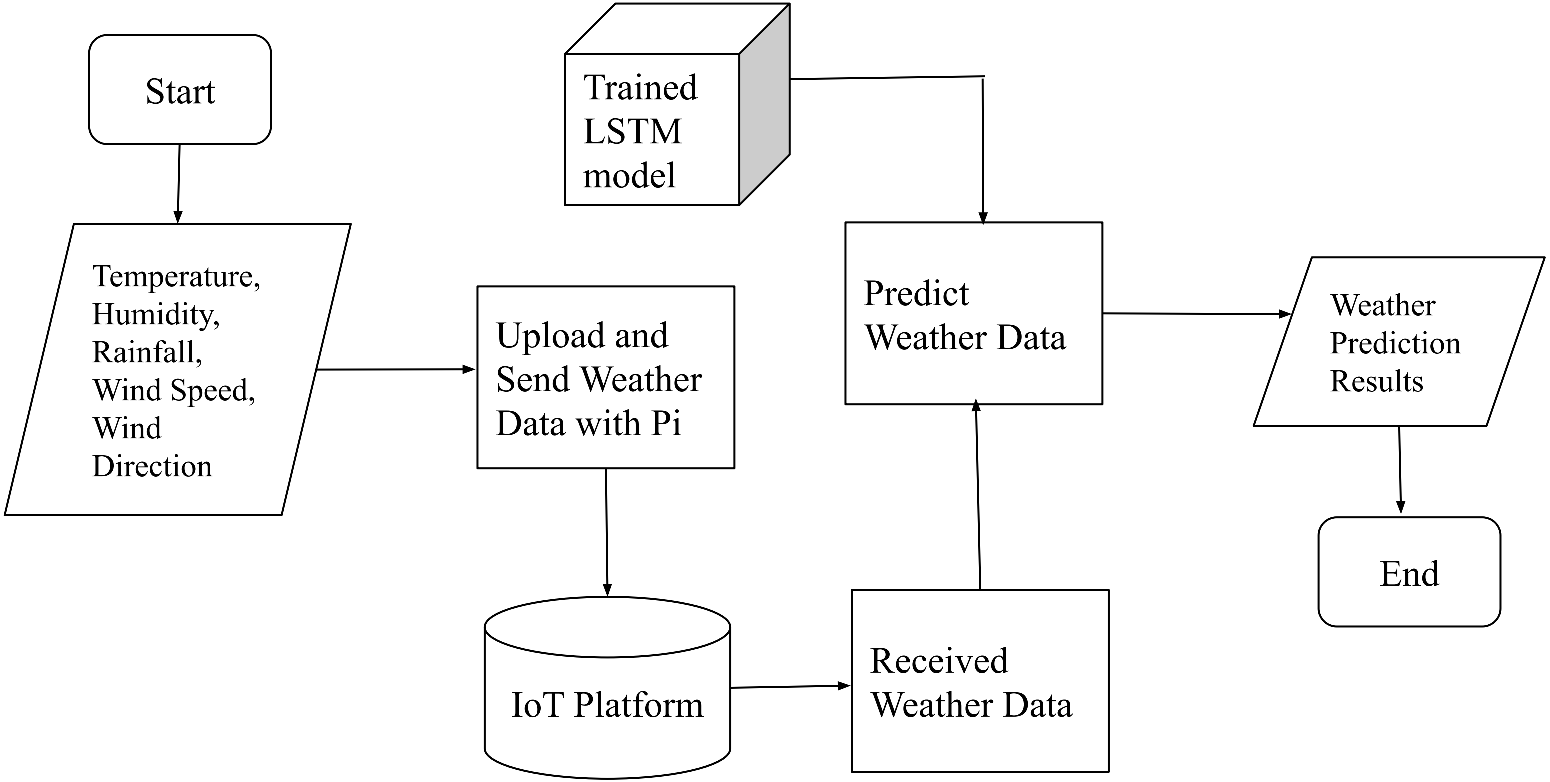
IoT related Time-Series Prediction System Architecture



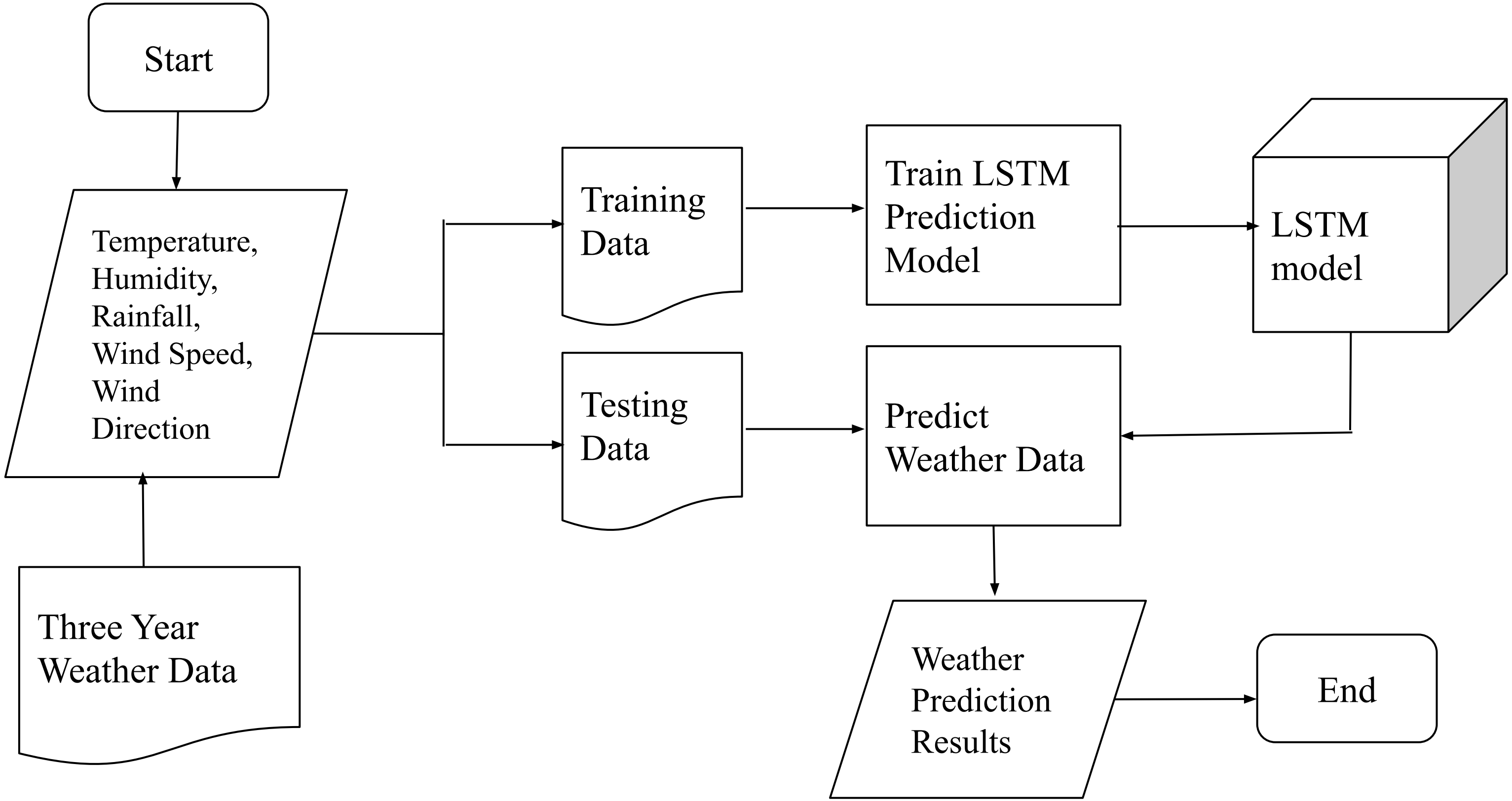
Time-Series Prediction System Architecture



IoT related Time-Series Prediction System Design



Time-Series Prediction System Design



Data Collection

- The weather prediction system uses one sensor device and raspberry pi.
- A raspberry pi are open hardware development boards that can be used to design and build devices that interact with the real world.
- The time-series weather data are temperature and humidity.

Sensors for IoT related Time-Series Prediction System

- DHT22 (Temperature and Humidity)
- Anemometer (Wind Speed)
- Wind Vane (Wind Direction)
- Rain Gauge (Rainfall)

DHT22 and Anemometer

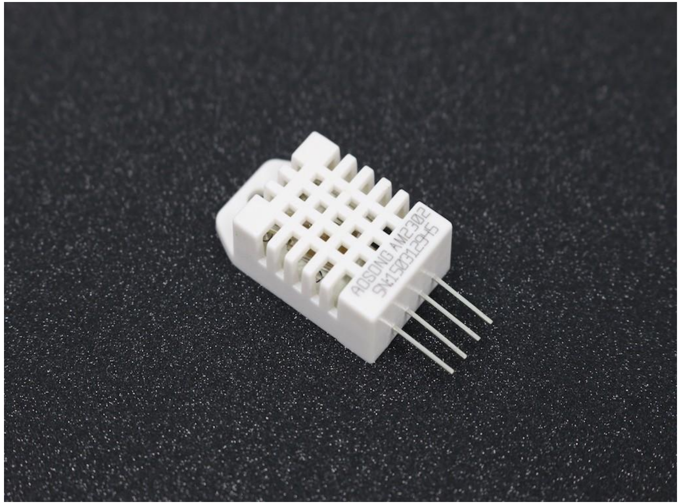


Fig. DHT22

Fig. Anemometer

Wind Vane and Rain Gauge

Fig. Wind Vane

Fig. Rain Gauge

Weather Station Kits

Fig. Weather Station Kits

Data Nature

- The time-series prediction system used three years weather data for Pyin Oo Lwin and Yangon.
- The IoT-related time-series prediction system used one week weather data for real-time system.
- The weather data for time-series prediction system are temperature, rainfall, humidity, wind speed and wind direction.
- The weather data for IoT related system are temperature and humidity.

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- The weather data are collected and stored as in the following forms:

Date	Time	Temp	Rain_Fall	Humidity	Wind Speed	Wind Direction
2015-01-01	9:30 A.M	32	0	58	3.6	E
2015-01-01	12:30 P.M	32	0	39	3.6	N
2015-01-01	5:30 P.M	32	0	68	1.2	E
2015-01-02	9:0 A.M	31.6	0	54	1.2	S

Tabel: Sample Weather data

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- The IoT related time-series prediction system uses sensors and collected weather data are uploaded to ThingSpeak, IoT analytics platform service.

- For IoT related prediction system, the collected data are downloaded to train the model.

- All weather data(temperature, humidity, rainfall ,etc) are standardized with float type to all value for data cleaning stage.

- For weather text data such as wind direction, it need to encode for training in LSTM.

Data Preprocessing

- Rescale the data to the range of 0-to-1, also called normalizing.
- Normalize the dataset using the MinMaxScaler preprocessing class from the scikit-learn library.
- After normalizing, the dataset is transformed into series to supervised learning problem.
- To define and fit model for LSTM, split the prepared three years weather dataset into train and test sets.
- The train dataset contains thirty-three months weather data and test dataset contains three months weather data.

Implementation

- The inputs weather data are reshaped into the 3D format expected by LSTMs, namely [samples, timesteps, features.
- A multilayer model is composed of two LSTM layers with a 100 memory units to form the base architecture for the model.
- The multilayer model is added with twenty percent of dropout layer.
- Adding dropout layer prevent overfitting by ignoring randomly selected neurons during training.

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- 20% is often used as a good compromise between retaining model accuracy and preventing overfitting.
- A dense layer is added into the model.
- LSTM model is compiled with mean squared error for loss function and used ‘rmsprop’ for optimization.
- The model is trained with 125 epochs, and 58 batches size and training data is not shuffle.
- The model used root mean squared error as a score function to evaluate the quality of the predictions.

Data Output Layer

- The real-time prediction system results will send message to specific phone of users.
- The twilio message library is used to send message in prediction system.

Analysis of Weather Prediction System

- The result of prediction system depend on the epoch, batch size and training data.
- The following tables show the result of prediction systems.

Epoch	Batch	TrainAccuracy	Loss	RMSE
140	64	0.9795	1.97E-03	0.023
132	32	0.974	9.32E-04	0.029
125	32	0.9767	7.55E-04	0.027
100	64	0.9779	1.10E-03	0.033
80	32	0.9732	9.47E-04	0.029
60	32	0.9743	9.59E-04	0.033

Figure. Analysis of IoT related Time-series Prediction System for Yatanarpon Cyber City Region

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Epoch	Batch	TrainAccuracy	Loss	RMSE
140	64	68.46	0.0204	4.56
132	32	69.81	0.0194	4.37
125	56	70.1	0.0208	4.533
100	64	68.75	0.021	4.6
80	32	67.88	0.0207	4.567
60	32	69.81	0.0213	4.692

Figure. Analysis of Time-series Prediction System for Pyin Oo Lwin Region

Cont’d

Epoch	Batch	TrainAccuracy	Loss	Validation Accuracy	Validation Loss	RMSE
140	64	81.6	0.0159	80.66	0.0183	5.406
132	32	81.97	0.0154	80.66	0.019	5.76
125	64	81.37	0.0161	81.39	0.0185	5.504
100	64	81.43	0.0201	81.02	0.0187	5.605
80	32	81.73	0.0159	80.29	0.0195	5.607
60	32	81.6	0.0162	80.29	0.0194	5.827

Figure. Analysis of Time-series Prediction System for Yangon Region

Overview of System Model

- The weather forecasting model using LSTM was implemented using Python.
- The LSTM was programmed using Keras.
- Keras is a high-level neural networks API, written in Python and capable of running on top of TensorFlow, CNTK, or Theano.
- Besides, Keras, other Python libraries such as matplotlib, numpy, pandas, and sklearn were also used.

System Layer Design of LSTM

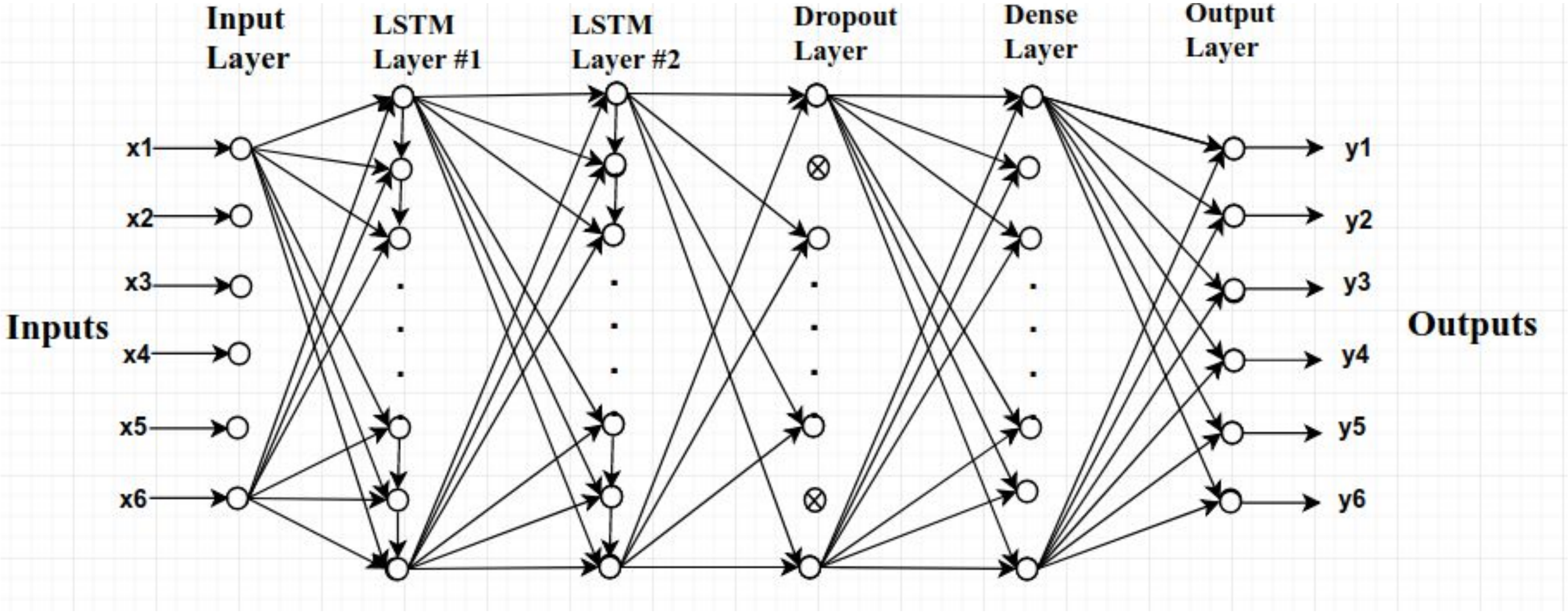

Fig: System Layer Design

Test Results

- The total data is splitted into seventy percent for training and thirty percent for testing.
- The LSTM model has two layers with 125 epochs and 56 batches.
- Adjusting epochs and batches size and increasing training data can improve the LSTM model’s accuracy.

Test Results for Yangon

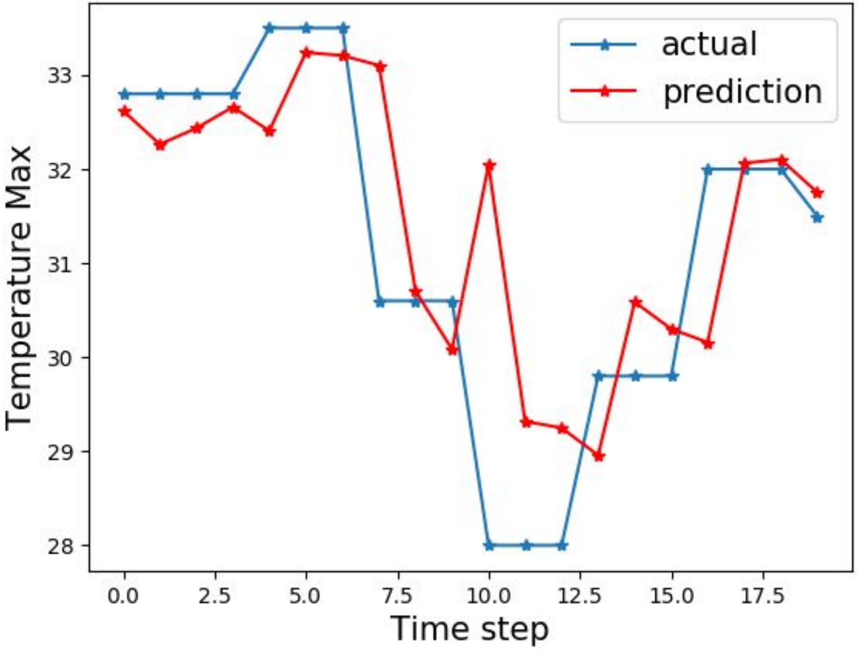

Fig: Comparison of prediction and actual for Temperature

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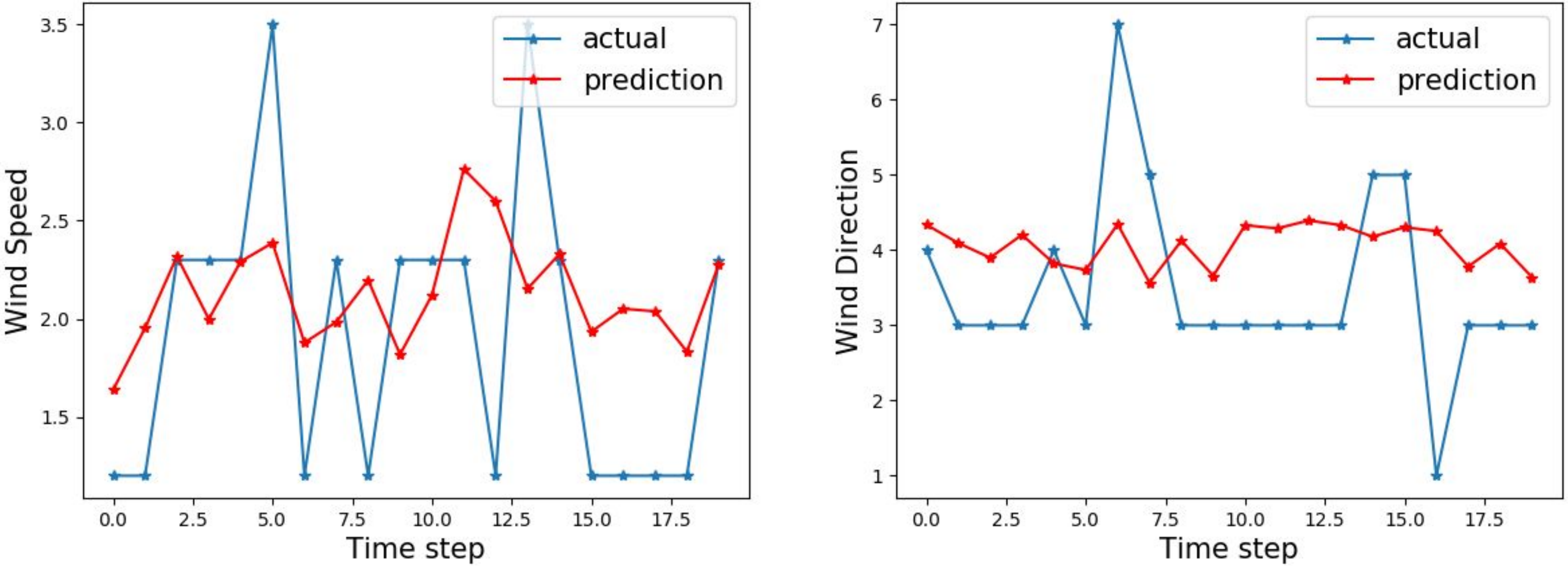

Fig: Comparison of prediction and actual for Wind Speed and Direction

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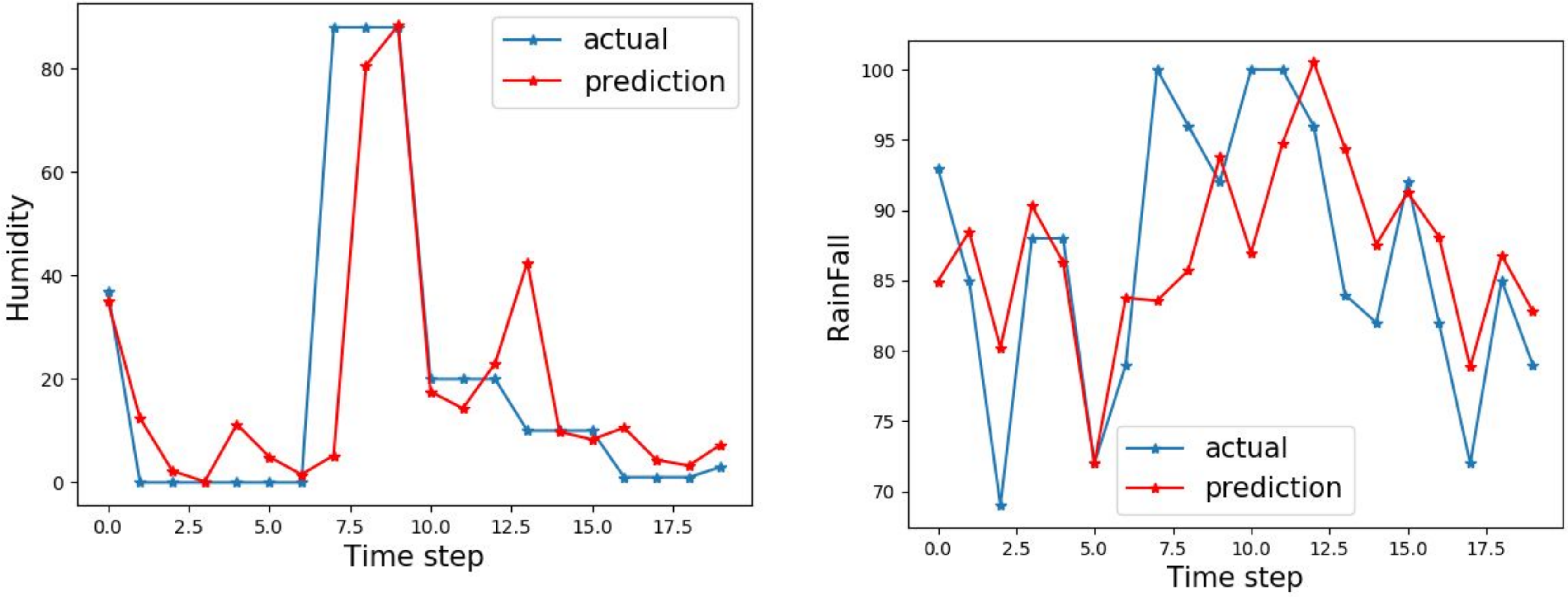

Fig: Comparison of prediction and actual for RainFall and Humidity

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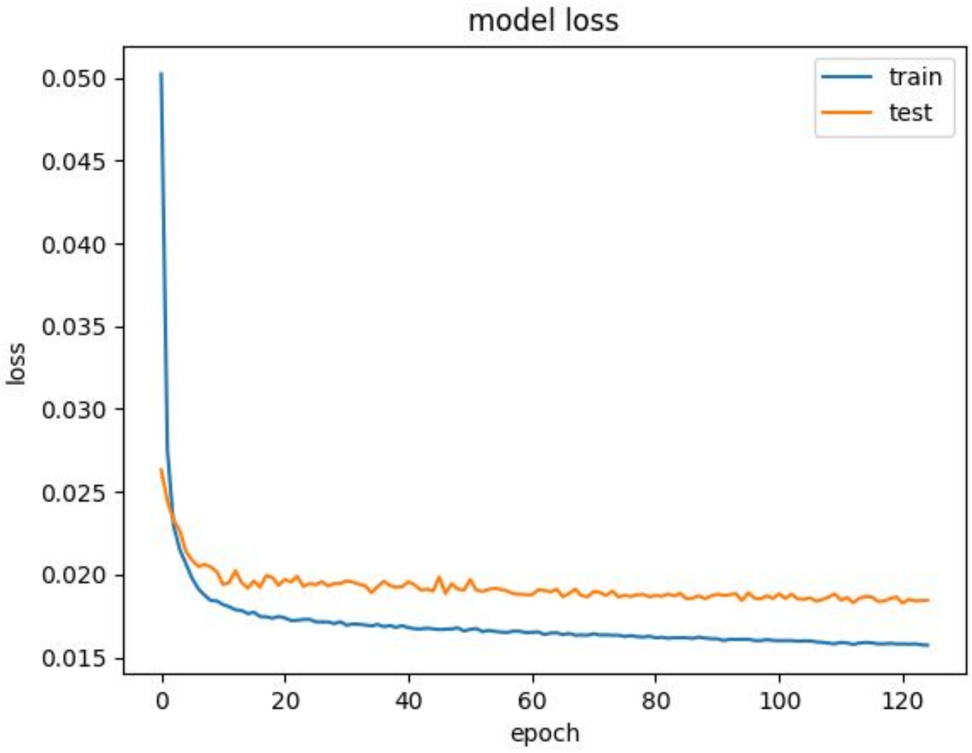

Fig:Comparison of Loss value and Epoch

Test Results for Pyin Oo Lwin

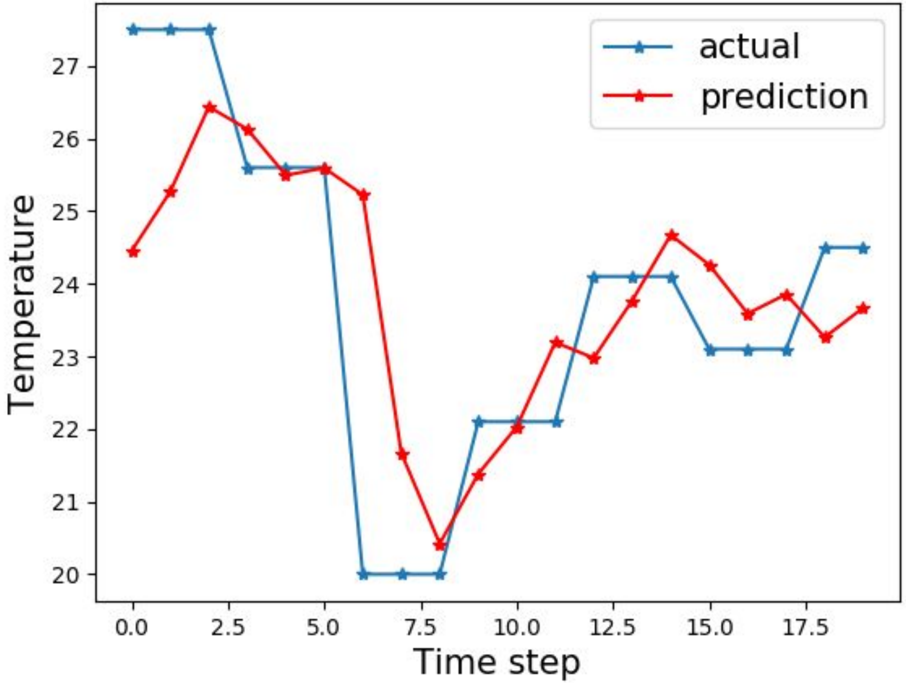

Fig: Comparison of prediction and actual for Temperature

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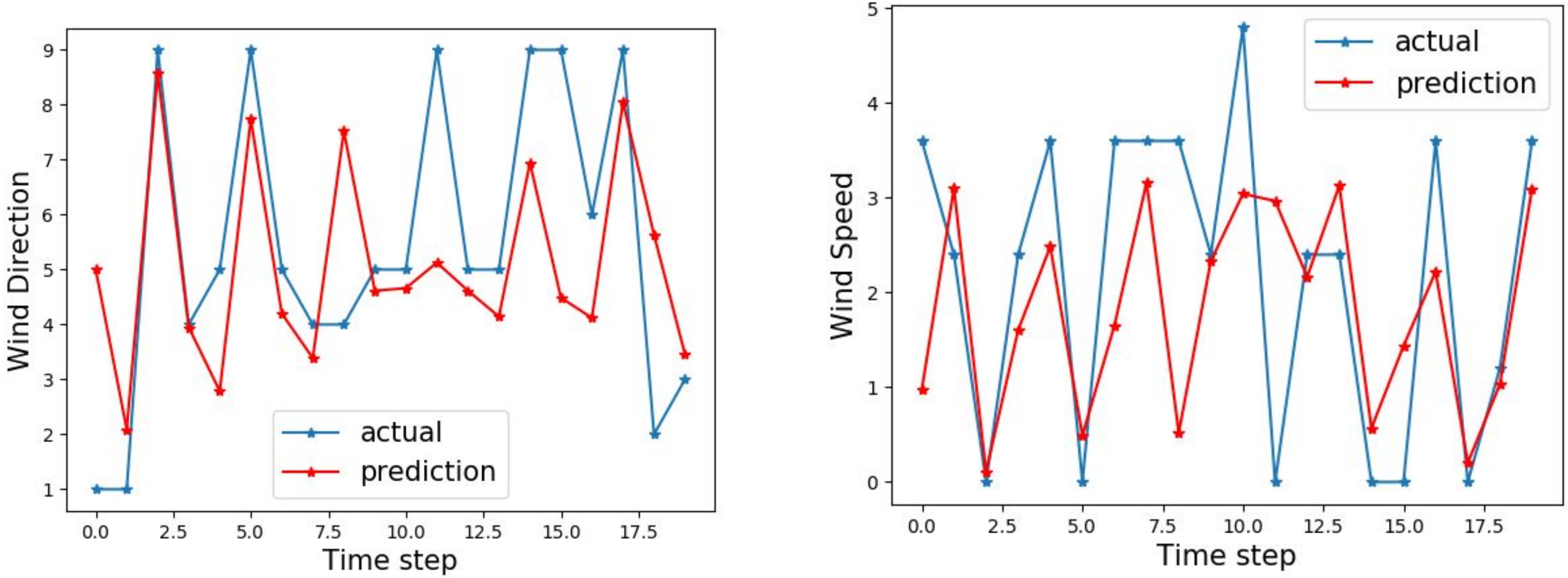

Fig: Comparison of prediction and actual for Wind Speed and Direction

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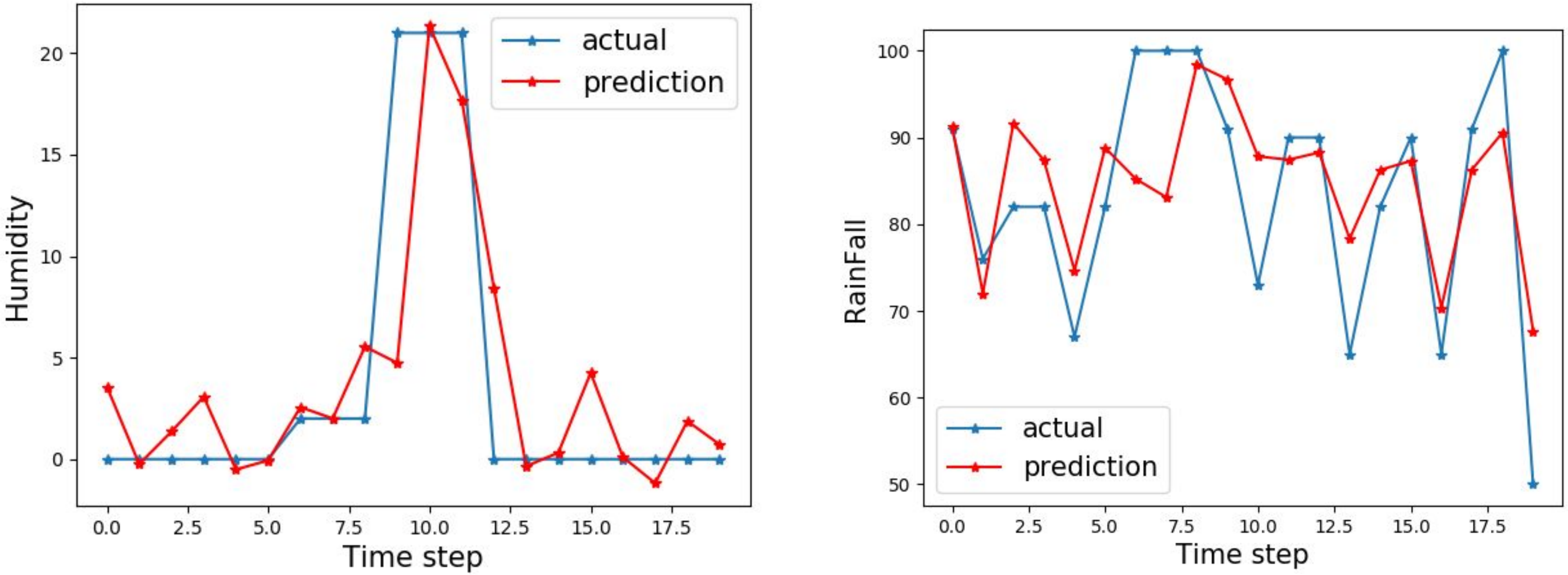

Fig: Comparison of prediction and actual for RainFall and Humidity

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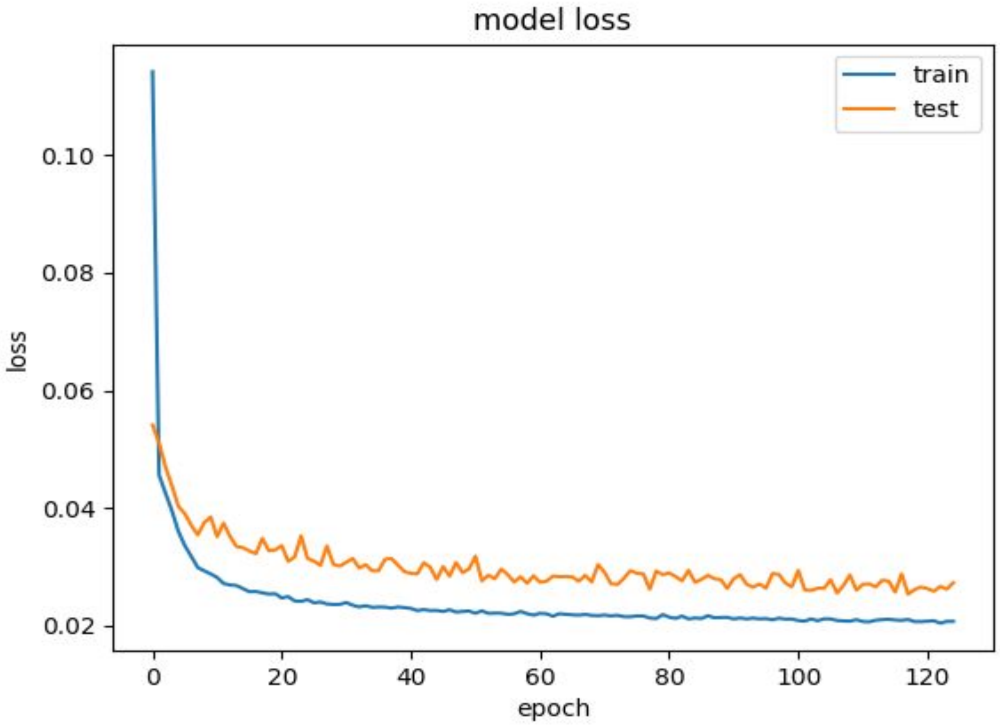

Fig:Comparison of Loss value and Epoch

Test Results for Yatanarpon Cyber City

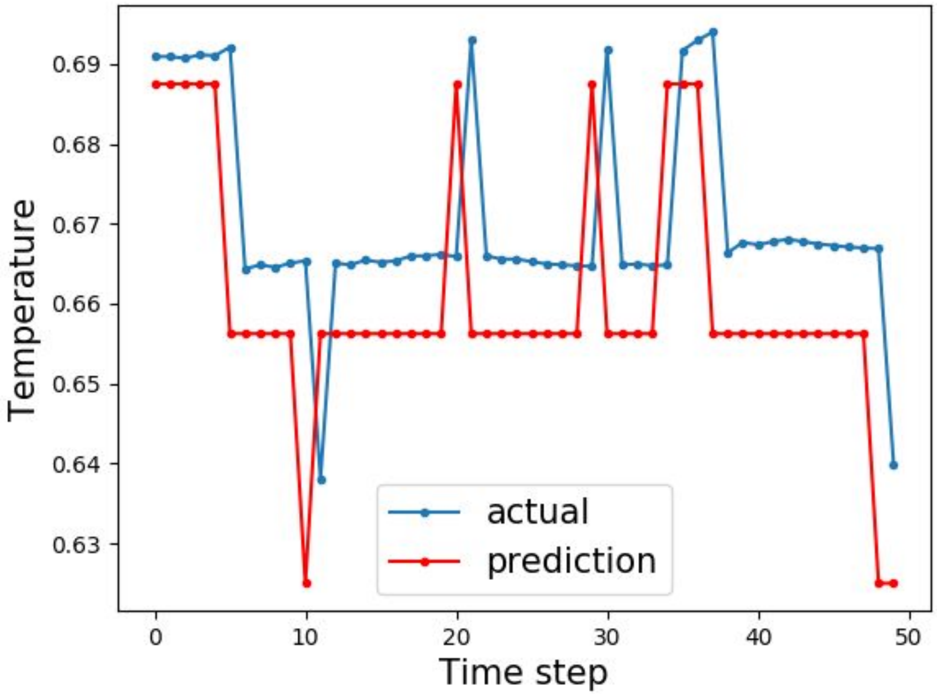

Fig: Comparison of prediction and actual for Temperature

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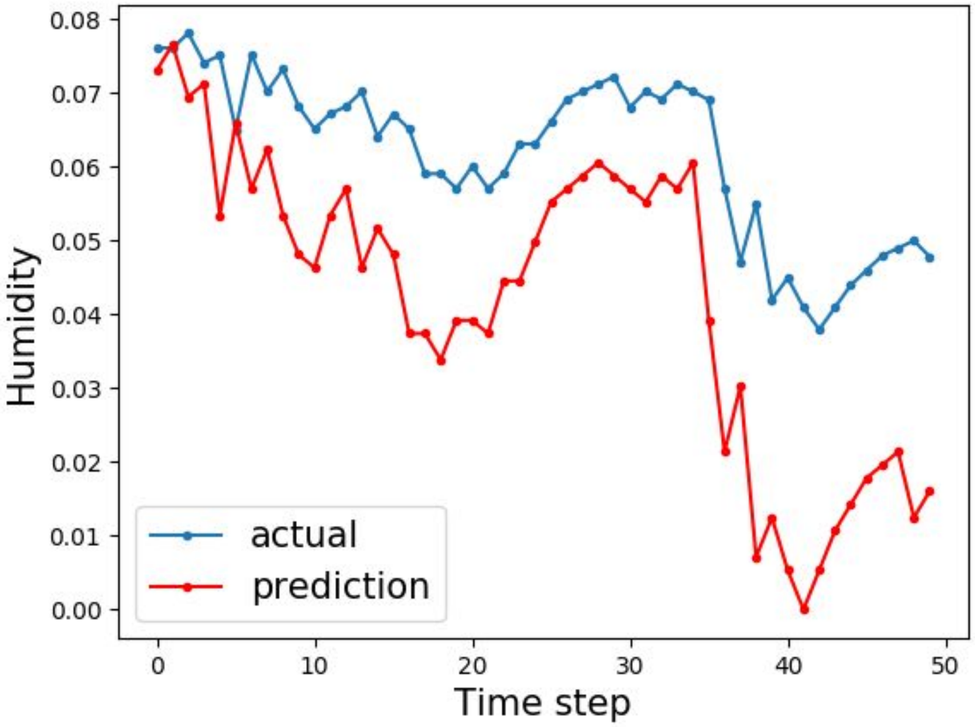

Fig: Comparison of prediction and actual for Humidity

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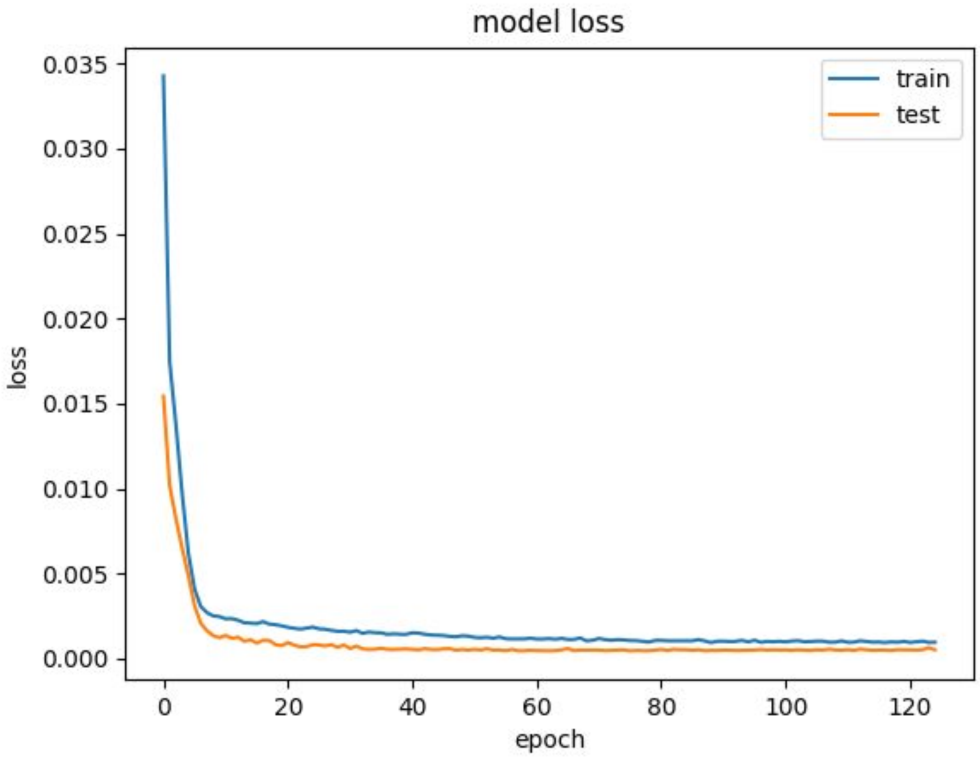

Fig:Comparison of Loss value and Epoch

Limitations

- The system limits that the trained weather data is only for Yangon, Pyin Oo Lwin and Yatanarpon Cyber City University location in Myanmar.

- The system performs prediction analysis on only five weather parameters.

- Long Short Term Memory (LSTM) is only used to perform prediction.

Further Extension

- Weather prediction using data from different locations on more parameters can be performed by the system.
- The system can also analyze the accuracy of weather prediction results with other deep learning techniques.
- The system can be applied as part of smart home IoT system.

Conclusion

- Internet of Thing(IoT) and deep learning is very useful in many applications and environments in daily life.
- The system help the people to know how much comfort level they have.
- The system will tend to focus on smart home system.

….. Thank You …..