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# Polyhouse Predictions on Meteorological Parameters Using Time Series Analysis and Precision Agriculture through CLOUD & FOG Interfaces

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**ABSTRACT:** Weather forecasting is the prediction of atmosphere parameters (variables) for a given location and time. Weather forecasting parameters include temperature, humidity, rainfall, vapour pressure, cloud cover etc. There exist a Number of methods and algorithms, such as Regression techniques, Time Series Analysis, Fuzzy logic, Neural Networks and NWP(Numerical Weather Prediction) which use mathematical models, to predict the weather forecasting conditions. In this paper, an attempt has been made to design and develop a “Weather Forecasting System for IoT enabled Polyhouse”. The proposed system may be used to observe, predict and monitor the weather conditions inside a polyhouse. Weather prediction is necessary within a polyhouse to take precaution from adverse effects of the weather.

**KEYWORDS:** Regression, Time Series Analysis, Neural Networks, NWP, Polyhouse.

### I.INTRODUCTION

The agricultural sector is a backbone and contributes very high for the of countries economy. Agricultural system faces several problems, especially, traditional farming is vulnerable to climate variables. The crop is prone to infestation. So, constant examination and disinfectant are needed. Open farming does not utilize its complete fertile land for production. Any crop has finite growth limited to a particular season. These problems can be overcome by using Greenhouse/Polyhouse farming. Polyhouse/Greenhouse is an effective approach for farming. It is used for better crop production and off-seasonal crop growth by providing the favourable environmental conditions. These environmental conditions such as temperature, moisture/humidity, light, air flow, soil nutrients, soil temperature, soil moisture etc are maintained in a polyhouse with the help of crop supporting systems.

A sound knowledge of climate factors and its interactions with crop is essential for successful greenhouse farming. Occurrences of erratic weather are beyond human control. However, it is possible to adapt to or mitigate the effect of adverse weather if a forecast of the expected weather can be had in time. The motive behind this paper is to make prediction of meteorological parameters more accurate in a polyhouse. The remainder of the paper is organized as follows: related work in Time Series Analysis and Precision Agriculture is presented in section II; Section III introduces data description and methodology. The proposed system is described in detail in section IV. In section V, the comparison results and model evaluation metrics are presented and discussed. In section VI, Cloud and FOG are introduced. Finally, conclusions are shown in section VII.

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## II. RELATED WORK

There have been many attempts to forecast weather parameters. Weather forecasting can apply to many horizons such as, short term, medium term and long term periods. Some authors design systems which can forecast yearly data, some others try to forecast quarterly or half yearly data [4] whereas some people try to forecast weekly data as well. Most of them concentrate on one-step ahead prediction. The traditional techniques for statistical forecasting include ARMA models [6], multivariate adaptive regression splines and time series analysis [5], and many others [1][2][3][7]. Precision Agriculture techniques using Wireless Sensor Networks (WSN) [8][9][10] are studied to collect weather parameters (temperature and humidity in this project) through sensors in a polyhouse. Mobile Apps are developed in [11]. For accuracy and robustness of the Time Series forecasting, error measurement parameters such as Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) are used.

## III. DATASET DESCRIPTION AND METHODOLOGY

**A. Dataset Used :** Weather forecasting data is provided by various agencies. KEA weather [14], AccuWeather, India Meteorology Department (IMD) [13], world weather online, India water portal [12] are some of the weather related agencies. In this paper, three multivariate prediction models and five univariate Time Series models are analyzed. Table 1 and Table 2 show their comparative study. The monthly meteorological data of different cities of India from 1901-2001 for a total period of 100 years from India water portal [12] is used to do comparative study. All the studies are based on a common dataset. The dataset contains four parameters: 1) Average temperature ( $^{\circ}\text{C}$ ), 2) Rainfall (mm), 3) Vapor pressure (h Pa), 4) Cloud cover (%). Three multi-variate models analyzed: 1) FIS (Fuzzy Inference System), 2) MLR (Multi Linear Regression) and 3) ANFIS (Adaptive Neuro-Fuzzy Inference System) have been examined for rainfall prediction. Five univariate models 1) LR (Linear Regression), 2) AR (Auto Regression), 3) MA (Moving Average), 4) ARMA (Auto Regressive Moving Average) and 5) ARIMA (Auto Regressive Integrated Moving Average) have been examined for temperature and humidity prediction.

**B. Methodology:** In this paper, predictions are made for rainfall, temperature and humidity. For rainfall prediction, the multivariate models take three inputs temperature, vapour pressure and cloud cover to predict attribute rainfall from dataset. Since rainfall depends mainly on these three factors. Two meteorological parameters, namely, Temperature and Humidity are considered for univariate prediction model. A best model is proposed from the results obtained in Table 1 and Table 2, which uses temperature and humidity sensors to read weather parameters in a polyhouse and store these values in a cloud database. This dataset is further used as input to the best ARIMA model for prediction.

## IV. PROPOSED SYSTEM

The proposed system makes use of two parameters namely-temperature and humidity. These two parameters are extracted from the environment using respective sensors. This data is then sent to the microcontroller, which in turn sends the data to the cloud database through Wi-Fi (Wireless Fidelity). Weather Prediction is performed over the data stored in the database. The proposed system architecture is shown in figure 1.

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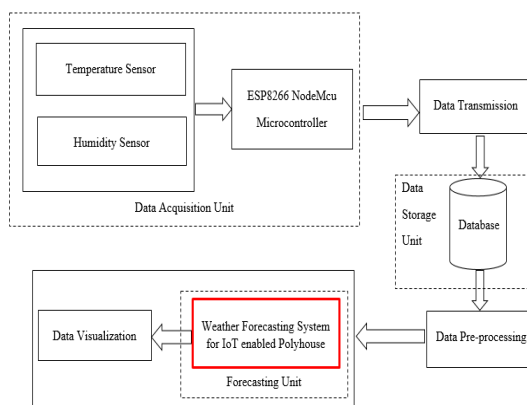


Fig1. Weather Forecasting System for IoT enabled Polyhouse

The process is explained in the following steps

1. Sensors deployed in the polyhouse get the data by reading through a micro-controller via the data pin of the respective sensor.
2. The ESP8266 Node MCU micro-controller sends this data to the Cloud Database through a Wi-Fi module.
3. Sensor data, extracted from the database, is given to the Prediction Algorithm as input.
4. The proposed Weather Forecasting System identifies the best ARIMA model for the prediction.
5. A Forecasted value given by the best model is displayed in a mobile interface.

## V. COMPARISON RESULTS

In this section four error estimates, namely, MAE, MSE, RMSE, and MAPE are used to measure the errors. Results are tabulated in Table1 and Table 2.

**Mean Absolute Error (MAE):** MAE is used to measure the average magnitude of the errors in a set of predictions, without considering their direction. It is the average of the test sample of the absolute differences between prediction and actual observation with all individual differences have equal weight. The following formula is used to calculate MAE.

$$MAE = \frac{1}{n} \sum_{j=1}^n |y_j - \hat{y}_j|$$

**Mean Squared Error (MSE):** MSE is used to measure the average of the squares of the errors or deviations—that is, the difference between the estimator and what is estimated.

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2$$

**Root Mean Squared Error (RMSE):** RMSE is a quadratic scoring rule used to measure the average magnitude of the error. It is the square root of the average of squared differences between prediction and actual observation.

$$RMSE = \sqrt{\frac{1}{n} \sum_{j=1}^n (y_j - \hat{y}_j)^2}$$

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**Mean Absolute Percentage Error (MAPE):** MAPE, usually, expresses the accuracy as a percentage, and is defined by the formula:

$$MAPE = \frac{1}{n} \sum_{i=1}^n \frac{|y_i - \hat{y}_i|}{y_i} \cdot 100\%$$

where  $y_i$  is the actual value and  $y_t$  is the forecast value.

The difference between  $y_i$  and  $y_t$  is divided by the Actual value  $y_t$  again. The absolute value in this calculation is summed for every forecasted point in time and divided by the number of fitted points  $n$ . Multiplying by 100 makes it a percentage error. Table1 and Table2 show the Model evaluation metrics for univariate Time Series prediction models and multivariate prediction models respectively.

	MAE	MSE	RMSE	MAPE
FIS	105.6 4	13675. 8	116.943 8	78.1583 9
MLR	70.97 8	5762.5 6	75.9115 3	49.0297 9
ANFIS	11.58 0	338.60 8	18.4013 2	8.86671 8

Table1. Comparison of Multivariate models

	MAE	MSE	RMSE	MAPE
LR	2.794 95	10.0151 0	3.16466 4	9.94723 3
AR	2.857 43	11.8273 9	3.43909 8	9.98344 7
MA	2.387 09	8.05763 0	2.83859 6	8.47522 0
ARM	2.861 38	11.2089 3	3.34797 5	10.1075 0
ARIMA	6.953 43	57.1300 8	7.55844 4	24.3896 6

Table2. Comparison of Time Series models

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## VI. CLOUD AND FOG

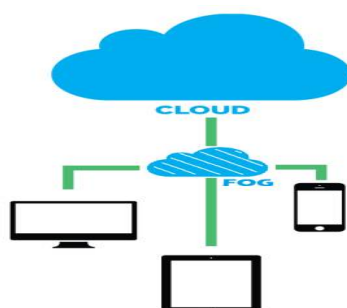


Fig2: Cloud and FOG Block diagram

The entire Polyhouse system is placed in the Cloud storage and the Proxy is placed in the FOG for the ease of transactions. Using the different devices connected in the network, the user can access the Cloud through FOG from anywhere in the world.

## VII. CONCLUSION

In this paper, sensors are used to collect the data related to the weather parameters - temperature and humidity in the data acquisition unit. In data storage unit, the data obtained in the data acquisition unit is stored into the cloud database. In forecasting unit, the data from the storage unit is used for prediction. This system can be further enhanced by predicting other weather parameters inside a polyhouse. An android App is developed for monitoring and controlling the polyhouse parameters. Security may appended to the cloud operations.

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