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Co-Design of Climate Agrometeorological Prediction System to Aid Small Scale Farmers

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Abstract: The Majority of farmers in Namibia are not able to access meteorological information and even where available processing requires human expertise which is rarely available. The purpose of this study is to develop an agrometeorological system to predict weather parameters that can aid small scale farmers to plan the type of crops to grow and the use of related pesticides. The aim of this study is to collect climate agrometeorological data from real-world environment using IoT sensors, pre-train the prediction model with the real-world environment dataset using IoT, to predict weather parameters such as temperature. In addition, an interactive Chatbot is developed for effective early warning of Agrometeorological conditions and the performance of the pilot prototype is evaluated. The mixed method research with the experimental approach is used for this study, both quantitative and qualitative data was collected through the use of interviews and questionnaires. An experiment is carried out to train and test the proposed model using real world dataset. Design Science Research Methodology (DSRM) was employed by designing and creating artifacts of the model and validating the results through pilot testing and the result of the study shows that predicting weather parameters such as humidity and temperature using IOT surpass other prediction methods with an accuracy rate of 98.2% with real-world environment dataset. The study further concludes that predicting weather parameter using IoT sensors provides fast, accurate and reliable real-time weather forecast. In addition, the study recommends translating the system in local languages to solve the communication barrier between the local users and the system.

1. Introduction

A common problem in developing countries is the lack of integrated means of processing and delivering Agrometeorological information to small scale farmers (Lawrence, 2019). Internet of Things (IoT) and Artificial Intelligence (AI) based sensing platforms are often employed to generate, pre-process an assimilate real-time data from heterogeneous sensors and streaming data sources (Saurabh, Soumyashree, 2015).

Weather forecasting is the process of technology and science which used to predict the atmospheric conditions for the given location. The great scientists have also attempted to predict the weather formally and informally from many centuries. Weather forecasts are made by collecting the data about the current state with different attributes of the climate at a given place and using meteorology to project how the attributes affect the atmosphere.

According to Materne & Inoue (2018), a model can be built by merging IoT and machine learning technologies, as it has predictive modeling ability that provides simultaneously track of many meteorological parameters that could be used to help forecast for real-time tracking.

Similarly, weather forecasts are formed by collecting as much data as possible about current atmospheric conditions and utilizing knowledge of atmospheric processes to forecast how the weather will change in the future. A real-time weather station, on the other hand, is a device that collects meteorological and environmental data from a number of sensors in order to offer accurate real-time weather readings. Meteorological Station based on the IoT model was designed, allowing users to get eal-time meteorological data from anywhere and the user can also gather the measures taken by the sensors at any time. Furthermore, this may be seen on a smartphone or tablet as well and with that said, if a user wants to know what the temperature is right now, they can receive it (John, 2017).

Objective:

The main objective of this study is to develop an agrometeorological system to predict weather parameters that can aid small scale farmers to plan the type of crops to grow and the use of related pesticides.

Sub-objectives are to:

- Collect climate agrometeorologicaldataset from real-world environment.
- Pre-train the prediction model and predict temperature using IoT.
- Develop an interactive Chatbot for effective early warning agrometeorological conditions.
- To evaluate the performance of the pilot prototype for effective prediction.

2. Methodology

The study used mixed research method with the experimental approach were both quantitative and qualitative approaches were used to gather data through questionnaires and interviews. Both qualitative and quantitative data was obtained from questionnaires at the Groot Aub community with local farmers. The qualitative data collected includes the types of crops grown within the area, types of pesticides they use, soil type and sowing methods. Quantitative data was collected from Namibia Meteorological Centre (NMC) whereby a dataset composed of maximum temperature, minimum temperature, precision, wind speed and cloud cover was downloaded from NMC databank. Moreover, an experiment was carried out to train and test the proposed model using real world dataset together with quantitative and qualitative data collected.

3. Experiment and Results

The procedure used to carry out this study involves the following steps in correlation with the objectives of the study are listed and described below.

1. Data collection
2. Data pre-train and prediction
3. Develop an interactive Chatbot
4. Performance evaluation of prediction model

The data collection period at Groot-Aub was done from 11 May - 29 June 2022 and at Meteorology Office was from 16 May 15 June 2022. Fifty questionnaires were issued and forty-eight were returned, giving a response rate of 93%, leaving a 7 % nonresponse rate whereby open ended questions were used while collecting data through questionnaires and interviews with farmers and meteorologists. Over 10 years' dataset was collected from Namibia Meteorological Service databank and it was used together with data monitored by the sensors to create a real-time dataset that was used in the experiment.

After collecting weather dataset from Namibia meteorological service and agricultural data from the local farmers, the data were then pre-processed and pretrained (refer to Appendix: B, Page 85-86). Data pre-processing involved searching for missing values in the datasets, the preprocessing of data also included converting qualitative or non-numeric data to numeric data and the dataset from Namibia meteorological service was converted to an acceptable data type so they can be able to be arranged in a chronologically order, then data was converted to Comma Separated Value (CSV).

To attain the objectives of the study, qualitative data collected (through the use of questionnaires and interviews with local farmer) were thematically analyzed by means of transcription and coding, were by related data were grouped according to their attributes and were labelled with phrases. Quantitative data was inferentially analyzed by using regression method wherebybRandomForestRegressor() function was used to do data regression and classification in order to obtain correct results.

According to Alan et al. (2020), DSR refers to a problem-solving paradigm that seeks to enhance human knowledge via the creation of innovative artifacts. The same author further stated that DSRM seeks to enhance technology and science knowledge bases via the creation of innovative artifacts that solve problemand improve the environment in which they are instantiated and further descriptions are depicted in Figure 1.

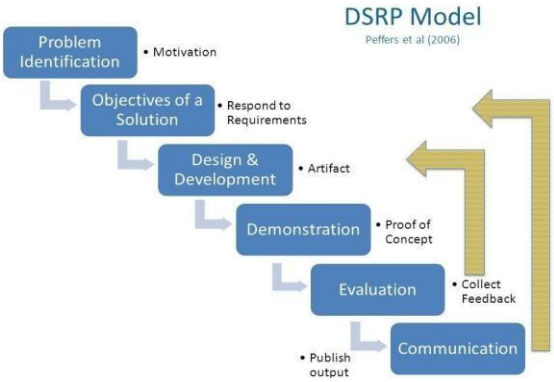

Fig 1. DSR Phases, Peffers et al (2006) .

4. Conclusion

As this study aimed to look specifically at how AI-IoT techniques integrated with an interactive Chabot can be used to predict atmospheric visibility that can be effectively used to reach small scale farmers with agrometeorological information for appropriate decision-making.

In order to accomplish this objective, the following specific objectives were formulated: Collect climate agrometeorological data from real-world environment using IoT sensors, Pre-train the prediction model with the real-world environment dataset using IoT, to predict weather parameters such as temperature. Develop an interactive Chatbot for effective early warning Agrometeorological conditions and finally, to evaluate the performance of the pilot prototype for effective prediction. Modern technology and big data make it difficult for farmers to get accurate information online in the time they need.

Different Chatbot or question answering systems have been developed, but few provide accurate and efficient answers. The challenge is to provide accurate answers to this already built Chatbot system. A welldesigned system uses various techniques such as stop-word removal, POS tagging, stemming, etc., and uses efficient classifiers to properly classify user questions and accurately identify user questions. The research project need to capture the user's query in natural language using a variety of techniques, such as converting it to an intelligent answer. This study explores different approaches and identifies the shortcomings, therefore the researcher can suggest an implementation RNN (Recurrent neural network) approach, this technique contains internal memory and can remember the previous input to predict the next output and due to its efficiency farmer queries can be answered accurately.

5. References

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