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Design and development of weather forecasting software for agriculture

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Abstract : Smart weather forecasting technology plays a pivotal role in agricultural production. We have developed a weather application based on The Deep Hybrid Model to measure wind speed, pressure, temperature, and rainfall. Additionally, the application is designed to obtain the user's current location through location listening and send this information to an API, where it is then arranged into an array list. The synchronization task is a method used to access data whenever needed, and this task runs continuously in the background. The weather API is used to retrieve the current temperature of popular areas within a 150 km radius, and then the data is stored in an array list. From these array lists, data is assigned by a temporary variable to retrieve information about wind speed, pressure, temperature, and rainfall.

IndexTerms **- Weather Forecasting, software, agriculture.**

I. INTRODUCTION

Agriculture is a paramount sector of our country's economy, both historically and presently, exerting the most direct and profound influence on the nation's stability and development. It generates substantial foreign exchange earnings and contributes to enhancing Vietnam's position and prestige on the international stage (Prof. Dr. Tran Duc Vien, 2023). However, data from the General Statistics Office and the General Department of Disaster Prevention from 2016 to 2020 reveal that agriculture is the sector most severely impacted by the consequences of climate change, with a significant loss rate of 64.8%. This figure is expected to rise considerably as Vietnamese agriculture remains highly dependent on the natural environment and lacks comprehensive action plans to address the challenges posed by climate change to agricultural cultivation (Nguyen Hung Cuong, 2020).

In line with global trends in the era of Industry 4.0, the application of technology in agriculture is an optimal solution that can help farmers achieve higher yields. Therefore, smart weather forecasting technology plays a pivotal role in agricultural production. Accurate, comprehensive, and detailed weather and climate information is essential for different agricultural production regions and sub-regions, as well as for each stage of crop growth and development. This information empowers managers, experts, and producers to develop strategies for enhancing crop and livestock productivity (Assoc. Prof. Dr. Mai Quang Vinh, 2017).

Based on these reasons, this paper describes the development process of a weather forecasting software designed to support agricultural cultivation in Vietnam, accessible via smartphones.

II. LITERATURE REVIEW

2.1. WEATHER FORECASTING

Daily atmospheric variations are referred to as weather. Weather data, such as air pressure, temperature, wind speed and direction, humidity, etc., are collected at various meteorological stations observed over the sea, ground, radar, and other observation methods to indicate the current weather conditions (Marzieh Fathi et al, 2021). Weather forecasting originated in the 19th century, but due to the application of Numerical Weather Prediction (NWP), there have been significant advancements in weather forecasting activities between the 1970s and 1980s (Xiao Z et al, 2012).

Weather forecasting is a crucial process that can impact many sectors such as agriculture, irrigation, and maritime commerce, and can save many lives from unexpected disasters (Pandey AK et al, 2017).

In this research, we focus on designing weather forecasting software for agriculture. To enhance agricultural production, weather forecasting and big data analysis in this field should be utilized. Weather forecasts can help farmers become aware of soil erosion, over-irrigation, and drought. Rainfall prediction helps farmers make informed decisions about their crops and they can also estimate food prices (Marzieh Fathi et al, 2021).

2.2. APPLICATION PROGRAMMING INTERFAC

An Application Programming Interface (API) provides services or data offered by a software application through a set of predefined resources such as methods, objects, or URIs (Stylos, Faulring, Yang, & Myers, 2009). By using these resources, other

applications can access data or services without having to implement the underlying objects and processes. APIs play a critical role in many modern software architectures because they provide high-level abstractions that facilitate programming tasks, support the design of distributed and modular software applications, and enable code reuse (Robillard, 2009).

As Myers and Stylos (2016) pointed out, all modern software extensively uses APIs. Instead of programming functionalities from scratch, the primary task of software developers today often involves "stitching together" functionalities provided by existing APIs (Stylos, 2009). Therefore, learning how to use new APIs is a daily task faced by many developers.

2.3. MODELS WEATHER FORECASTING

In recent decades, deep learning and neural network-based weather forecasting techniques have developed significantly. Deep learning technology has numerous applications in computer vision; time series problems can effectively predict spatial and temporal information (Utku & Kaya, 2022; Mladenovic et al., 2022). A typical example of spatiotemporal data is meteorological data.

Most weather forecasting work to date has relied on generative approaches, where weather systems are simulated through numerical methods (L. F. Richardson, 2007; G. Marchuk, 2012; V. M. Krasnopolsky & M. S. Fox-Rabinovitz, 2006) or on time series analysis such as ARIMA models and simple classifiers based on Artificial Neural Networks or Support Vector Machines (Aditya Grove et al, 2015). These statistical models often make strong assumptions such as spatial independence to overcome the curse of dimensionality, which is not true in reality.

To date, the use of machine learning for weather prediction has been limited in several ways. First, most methods only consider one variable at a time and do not explore the joint spatiotemporal statistics of multiple weather phenomena. Additionally, to the best of our knowledge, long-range spatiotemporal dependencies have not been explicitly modeled. Therefore, models have not accounted for long-range phenomena based on natural laws, such as winds aligning with pressure as captured by the structure and dynamics of isobars.

After reviewing the literature on weather forecasting models through 34 random papers, we selected The Deep Hybrid Model with observational variables suitable for the purpose of this paper.

"A Deep Hybrid Model for Weather Forecasting" of Aditya Grover et al (2015) considered four weather variables in The Deep Hybrid Model: wind speed, v; pressure, p; temperature, t; and rainfall, d. Wind observations were represented as a two-dimensional vector, v = [vx, vy], while all other weather variables were scalar. This approach constructs a weather model guided by the following principles: Temporal exploitation, Spatial interpolation, and Variable interactions.

Accordingly, the model can be seen as having three main components. The first component is a set of individual forecasts for weather variables trained on historical data. Many available machine learning procedures can be applied to the recorded data to construct these individual forecasts. The second component functions to refine the inferences made by the individual forecasters by constraining the outputs to be spatially smooth and consistent with constraints imposed by physical laws. The third component comprises a deep belief network that leads to favoring solutions that respect the expected joint statistics of the weather variables.

III. METHOD

We have developed a weather application that obtains latitude and longitude based on the user's location. This information is provided to an API. The API retrieves data and this information is then provided to the application. Through the current location positioning of the user, the location data is arranged into an array list. A synchronization task allows users to access data whenever they need and runs continuously. The current temperature of popular areas within a 150km radius is retrieved using a weather API and then the information is stored in an array list. Figure 1 shows the proposed model.

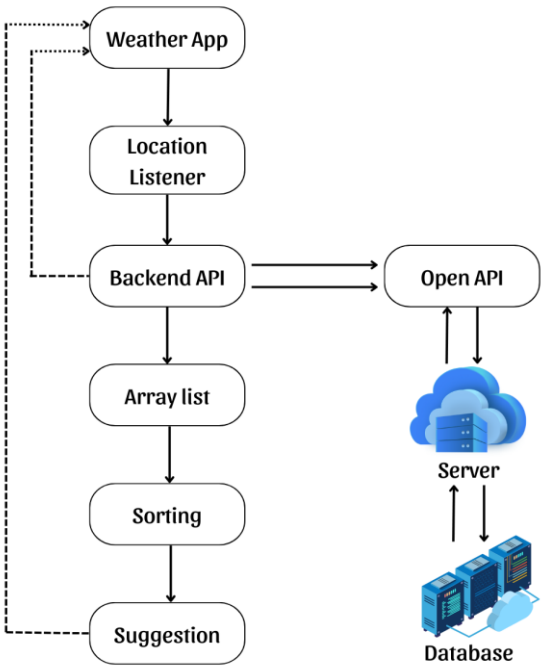


Figure 1. Architecture

IV. RESULTS

The application utilizes a weather API to fetch real-time temperature data for popular locations within a 150-kilometer radius of the user's specified location. The retrieved temperature data is efficiently organized into an array list for subsequent processing. To identify the coldest location, the application iterates through the array list, assigning each temperature value to a temporary variable. By comparing these values, the minimum temperature and its corresponding area are determined. The application then presents this information to the user in a user-friendly format, suggesting the area with the lowest temperature and also displaying the current temperature at the user's location.

Step 1: To initiate the weather data retrieval process, users are required to log in to their account. Once authenticated, they are prompted to select their current location on an interactive map as depicted in Figure 2. This step ensures that the application can accurately tailor the weather information to the user's specific geographic area.

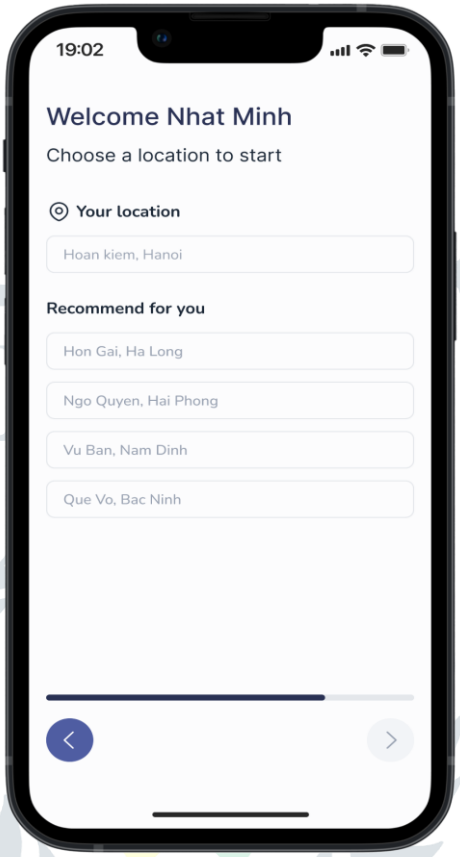


Figure 2. Welcome screen

Step 2: Once the user has selected their current location, the application proceeds to retrieve and display a list of popular nearby locations, as illustrated in Figure 3. This feature allows users to explore and compare weather conditions in different areas of interest



Figure 3. Weather on particular location

Step 3: After the user selects a specific location from the list of popular places, the application fetches and presents a detailed weather forecast for the chosen location. This forecast typically covers the next seven days and includes information on temperature, precipitation, wind conditions, and other relevant meteorological data, as visualized in Figure 4.



Figure 4. Time of day forecast

To provide real-time weather information, the application continuously monitors the user's device location using a location listener. The acquired location data is efficiently stored in an array list, allowing for quick retrieval. To enrich the user experience, the application interacts with a weather API to gather current temperature data for popular locations within a 150-kilometer radius. This data is also stored in an array list. By iterating through these array lists and assigning values to temporary variables, the application can extract specific weather parameters such as wind speed, pressure, temperature, and precipitation, enabling detailed analysis and personalized weather forecasts.

V. CONCLUSION

Weather forecasting has made significant strides over the centuries, with remarkable improvements in recent decades.These advancements, driven by deeper insights into atmospheric processes, computational advancements, and refined prediction models, have made temperature and precipitation forecasts a staple in many countries. However, a pressing challenge lies in tailoring these forecasts to meet the specific needs of end-users, such as farmers. By integrating social and climate sciences, researchers are working to bridge this gap. Studies have shown that farmers are increasingly receptive to climate forecasts, even while recognizing their limitations. This growing appreciation, coupled with a better understanding of farmers' decision-making processes, empowers forecast developers to create more tailored forecast products that directly address the needs of specific user groups, ultimately increasing the value of weather forecasts.

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