JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Weather Forecasting Using Support Vector Machinesand Artificial Neural Networks

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Abstract

Weather forecasting is a critical aspect of modern life, affecting various industries and human safety. Traditionally, Numerical Weather Prediction (NWP) models have been employed, but machine learning approaches offer promising alternatives with increased accuracy and efficiency. In this paper, IT explore the applications of Support Vector Machines (SVM) and Artificial Neural Networks (ANN) to weather forecasting. SVM is evaluated for its performance in binary classification tasks (e.g., rain prediction), while ANN is used to exploit spatial and temporal patterns in meteorological data. The results indicate that ANN outperforms SVM in complex multi-variable scenarios, while SVM excels in simpler, low-dimensional tasks.

Keywords: *Weather Forecasting, Support Vector Machines (SVM), Artificial Neural Networks (ANN), Machine Learning, Meteorological Data.*

1.Introduction

Exact weather conditions estimating is fundamental for farming, catastrophe the board, avionics, and day to day existence exercises. Traditional approaches like Numerical Weather Prediction (NWP) rely on complex simulations of atmospheric physics, which are computationally expensive and limited by model resolution. Machine learning (ML), especially Support Vector Machines (SVM) and Artificial Neural Networks (ANN), offers data-driven alternatives that can enhance prediction accuracy and speed.

This paper investigates the effectiveness of SVM and ANN in weather forecasting, focusing on their respective strengths and weaknesses. While SVM is a robust classifier well-suited for binary classification tasks such as predicting the likelihood of rainfall, ANN's strength lies in identifying patterns in spatial and temporal data, making it an excellent tool for more complex weather forecasting tasks involving multiple variables.

2. Related Work

SVM has been widely used in classification tasks across various domains, including weather prediction. Previous studies demonstrate that SVM performs well when dealing with small datasets and binary classification problems, such as rain/no rain predictions.

ANN, originally developed for image processing, has gained popularity for analyzing spatial data. Recent studies have shown that ANN can effectively model weather patterns due to its ability to capture spatial correlations in meteorological data. ANN models have been applied successfully in short-term weather forecasting, rainfall prediction, and temperature classification.

3.Methodology

This section describes the data collection, pre-processing, and model design for both SVM and ANN.

The following steps are used to achievethe objectives of this paper

1. Setup
2. Data collection
3. Data pre-processing
4. Training models

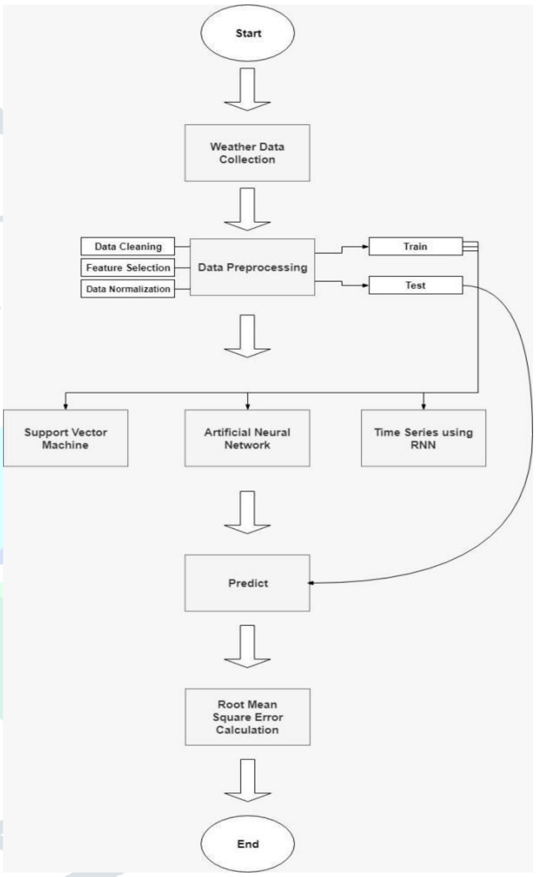

Figure 1: Flow chart of research methodology

3.1 Dataset

We utilized the **National Oceanic and Atmospheric Administration (NOAA)** dataset, which includes historical data on temperature, humidity, wind speed, precipitation, and geographical coordinates. The dataset covers a span of 10 years across multiple locations.

Key features include:

- **Temperature** (daily averages)
- **Humidity**
- **Wind Speed**
- **Precipitation**
- **Geographical Location (Latitude, Longitude)**

3.2 Data Pre-processing

- **Handling Missing Data**: Missing values in the data set were filled using linear interpolation techniques.
- **Normalization**: All features, such as temperature and wind speed, were normalized to ensure effective training of the machine learning models.
- **Feature Selection for SVM**: For SVM, a subset of features (temperature, humidity, wind speed) was chosen based on their high correlation with weather outcomes.

3.3 Support Vector Machine (SVM)

SVM is employed as a binary classifier to predict whether there will be rainfall the following day based on various input features (temperature, humidity, etc.). The Radial Basis Function (RBF) kernel was chosen due to its ability to model non-linear relationships in the data. Hyper parameters such as **C** (regularization parameter) and **gamma** (kernel coefficient) were optimized using grid search cross-validation.

The SVM model predicts rainfall or no rainfall by classifying the weather conditions into two categories based on historical data.

3.4 Artificial Neural Network (ANN)

CNN is designed to handle multi- dimensional meteorological data. The input weather data is structured as a extemporization grid where each grid point contains weather information from a specific geographical location over time.

The ANN architecture includes:

- **Input Layer**: A multi-channel input layer where each channel corresponds to a weather feature (e.g., temperature, humidity).
- **Artificial Layers**: Two Artificial layers with 32 and 64 filters, each followed by ReLU activation and max-pooling

  ayers to extract spatial features from the input data.
- **Fully Connected Layer**: A fully connected layer with 128 neurons followed by a softmax output layer, used to classify multiple weather events (e.g., temperature range, likelihood of precipitation).
- **Output Layer**: The output layer predicts multiple weather conditions

simultaneously (temperature, rainfall, etc.).

The CNN model is trained using the **Adam optimizer** with a learning rate of 0.001. **Categorical cross-entropy** is used as the loss function, given the multi-class nature of the predictions.

4. Results and Evaluation

4.1 Evaluation Metrics

Both SVM and ANN models are evaluated using the followingperformance metrics:

- **Accuracy**: The percentage of correct predictions.
- **Precision**: The accuracy of positive predictions (e.g., how often the model correctly predicts rain when it actually rains).
- **Recall**: The proportion of actual positive events that were correctly predicted.
- **F1 Score**: The harmonic mean of precision and recall.
- **Confusion Matrix**: A confusion matrix is used to visualize the performance of both models inmulti-class classification.

4.2 SVM Results

The SVM model demonstrated high performance in binary classification tasks, such as predicting rainfall. The model achieved an accuracy of **83%** for rainfall prediction, making it effective for simple binary forecasting problems.

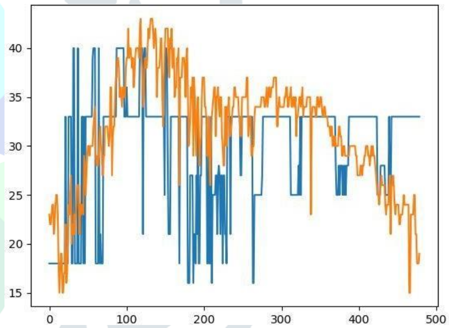

Fig 2: actual vs predicted temperature bySVM

4.3 ANN Results

The ANN model, designed to capture both spatial and temporal patterns, outperformed the SVM model in handling multi-class weather prediction tasks, such as predicting temperature,

humidity, and precipitation simultaneously. ANN achieved an accuracy of **92%** across all weather variables.

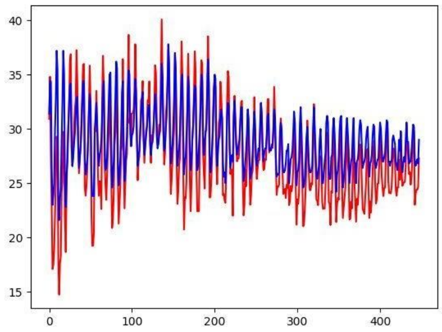

Fig 3: actual vs predicted temperature by ANN

5. Discussion

The results demonstrate that ANN is better suited for complex, multi-variable weather forecasting due to its ability to extract features from spatial temporal data. ANN's superior performance is especially evident when predicting multiple weather conditionssimultaneously.

On the other hand, SVM proves to be effective in binary classification tasks, such as rainfall prediction, where the problem involves fewer variables and requires lower computational power.

5.1 Challenges

- **Data Quality**: Both modelsdepend heavily on the quality of the input data. Missing or noisy data can significantly degrade performance.
- **Model Complexity**: ANN requires more computational resources and time for training, which makes SVM a better option in resource-constrained environments.

6. Conclusion

This paper has demonstrated the application of SVM and ANN in weather forecasting, with ANN outperforming SVM in multi-variable forecasting tasks. SVM remains an effective method for simpler classification tasks. Future research could focus on hybrid approaches that combine the strengths of both models to improve weather prediction in real-time applications.

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