Prediction of Monthly Rainfall of Nainital Region using Artificial Neural Network (ANN) and Support Vector Machine (SVM)

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ABSTRACT

Artificial Neural Network (ANN) and Support Vector Machine (SVM) are the most widely used supervised techniques for data analysis and modeling. In this chapter we used the back propagation neural network model for predicting the average monthly rainfall of Nainital town based on wet bulb, dry bulb, minimum temperature, maximum temperature and wind speed in Nainital town. Our results show that the ANN techniques extremely well with the actual data values as compared to the SVM techniques. From these results we can predict the rainfall for the future.

Key Words: *Rainfall, Support Vector Machine (SVM), Artificial Neural Network (ANN)*

1. INTRODUCTION

Rainfall is natural climatic phenomena whose prediction is challenging and demanding. The important hydrological event rainfall is the quantity of water falling in drops (vapor condensed) in the atmosphere. When water droplets in clouds become too heavy to stay in air, they fall out towards the ground [1]. Rainfall mainly controls our water supplies, which are the basis for crops production and other needs for survival of life on the earth. It is especially important for rain fed land agriculture. Rainfall forecasting is also important for engineering, mainly for the design of hydrological power projects, because the system requires prior information about average rainfall, maximum/minimum rainfall, maximum intensity, duration etc. [2]. In urban areas, rainfall also has a strong influences on traffic control, operation of sewer systems and others activities. True quantitative rainfall forecasting is generally difficult and also a challenging task for anyone because of our complex atmospheric processes. Thus, rainfall is treated as one of the most complex and difficult events among other hydrological events. Forecasting techniques namely the statistical methods (ARIMA, regression, Adaptive neuro fuzzy inference system (ANFIS), Fuzzy inference system (FIS), Genetic algorithm (GA) etc. are proposed in the literature. But Artificial Neural Networks and Support Vector Machine have been extensively used in these days in various aspects of science and engineering because of their ability to model both linear and non-linear systems without the need to make assumptions as are implicit in most traditional statistical approaches. ANN has been an aggressive model over the simple linear regression model. [3].

Review of Literature

[4] implemented an Artificial Neural Network method in predicting monsoon-rainfall over Kerala, a southern state of India. This paper proved that a NN approach could be applicable to predict rainfall over districts of Kerala up to 2003. But, a major drawback of this paper is that it did not analyze the autocorrelation structure of the rainfall time series and choose the input matrix quite arbitrarily. [5] discussed various aspects of summer monsoon rainfall prediction. [6] discussed various problems associated with prediction of Indian summer monsoon rainfall. [7] discussed the reasons behind failure in prediction of Indian summer monsoon rainfall.

Artificial neural networks were originally proposed to developed mathematically model the brain functions such as learning, pattern recognition, classification, and generalization. In the last decade, ANNs have been used in almost all the, branches of sciences, engineering and technology including atmospheric sciences. The Feed Forward Neural Networks (FFNNs) have been used, in satellite data retrieval and interpretation of satellite imagery [8]. The FFNNs have the ability to approximate any nonlinear functional relationship between a set of input-output variables and it has triggered numerous applications including those in the nonlinear identification and prediction of weather systems. [9, 10] used FFNNs in hydrology as rainfall- runoff models.

The Nainital town is famous for its tourism at the national as well as international level. The life of the Nainital town is mostly or totally dependent on the Naini Lake situated at the center of the town surrounded by hills on three sides. The water level of the lake is fully dependent on the rainfall in and around the Nainital town. The drinking and other needs of water to the residents and business purposes are supplied from the lake only. So the prediction of rainfall in Nainital town becomes important to maintain the water level of Naini Lake and water supply from the lake to the town in different months and time. In this chapter, we try to predict the monthly average rainfall in Nainital town.

MATERIALS AND METHODS

The data used for the prediction of monthly rainfall has been taken from the weather department center at Government Inter College Nainital.

Following steps are used to develop the proposed models and to predict the monthly rainfall.

- The daily rainfall data and other parameters viz. dry bulb, wet bulb, maximum temperature, minimum temperature, wind speed are taken from the weather department center at Government Inter College Nainital.
- The monthly average rainfall and monthly average of other parameters are calculated according to the data available.
- The monthly average data is than normalized taking the interval [0,1] with following formula for normalization

$$Normalization\ (N) = \frac{x-a}{b-a}$$

  Where x is the actual value of rainfall a is the minimum range and b is the maximum range of the data.
- The monthly average rainfall is taken as output and rest, of the parameters viz. Sunspot Area, Solar Active Prominences (high and low latitudes) as inputs for both the models.
- The normalized data is used for analysis through ANN and SVM models.
- An ANN models once two and then ten hidden layers are used for the accuracy of the prediction.
- All the monthly and yearly data are then used for training as well as testing.
- Similarly for SVM model, the normalized data has been used.
- Finally predicted values through SVM and ANN are compared with actual rainfall data. MSE is also calculated.
- The comparison of predicted values through the developed models and actual values of average monthly rainfall are done graphically.

RESULTS AND DISCUSSION

For prediction of rainfall in Nainital, the Artificial Neural Network (ANN) and Support Vector Machine (SVM) have been used. At first, the ANN model have been developed taking four input nodes, two hidden nodes and one output node. Further, the second ANN model has been developed for ten hidden nodes. Machine algorithm is also developed for SVM with same inputs and output. By using SVM and ANN techniques we construct the models for training set and consider the same set of data for testing also. With the help of both techniques we can find the amount of rainfall in the region with the help of some parameter like dry bulb, wet bulb, maximum temperature, minimum temperature and wind speed.

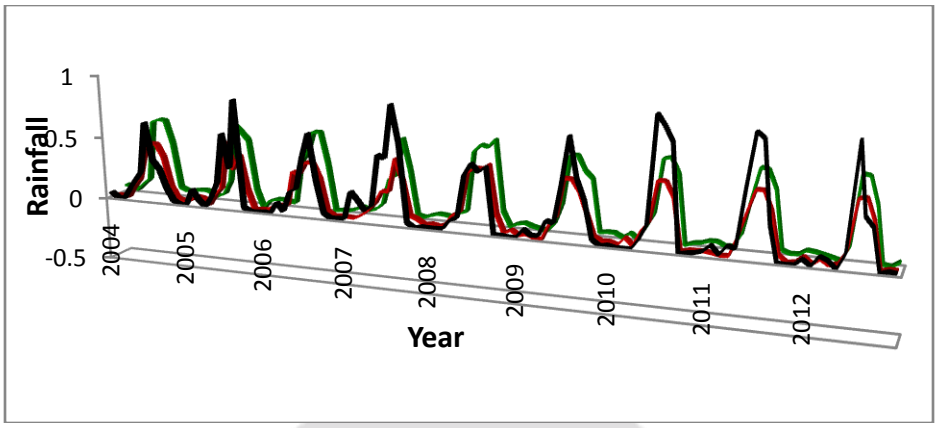


Fig. 1 The comparative plot of Actual (black), ANN-H-2 (green), SVM (red) rainfall

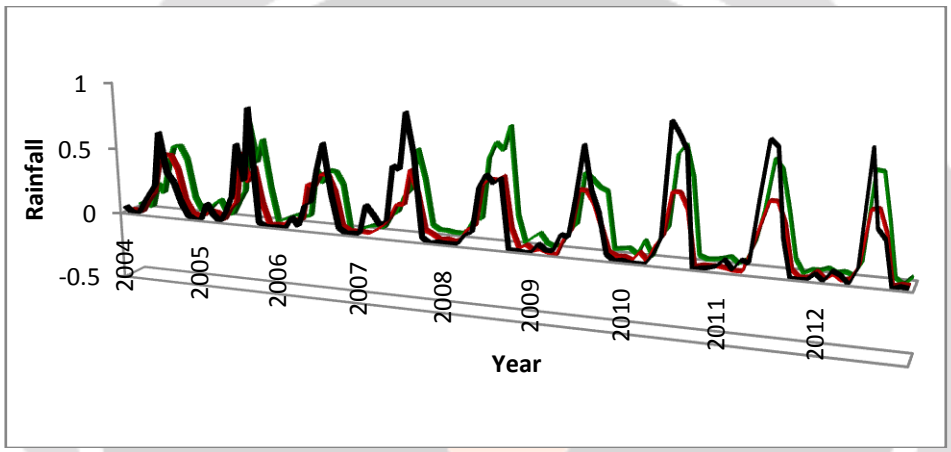
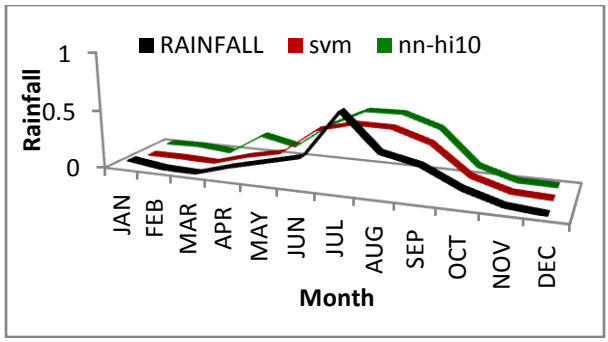


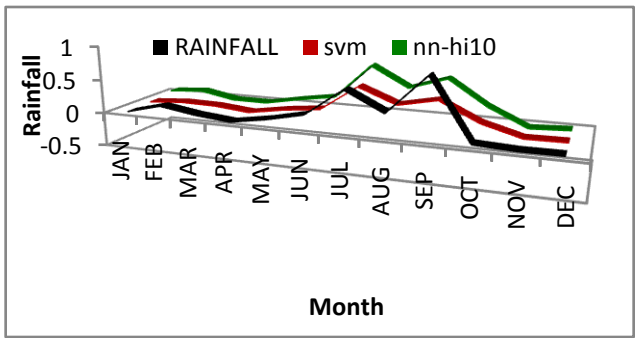
Fig. 2 The comparative plot of Actual (black), ANN-H-10 (green) and SVM (red) rainfall

According to the results, Artificial Neural Network (ANN) was acceptably accurate and can be used for predicting the rainfall. Fig. 1 and Fig. 2 shows the plot of predicted models vs. observed values of the monthly average rainfall data from year 2004 to 2012 by both the ANN and SVM. In both the above cases, it is clear that the ANN gives better predictions than SVM models. This is also justified by the fact that MSE for SVM is 0.010 and for ANN (H-2) and ANN (H-10) are 0.00814 and 0.0070 respectively. In fact the above arguments confirm that the ANN technique is extremely well with the actual data values as compared to the SVM techniques. Both the techniques were tested using the test data set for the period 2004-2012.

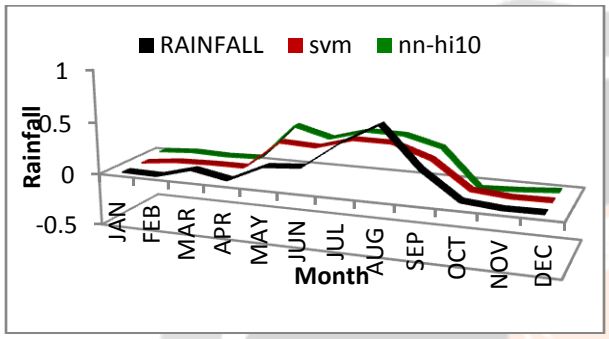
Further to elaborate the results of the developed models, the predicted monthly average rainfall through both the models are compared with actual average rainfall of each month and graphically shown in following figures (Fig. 3 and 4) for each year from 2004 to 2012. From Fig. 3 and 4, it can be observed that the monthly average rainfall predicted by the ANN model are quite closer to actual average rainfall for all the months from 2004 to 2012 as compared to the SVM models. This shows that the models developed can be used for the prediction of average monthly rainfall in place of the other heuristic models developed so far and available in the literature. [11, 12, 13, 14].



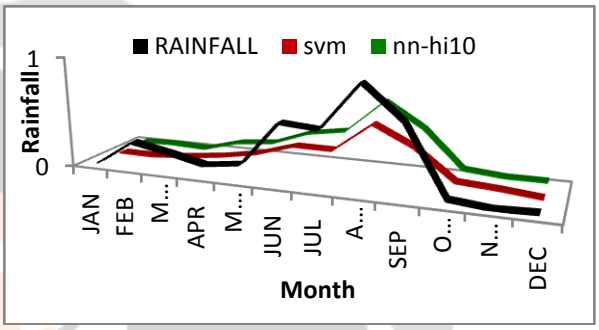
(a) 2004



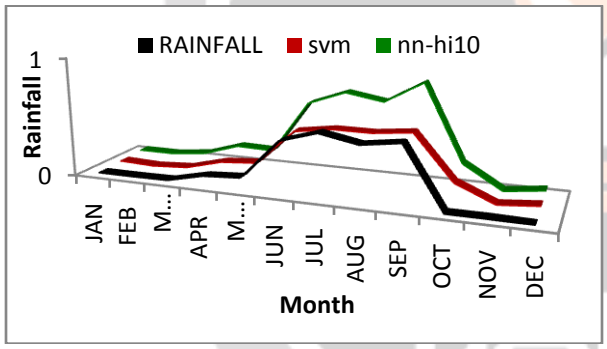
(b) 2005



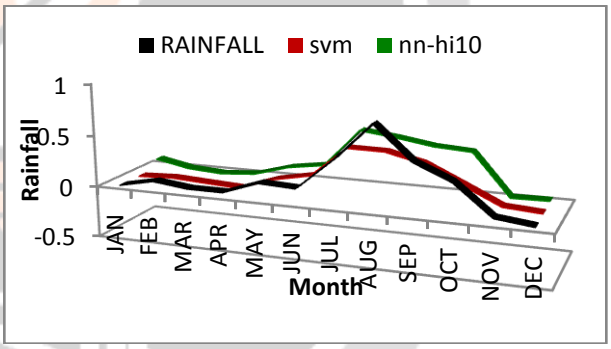
(c) 2006



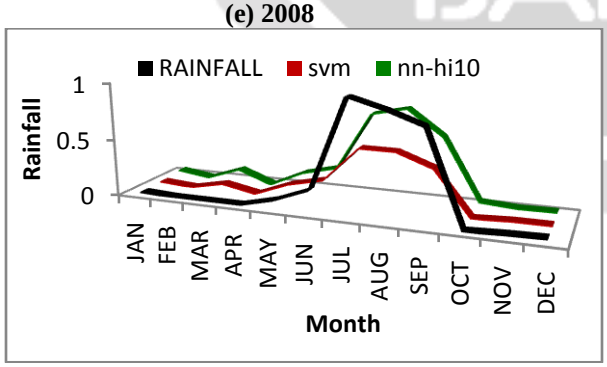
(d) 2007



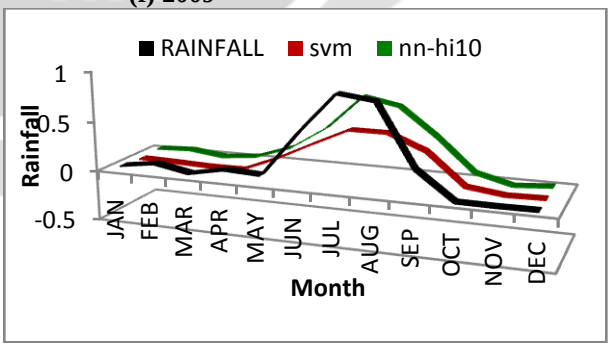
(e) 2008



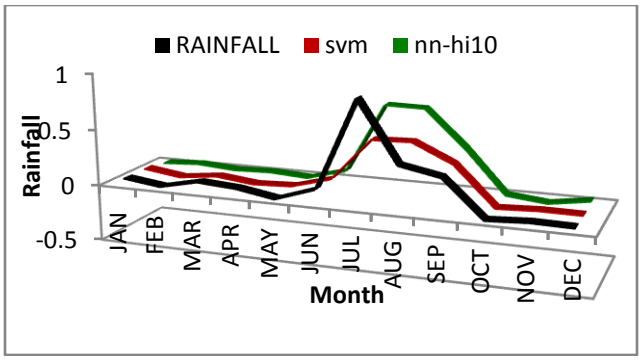
(f) 2009



(g) 2010

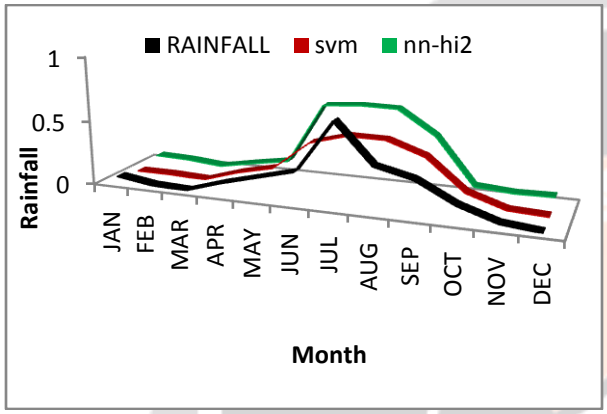


(h) 2011

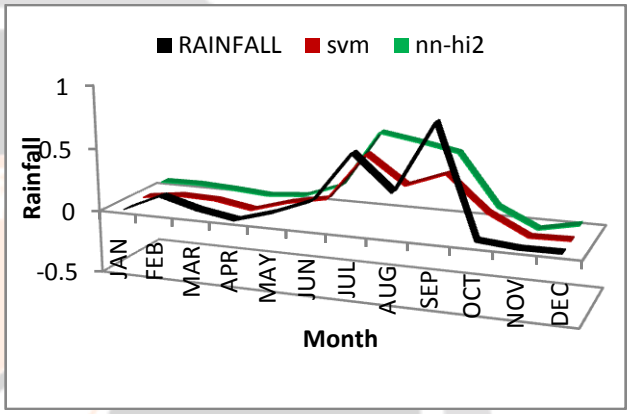


(i) 2012

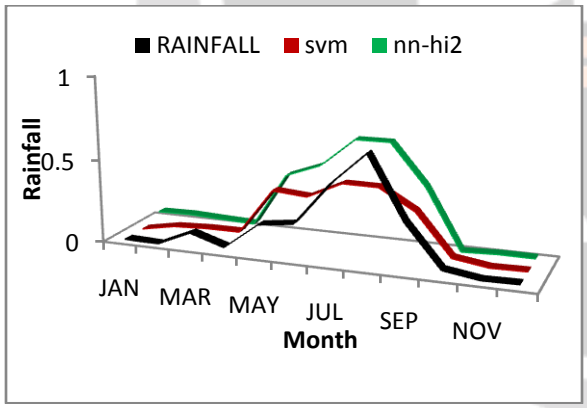
Fig. 3 (a-i) Comparative plots for ANN (H-10), SVM and Actual rainfall for the year 2004-2012



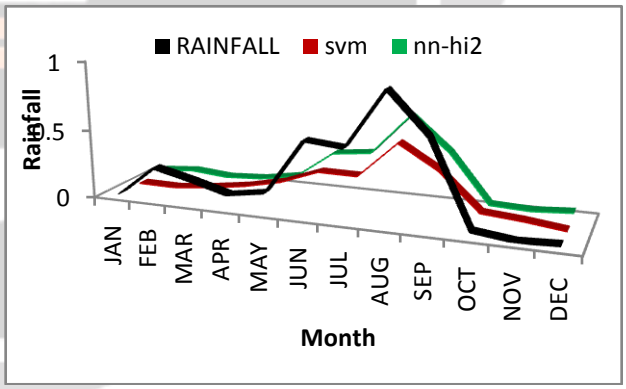
(a) 2004



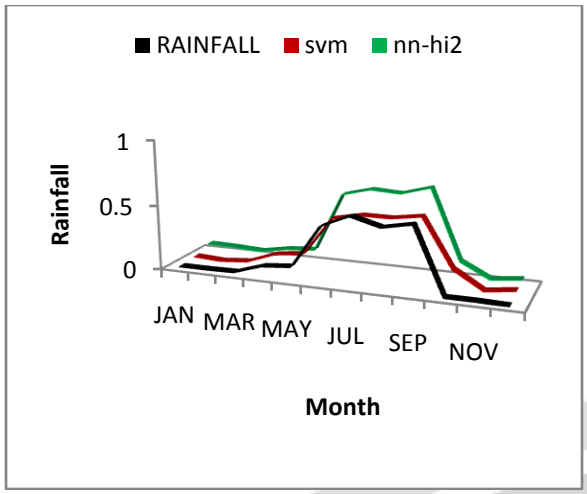
(b) 2005



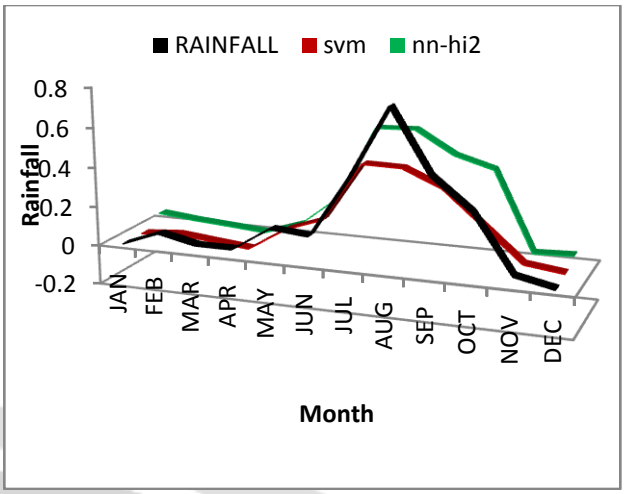
(c) 2006



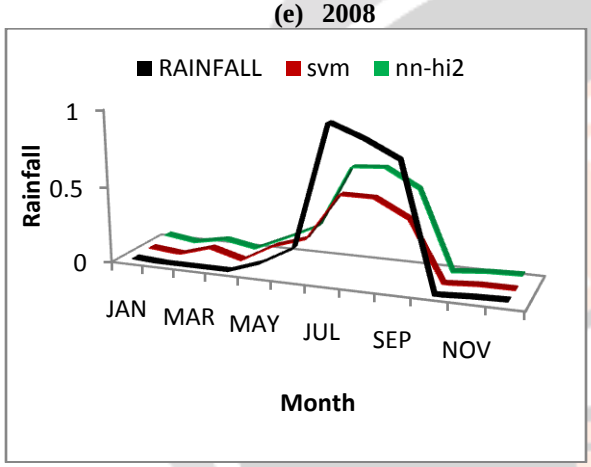
(d) 2007



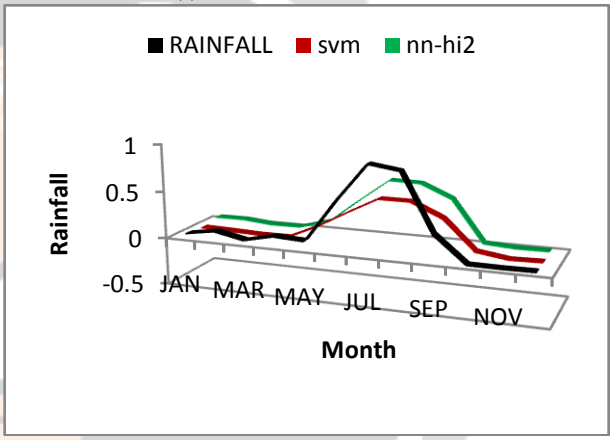
(e) 2008



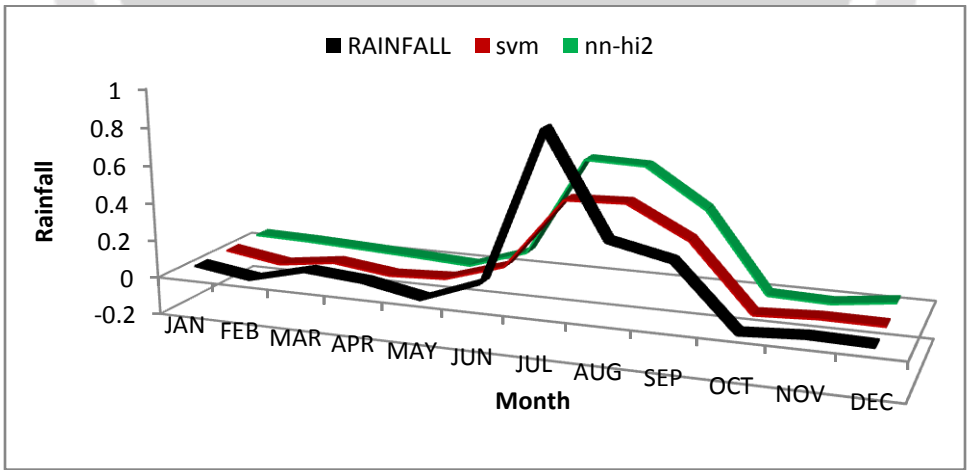
(f) 2009



(g) (2010)



(h) (2011)



(i) 2012

Fig. 4 (a-i) Comparative plots for ANN (H-2), SVM and Actual rainfall for the year 2004-2012

CONCLUSION

This paper reveled a comprehensive investigation on rainfall predictions of Nainital region by using Artificial Neural Network and Support Vector Machine for the period of 2004 to 2012. The survey also gives a conclusion that the forecasting techniques that use ANN and SVM are suitable to predict rainfall than other forecasting techniques such as statistical and numerical methods. The results of the two models shows that the SVM and ANN model has lesser errors in monthly rainfall estimation.

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