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AIR TRAFFIC CONTROL USING MACHINE LEARNING AND ARTIFICIAL NEURAL NETWORK

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Abstract

Air Traffic Control (ATC) is important for human health because flight accidents occur in air space often and it leads to death. Air traffic can control or avoid through predict the parameters of airline system. In this paper, Machine Learning (ML) and Artificial Intelligence (AI) methods proposed to predict and control the air traffic. The proposed methods machine learning and artificial intelligence are predicting the air traffic from air traffic dataset. Air traffic can predict through different statistical methods such as logistic regression (LR), decision tree (DT) and naïve bayes. These algorithms are performing less due to prediction of air traffic based on accuracy and time. These algorithms give huge difference in prediction such as accuracy level and speed. To solve the above problem, air traffic data fed to the pre-trained for prediction of air traffic. The proposed method machine learning and artificial intelligence gives high accuracy prediction compared to other statistical algorithms. Machine learning and artificial intelligence methods gives high accuracy of about 96% compared to conventional methods.

Keywords: Air Traffic data, Machine Learning (ML), Artificial Intelligence (AI), Air Traffic Control (ATC).

INTRODUCTION

In recent years, Air traffic is major problem in this world. Air traffic occurs by some delays such as air system delay, security delay, airline delay, late aircraft delay and weather delay. Air traffic prevents through prediction of these delays. These delays are predicted through different methods but Artificial Intelligence (AI) and Machine Learning (ML) methods gives high efficiency and accurate prediction. Air traffic data are learned through artificial intelligence and machine learning methods.

Artificial intelligence is an important method in computer science for huge dataset. In last few decades, air traffic congestion prediction is done through various air traffic parameters in artificial intelligence model. Artificial intelligence contains some classification such as probabilistic models, game theory and neural network. These methods are applied in wide range of fields especially in transportation for traffic congestion prediction. Machine learning is a subset of artificial intelligence and it is a conventional method which used to resolve the problem of air traffic.

A machine learning method is trained to forecast the likelihood of each flight selecting a cluster of routes based on several route variables such as navigation charges, route length, congestion, and so on. Machine learning algorithm predict air traffic through various air traffic parameters such as arrival delay, weather delay and airline delay with high accuracy. This prediction avoids flight accidents in airspace and reduce delay process. Machine learning algorithm contains different subsets such as Linear Regression (LR) and Multiple Linear Regression (MLR). Air

transportation is huge cost and small mistake leads to very dangerous risk for passengers. Air traffic can sometimes affect passengers in the way of time loss and flight delay sometimes gives mental pressure.

Problem statement

There are lot of predicting methods available in air traffic prediction from air traffic data. But these methods such as Logistic Regression (LR), Decision tree (DT) and naïve bayes classifier are performs less, gives low accuracy, time complexity and low speed during prediction. And, these methods have limited input and output variables. The above problems are solved through the machine learning and artificial intelligence methods.

Contributions

To predict and control the air traffic, predicting methods plays a vital role. To solve the above problem machine learning and artificial intelligence methods are proposed.

(i) To determine the air traffic through proposed methods machine learning and artificial intelligence from air traffic dataset.

(ii) To detect the high accuracy prediction of air traffic dataset through proposed methods machine learning and artificial intelligence.

(iii) To control the air traffic and avoid flight accidents through proposed methods machine learning and artificial intelligence.

Literature survey

Prediction of trajectory is necessary component of air traffic management system but it hampered by trajectory uncertainty because of rules of air traffic controller. So, trajectory predicts through neural network and machine learning [ML] algorithm to avoid air traffic [1]. Air traffic problem is frequently occurred in airspace during recent years. Artificial intelligence [AI], machine learning [ML] and recurrent neural network [RNN] algorithms are used to predict future scenario from historical flight and weather data. This early prediction used to avoid flight accidents and it manage the air traffic [2]. In this paper, air space is classified into different sectors for good management of air traffic and air traffic controller workload. These sectors managed by two team of air traffic controllers but sometimes air traffic problems occurred in air space often. To avoid air traffic by prediction of altitude, speed, trajectory, and course change through supervised machine learning [ML] method [3]. In this paper, to improve capacity and accuracy of air traffic management (ATM) through Bidirectional Long Short -Term Memory (Bi-LSTMs) and Extreme Learning Machines (ELM) with deep learning network methods and these methods used to avoid air traffic accidents in airspace [4]. In this article, Dynamic Air-traffic Management (DAM) technologies used to develop the performance of Air Traffic Flow Management (ATFM) and growth in efficiency of air traffic to avoid air traffic problems [5]. Here, to control the air traffic and resolve the conflicts of aircraft through Deep Multi-Agent Reinforcement Learning method [6]. In this research, Artificial Intelligence (AI) and Machine Learning (ML) methods used to increase the transparency and personalization of air traffic management system and control air traffic by increasing of these parameters [7]. Analytical air ground data link model used to predict the future air traffic control communications for reduce air traffic accidents [8]. In this paper, artificial neural network and back propagation network algorithms used to control the air traffic in airspace. These algorithms can access automation process in air traffic control (ATC) system [9]. In this article, to implement the control of aircraft through Artificial intelligent (AI) and Machine Learning (ML) algorithms. Air traffic is avoided by increasing complexity of air traffic (in altitude) for safe ride [10]. In this paper, predict the air traffic by improve accuracy and robustness through recurrent 3D convolutional neural network (R-3DCNN) model. Long short-term memory (LSTM) model is used to predict the air traffic flow with various flight levels [11]. Airline operation control (AOC) system disruption occurs often in recent years. This problem solved through Multi Agent System (MAS). This disruption proposed as MASDIMA (Multi-Agent System for Disruption Management in AOC) in air traffic control [12]. In this paper, to predict the accuracy of aircraft coordinates through Deep Learning [DL], Long Short-Term Memory [LSTM] and inception modulus. Automatic dependent surveillance-broadcast (ADS-B) technology used with these algorithms for accurate prediction [13]. Air traffic occurs by

bad weather, traffic flows, flight delay and population. In this paper, to control air traffic through automation and optimization methods in air space [14] [15].

Inference from literature survey

Prediction of air traffic has different methods such as Bidirectional Long Short -Term Memory (Bi-LSTMs), Extreme Learning Machines (ELM), Recurrent Neural Network (RNN), Deep Multi-Agent Reinforcement Learning method, recurrent 3D convolutional neural network (R-3DCNN) model, long short-term memory (LSTM) model and deep learning. Extreme Learning Machines gives inaccuracy and unstable to predict the air traffic. Recurrent Neural Network only work with independent variables and limited usability during prediction of air traffic. long short-term memory works with multiple variables but it gives less accuracy. To solve the above problems machine learning and artificial intelligence methods are proposed. The proposed methods machine learning and artificial intelligence gives high accuracy prediction, good performance, high speed, and less time.

Methodology

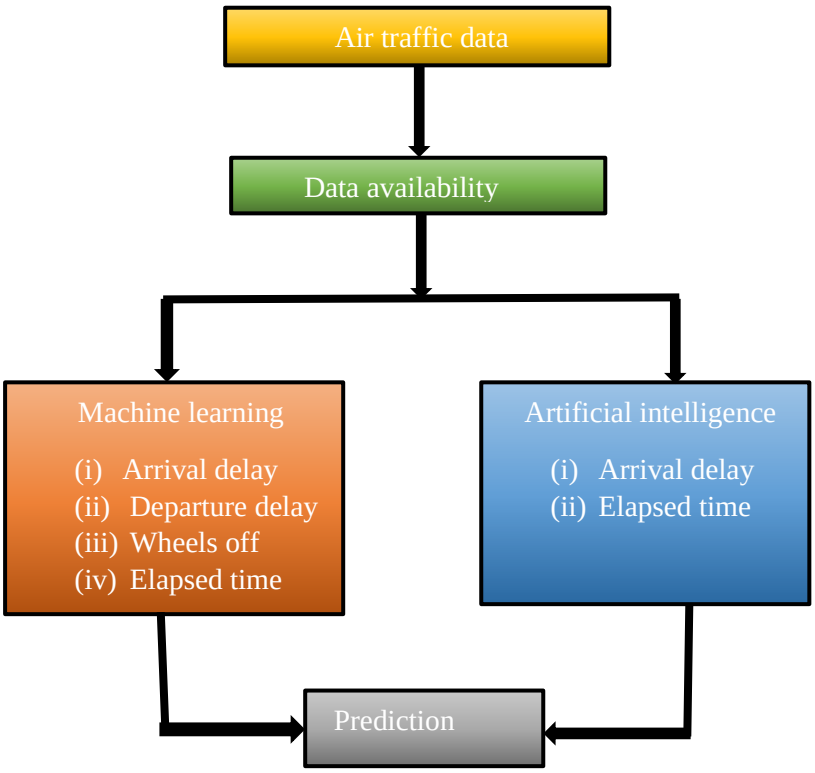


Fig 1 *Block diagram*

The Figure 1 represents the block diagram of proposed methods machine learning and artificial intelligence using air traffic dataset to predict and control the air traffic. The air traffic dataset has many variables such as arrival delay, departure delay, wheels off and distance. These data are pre-processed then compared with different algorithms. Other statistical methods give less accuracy and poor performance. Therefore, machine learning and artificial intelligence methods proposed. Machine learning has some variables such as arrival delay, departure delay and wheels off for prediction of air traffic through linear regression and multiple linear regression. Artificial intelligence has some variables such as arrival delay and distance for prediction of air traffic through neural network. The proposed methods machine learning and artificial intelligence used to predict the air traffic with high accuracy and less time. This accurate prediction used to

control the air traffic and avoid flight accidents in air space.

3.1 Machine learning

Machine learning is the most famous method of predicting future and it is classifying the data to make required resolution for people. Machine learning is a subset of artificial intelligence, it enhances from experience without pre-programmed and have the capability to learn automatically. It gives importance to computer programming development that can access data and use it to learn for automatically. For example, medical diagnosis, image processing, prediction, classification, learning association, regression etc. Machine learning is an unbelievable development in the field of artificial intelligence. While Machine learning has some terrifying intimations, these machine learning is a one of the ways to developing our lives through technology. The patterns related with diseases and health conditions are detect by studying thousands of healthcare records and other patient data in machine learning algorithms. Innovate cancer diagnosis and treatment and raises the healthcare access done in machine learning by recent developments. Machine learning contains four applications in healthcare industries are disease identification, diagnosis in medical imaging, drug discovery, robotic surgical tools. In machine learning, it first got the vast amount of input data then analysing the learned patterns. Then it compared the patterns with historical data for finding the better results. After finding the patterns, it makes some predictions about the data. After prediction, it stores the feedback in specified location. So, it trains repeatedly by the past incidents which can identify the pattern to make prediction about the future. Machine learning contain sub fields such as linear regression and multiple linear regression. Linear regression shows the linear relationship between input variables and output variables. The main purpose of linear regression is to find the best fit for given data. Multiple linear regression shows the relationship between two (or) more independent variable and dependent variable to predict the output.

3.2 Artificial Intelligence

Artificial intelligence (AI) is development of computer system and it can perform like human being. Artificial intelligence may possess the features of human intelligence. Purpose of artificial intelligence is problem solving, decision making and understanding human communication with any language in computers. AI trained by huge amount of historical data AI used in social media, text editors, maps, navigation, digital assistants, face detection and recognition. AI classified into three types such as Artificial Narrow Intelligence (ANI), artificial general intelligence and Artificial Super Intelligence (ASI). AI contain sub field such as neural network. Neural network mimics the human brain and it refers the neurons or artificial in nature. Neural network used to find the hidden layers for accurate prediction. Neural network in AI receives input signal as pattern form and image as vector form. Neural network used for bulk or huge dataset to predict the output. Neural network inclusively called as Artificial Neural Network (ANN) with machines. The features of artificial neural network is speed, processing, size and complexity.

Result and discussion

The air traffic datasets divided into various types of attributes such as arrival delay, departure delay, wheels off and elapsed time. An arrival delay refers, aircraft not arrive the specified airport at specified time. An arrival delay occurs due to adverse weather conditions, bird striking, starting trouble, knock on effect, connecting passengers, crew legality and strikes. Departure delay refers, flight departure time or human departure time. Wheels off refers, to depart on wheels. Aircraft wheels when falls off it is difficult to landing the flight. The flight landing following the instructions of air traffic controllers. Elapsed time refers, total amount of time that passes between starting and end of the event. Elapsed time calculated through breaking the intervals and add up the intervals of events. This elapsed time can say in two ways such as AM/PM and Hours/Minutes. Airline can pay fine for flight delays and passengers can refund the cost of tickets. Passengers can cancel the flight or rebook the next available flight if flight delay occurs.

There are different methods used to predict the air traffic such as machine learning and artificial intelligence. Machine learning has sub fields such as linear regression and multiple linear

regression. Linear regression has two variables to predict the air traffic such as arrival delay and elapsed time. Multiple linear regression has three variables to predict the air traffic such as wheels off, departure delay and arrival delay. Artificial intelligence has sub field such as neural network. Neural network has two variables to predict the air traffic such as elapsed time and arrival delay. Linear regression has some disadvantages such as poor performance and sensitive. Multiple linear regression overcomes the disadvantages of linear regression. However multiple linear regression has some disadvantaged such less accuracy and less speed. Neural network overcomes the problem of multiple linear regression. Neural network gives high accuracy level of prediction, good performance, high speed, and less time. The flight accidents avoid through high accuracy prediction of air traffic and it control the air traffic in air space. The attributes corelated with other attributes to predict the air traffic through proposed algorithms such as machine learning (linear regression and multiple linear regression) and artificial intelligence (neural network).

In linear regression, air traffic can calculate through following formula,

Arrival delay = 0.3196. Elapsed time – 42.5094 ……. (1)

Equation 1, gives 60% accuracy level for air traffic dataset. linear regression gives regression values as 0.5993 and R-squared value as 0.3591.

Table 1 shows the statistical parameters of multiple linear regression for air traffic dataset. Table 2 shows the analysis of variance of multiple linear regression for air traffic dataset. Table 3 shows the overall fit of multiple linear regression for air traffic dataset. Table 4 shows the summary of residuals for multiple linear regression. Table 5 shows the working progress of neural network.

Table 1 *statistical parameters of multiple linear regression for air traffic dataset*

Predictor	Estimate	Standard error	t-statistic	p-value
Constant	-21.7708	19.7345	-1.1032	0.3064
Departure delay	-0.3209	0.873	-0.3675	0.7241
Wheels off	0.3127	0.5106	0.6124	0.5596

In Table 1, standard error refers the average distance of observed values fall from the regression line and standard error of measurement used to determine the accuracy of result. Departure delay has good standard error (0.873) for multiple linear regression. The t-statistics refers test statistics and t-statistic calculate through the coefficient divided by its standard error of multiple linear regression. Wheels off has better t-statistic value (0.6124) air traffic data. The p-vale refers, each term tests the null hypothesis (no effect) and departure delay has high p-value (0.7241) for air traffic dataset in multiple linear regression.

Table 2 *Analysis of variance of multiple linear regression for air traffic dataset*

Source	Df	SS	MS	F-statistic	p-value
Regression	2	52.603	26.3015	0.2178	0.8096
Residual error	7	845.497	120.7853	-	-
Total	9	898.1	99.7889	-	-

In Table 2, the source parameters such as Df, SS, MS, F-statistic, and p-values are calculated through multiple linear regression. The source parameter Df represents degrees of freedom and it defined as sum of regression and residual degrees of freedom. Degrees of freedom used to measure the SS value. Total degrees of freedom (df) of air traffic dataset are 9. The source

parameter SS represents the sum of squares that used to find the relationship between dependent and independent variables of air traffic dataset. Total sum of squares (SS) value of air traffic dataset is 898.1. The source parameter MS represents mean squared error value of air traffic dataset. This mean squared value calculate through mean of sum of square value air traffic dataset. Total mean square error (MS) value of air traffic dataset through multiple linear regression is 99.7889. The source parameter F-Statistic used to test the hypothesis of slope. F-statistic value of air traffic dataset is 0.2178. The p-value of multiple linear regression is 0.8096.

Table 3 *overall fit of multiple linear regression for air traffic dataset*

R-squared	**0.0586**
Adjusted R-squared	-0.2104
Residuals standard error	10.9902
Overall F-statistic	0.2178
Overall p-value	0.8096

In Table 3, R-squared value of air traffic dataset for multiple linear regression is 0.0586. Adjusted R-squared value of air traffic dataset for multiple linear regression is -0.2104. Residuals standard error value of air traffic dataset for multiple linear regression is 10.9902. Overall F-statistic value of air traffic dataset for multiple linear regression is 0.2178. Overall p-value of air traffic dataset for multiple linear regression is 0.8096.

Table 4 *Summary of residuals of multiple linear regression for air traffic dataset*

Minimum (min)	**-10.4944**
1st Quartile (Q1)	-6.5352
Median	-3.7883
3rd Quartile	5.8262
Maximum	16.284

In Table 4, minimum residual value of multiple linear regression for air traffic dataset is -10.4944. The first Quartile (Q1) residual value of multiple linear regression for air traffic dataset is -6.5352. Median residual value of multiple linear regression for air traffic dataset is -3.7883. Third Quartile residual value of multiple linear regression for air traffic dataset is 5.8262. Maximum residual value of multiple linear regression for air traffic dataset is 16.284.

In multiple linear regression, air traffic can calculate through following formula,

Arrival delay= -21.7708 - 0. 3209. Departure delay + 0. 3127. wheels off……. (2)

Multiple linear regression has 12% error and it gives 88% accuracy for air traffic dataset. This error and accuracy calculated through equation 2. In equation 2, departure delay and wheels off has specified value in input data of air traffic dataset. Multiple linear regression gives high accuracy compared to linear regression.

Table 5 *Working progress of neural network for air traffic dataset*

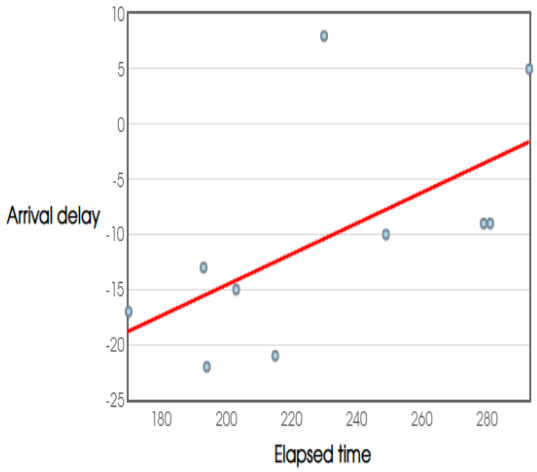
Parameters	Values
Bias (b)	11.2614
Slope(M)	0.3628
Regression (R)	0.9633
Epoch	6 iterations
Performance	6.31
Gradient	4.83
Mu	1.00
Validation checks	6

In Table 5, bias (b) used to fit the dataset with better curve and neural network has high bias value (11.2624) for air traffic dataset. Slope (m) helps to calculate the bias value and neural network has high slope value (0.3628) for air traffic dataset. Regression (r) refers the relationship between the variables to predict the output and neural network has high regression value (0.9633) for air traffic dataset. Neural network has good performance (6.31), good gradient value (4.83) and high epoch (6) for air traffic dataset. This high epoch gives high accuracy level because of long iteration. The gradient value refers the rate of change of air traffic quantity level. Mu is the control algorithm and it has the value 1.00 for air traffic dataset. Validation checks used to select the training parameters and it avoid over fitting for air traffic dataset in neural network. Neural

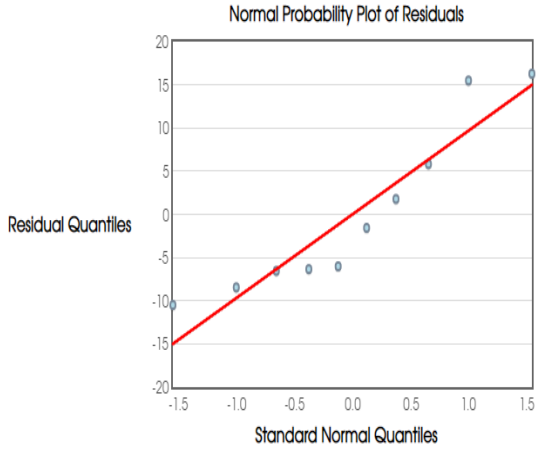
network has 6 validation checks for air traffic dataset. Compared to other conventional methods neural network algorithm has good performance, gradient value, high epochs, better mu value and high validation checks to predict the air traffic. Neural network has high accuracy (96%) compared to linear regression and multiple linear regression. This high accuracy prediction used to control the air traffic and avoid the flight accidents.

Figure 2 shows the output of machine learning (linear regression and multiple linear regression) such as regression plot and residual plot for air traffic dataset. Figure 3 shows the output of artificial intelligence (neural network) such as regression, best validation performance, error histogram, gradient, Mu and validation checks for air traffic dataset.

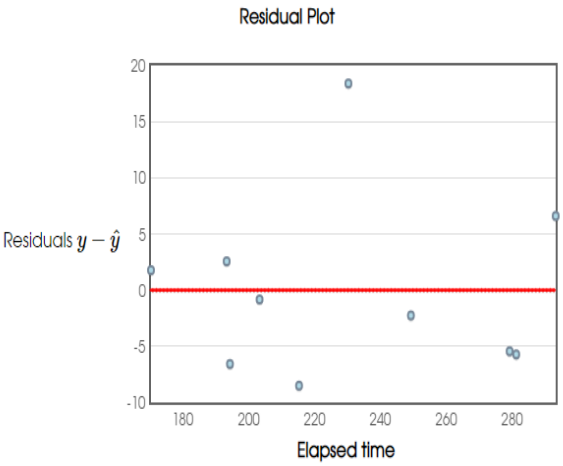
Machine learning (Linear regression and Multiple linear regression)



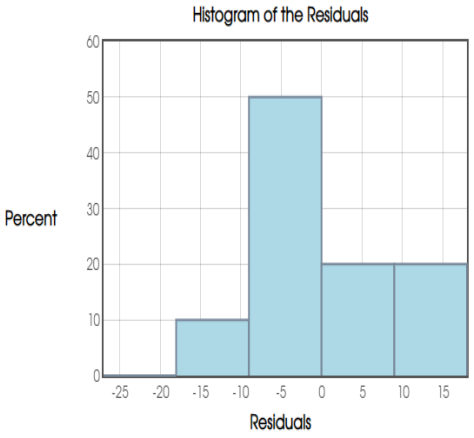
(a) Regression plot for linear regression



(b) Regression plot for multiple linear regression



(c) Residual plot for linear regression

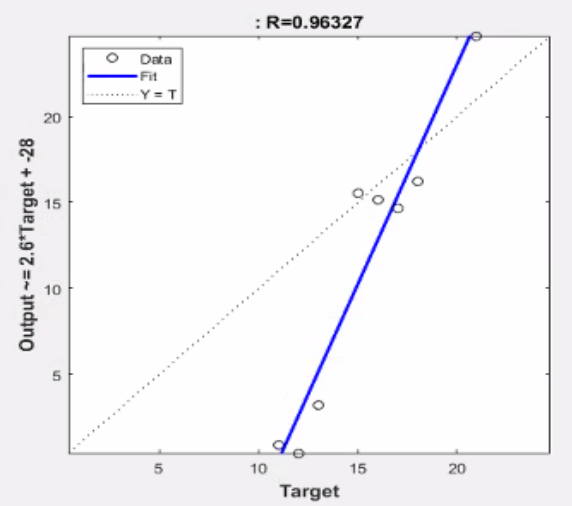


(d) Histogram of Residual plot for multiple linear regression

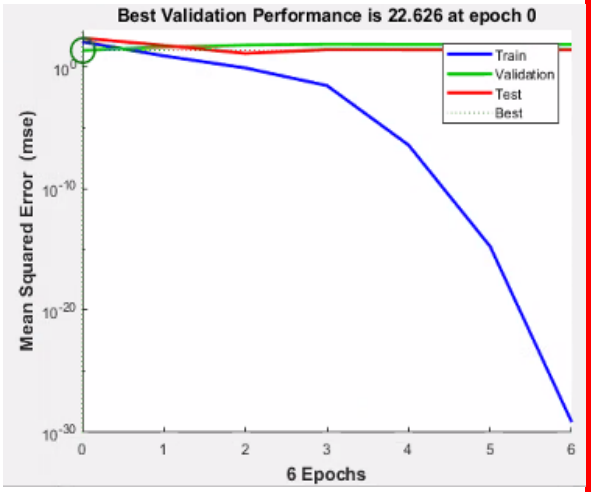
Fig 2 *shows the output of machine learning algorithm (linear regression and multiple linear regression) for air traffic data*

In Figure 2, (a) image shows the output of linear regression. X-axis contains elapsed time variable and Y-axis contains arrival delay variable of air traffic data. A (b) image shows the output of multiple linear regression. X-axis contains two input variables such as departure delay and wheels from air traffic dataset and Y-axis contains arrival delay variable of air traffic data. Linear regression and multiple linear regression show its output as linear line for air traffic dataset. A (c) image shows the residual plot for linear regression and it plotted between elapsed time and arrival delay variables of air traffic dataset. A (d) image shows the histogram of residual plot for multiple linear regression and it plotted between departure delay, wheels off and arrival delay of air traffic data. This histogram shows the shape of large number of datasets with bar graph. Multiple linear regression shows the result as linear line and it gives high accuracy compared to linear regression in machine learning for predict the air traffic.

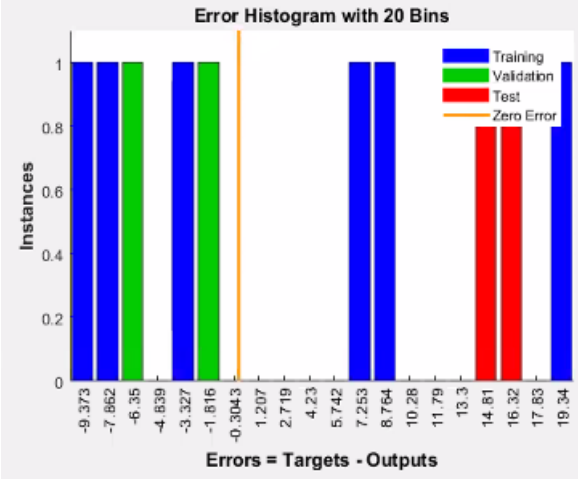
Artificial intelligence (Neural network)



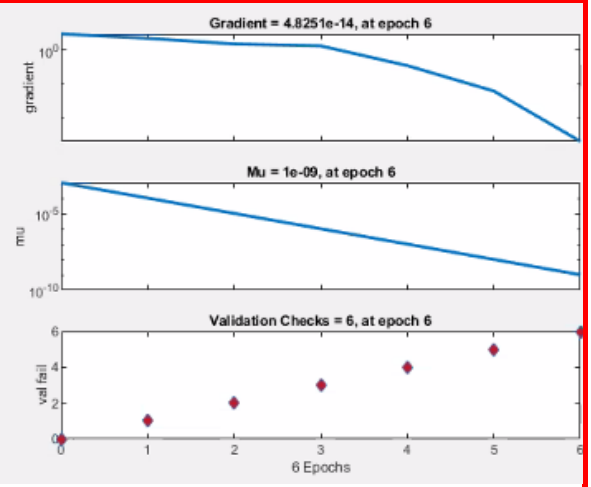
(a) Regression of air traffic dataset



(b) Best validation performance of air traffic dataset



(c) Error histogram of air traffic dataset



(d) Gradient, mu and validation checks of air traffic dataset

Fig 3 *shows the outputs of Artificial intelligence (neural network) for air traffic dataset*

In Figure 3, A (e) image shows the regression of neural network for air traffic dataset and it has regression value 0.96327. A (f) image shows the best validation performance of neural network for air traffic dataset. A (g) image shows the error histogram of neural network for air traffic dataset. A (h) image shows the gradient, mu and validation checks of neural network for air traffic dataset. Compared to other methods the proposed method neural network in artificial intelligence gives high regression value, best validation performance, less error, high gradient, Mu and validation checks values. Compared to other statistical methods the proposed method neural network in artificial gives high accuracy prediction of air traffic and this accuracy prediction used to control the air traffic and avoid flight accidents in air space.

Conclusion

In this paper the proposed methods machine learning and artificial intelligence predicts air traffic from air traffic dataset. Compare to other statistical methods machine learning and artificial intelligence methods produce enhanced output for air traffic dataset. Machine learning and artificial intelligence methods gives satisfactory performance, response, regression, and clear plots of air traffic dataset compared to other methods. Machine learning and artificial intelligence method gives high accuracy about 96%, less time and speed for air traffic dataset. This prediction used to control the air traffic and avoid the flight accidents in air space.

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