



# Development Of Machine Learning Models For A Rapid Battery Charger System

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## Abstract: -

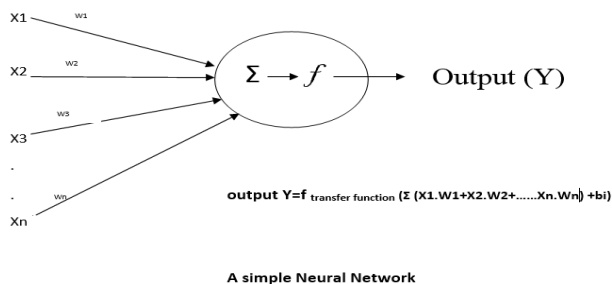
Machine learning models are used to solve different nonlinear and complex problems. This paper presents three machine learning approaches to design and develop an intelligent rapid battery charger system. Our intelligent rapid battery system can decide the charging current using two inputs i.e. temperature and temperature gradient. For design purposes, we developed Artificial Neural Networks (ANN), K-Nearest Neighbor (KNN) and Multi-Regression based machine learning models for a rapid battery charger system. We trained all three machine learning models in python. For results, we observe that the performance of ANN outperforms KNN and multi-regression machine learning models.

**Keywords:** Machine Learning, ANN, KNN, Multi-Regression

## I Introduction

Artificial neural network (ANN) is the branch of artificial intelligence and can be used to develop intelligent applications. ANN can be used in any situation when we require a machine to make rapid and accurate decisions without the assistance of a domain expert. Different problems, such as Regression, classification, and clustering, can be solved with ANN. An Artificial Neural Network (ANN) is a widely dispersed network of artificial neurons trained on existing datasets [1-8]. Artificial Neural Networks have been designed to deal with the sophisticated and nonlinear problems in today's world. In 1958, Frank Rosenblatt was the first to present it. The Artificial Neural Network (ANN) was developed to understand better how the human brain processes visual input and recognizes things. The way ANN works is comparable to how actual neurons work [2-10].

There are two phases to modelling an ANN system: First, we determine the ANN design, which includes the number of hidden layers and neurons in each hidden layer. The ANN system is then trained on the provided training data. The training step determines the best number of neurons for each ANN layer.



**Figure 1.1 Single Layered Neural Networks**

Figure 1.1 depicts a fundamental and simple single layer network. The perceptron is a single-layered neural network with only one input layer. We can get the results by varying the parameters.

The activation function is a 'Simple Linear Equation to solve linear regression issues.' For ANN regression models, Equation 1 is employed as an activation function.

$$y = w_0 + w_1x_1 + w_2x_2 + w_3x_3 + \dots + w_nx_n \quad (1)$$

This paper is divided into three more sections. Section II contains the literature related to ANN and other machine learning models. Moreover, section III presents the three machine learning models for a rapid battery charger system. section IV includes the conclusion of our work.

## II Related Work

Artificial neural networks have made a significant contribution to practically every field of inquiry. To address the problematic and nonlinear challenges, the researchers are enlisting the help of ANN. In the area of education, neural networks are used to evaluate the performance of college students. The desirable properties were chosen using a Multi-Layer Perceptron Neural Network and 10 – fold cross-validation. The backpropagation method is used to consider the intriguing features, and rule mining techniques are used to discover the conditional properties to determine a student's predicted performance [6-14]. The most popular machine learning approaches such as KNN, SVM, Decision Trees, and Random Forests, are available. The KNN machine learning model can be used to address both regression and classification issues. This method operates by relying on the recommendations of 'k' closest neighbours. Different approaches, such as Euclidean, Manhattan, and Minkowski, can be used to compute the nearest neighbours. Equations 2, 3 and 4 demonstrate the Euclidean, Manhattan, and Minkowski equations.

$$\text{Euclidean} = \sqrt{\sum_{i=1}^k (x_i - y_i)^2} \quad (2)$$

$$Manhattan = \sum_{i=1}^k |x_i - y_i| \tag{3}$$

$$Minkowski = \left( \sum_{i=1}^k (|x_i - y_i|)^q \right)^{1/q} \tag{4}$$

The Support Vector Regression (SVR) is a regression approach that uses the same ideas as the Support Vector Machine (SVM). Regression seeks to find a function that approximates the mapping from an input domain to real numbers based on a training sample. Let us take a deeper look at how SVR works in practice. Figure 1.2 [3,15] shows the green line representing the decision boundary between these two red lines and the hyperplane. Our aim with SVR is to examine the points within the decision boundary line as we move forward. The best-suited line for us is the hyperplane with the most points. The first question we have is: what is the decision boundary? Consider these lines at any point 'a' from the hyperplane. As a result, we draw these lines at 'a' and '-a' distances from the hyperplane. This 'a' is referred to as Epsilon in the text [4,16]. The outputs may be estimated using equations 4,5, and 6.

hyperplane equation

$$Y = wx+b \tag{4}$$

decision boundary equation

$$wx+b= +a \tag{5}$$

$$wx+b= -a \tag{6}$$

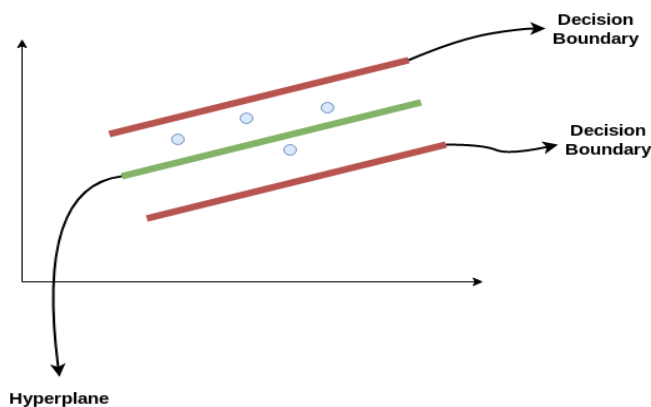


Figure 1.2 SVR working

Multiple Regression is a type of linear Regression that considers the connection between multiple variables. There is just one predictor and one response variable; however, in Multiple Regression, there are several predictor variables and one response variable.

Equation 7 is the typical mathematical equation for Multiple Regression.

$$y = a + (b1*x1) + (b2*x2) + \dots + (bn*xn) \quad (7)$$

In equation 7, y is the response variable. Next, a, b1, b2...b\*n are the coefficients and x1, x2, ...x\*n are the predictor variables [5].

### III Development of Machine Learning Models for Rapid Battery Charger System

In this section, we present three machine learning-based models to design a rapid battery charger system. For designing purposes, We trained ANN, KNN and multi regression machine learning models. All machine learning models are implemented in python. For implementation purposes, we considered the rapid battery charger dataset. As shown in table 1, The rapid battery charger system consists of two inputs and one output variable. The inputs for the rapid battery charger are temperature and temperature gradient. The output of our system is a charging current. To bring our all input on a common scale, we first normalized our dataset. The performance of our machine learning models could be improved due to normalization. After normalization, we trained ANN, KNN and Multi-Regression machine learning models.

Table 1.1 Rapid Battery Charger Training Dataset

Temperature	Temperature Gradient	Charging Current
0	0.0	4.0
30	1.0	4.0
37	0.2	4.0
40	0.0	3.0
40	1.0	2.0
41	0.5	2.0
42	1.0	1.0
43	0.5	1.0
43	1.0	1.0
44	0.0	0.1
44	0.4	0.1
45	0.1	0.1
45	0.5	0.1
50	1.0	0.1
43	0.5	1.0
43	1.0	1.0

Figure 1.3 shows the block diagram of a machine learning based intelligent rapid battery charging system. To analyze the performance of all three machine learning models. We partitioned this dataset into 70% and 30% ratios. The 70% dataset is taken for training purposes and the 30% dataset is taken for testing purposes.

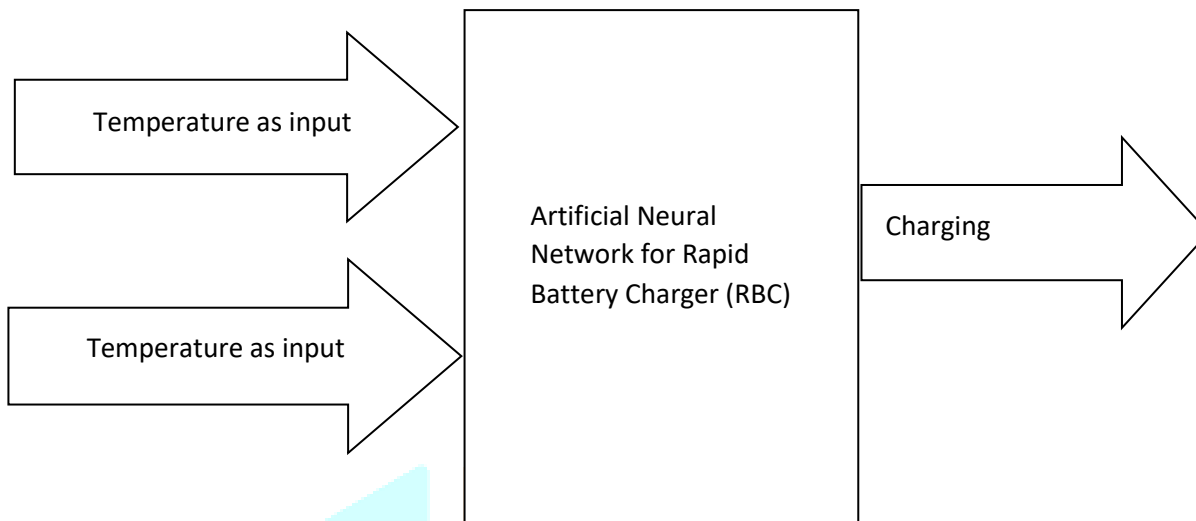


Figure. 1.3: Desired ANN System for Rapid Battery Charger

Table 1.2 MSE results for all different algorithms for Rapid Battery Charger (RBC)

Algorithm	MSE
KNN	0.04867562
Mutil Regression	0.07411980
ANN	0.02218187

Table 2 presents the performance results of all three developed machine learning models for battery charger systems. The performance of all the models is compared based using Mean Square Error (MSE). According to the results, KNN gives the MSE of 0.04867562, whereas the multi regression model gives the MSE of 0.07411980. The ANN model gives the MSE of 0.02218187, the lowest among all the implemented machine learning models. From the given results, we have observed that the ANN approach's performance is more efficient than the other approaches applied.

#### IV Conclusion

Machine learning models are widely used in various areas to handle nonlinear and complex problems. It provides a variety of ways for designing and implementing machine learning models. In this paper, we have developed three distinct machine learning models, which can decide the charging current for the rapid battery charging system using two inputs i.e. temperature and temperature gradient. We trained ANN, KNN, and multi regression models for rapid battery charger systems. All machine learning models

are compared using Mean Square Error (MSE). From the results, we observe that the performance of the ANN-based rapid battery charger system is better than KNN and multi regression-based systems.

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