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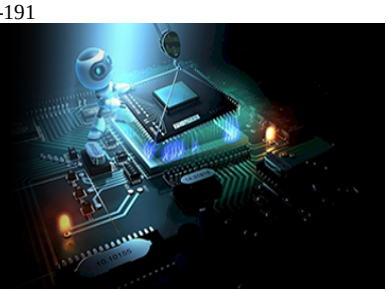

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An innovative method for finding out the glycemic index of raw food items based on two layer feed forward neural networks

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Abstract
Nowadays, Artificial Neural Networks play a vital role in diverse fields of applications. New researches are evolving in Artificial Neural Networks now and then in the past few decades. Researches in Artificial Neural Networks have grown rapidly over the past few years. This research work deals with an innovative approach for finding out the Glycemic Index of raw food items using two layers feed forward Neural Networks. This is an innovative theoretical idea by which two layer feed forward Neural Networks are imparted training to learn for some known GI values of some of food items called training set. After training, the two layers feed forward Neural Networks system will be used to find out the GI value of new raw food items which were not trained. In this research work, some of the GI values for some raw food items are taken, their contents, amount of nutrients are given as inputs, weight adjustments are given based on their amount of nutrients and the network is trained. After training, the network will be used for finding out GI values of food items which were not trained.

Keywords: Glycemic index**,** neural networks, nutrients, weight adjustments

1. Introduction
Research in Artificial Neural Networks [3, 5, 6] has grown rapidly over the past few years. Artificial Neural Networks [5] are based on biology. They are composed of elements that are related to the most elementary functions of the biological neuron. These elements are organized in a way that is related to the anatomy of the brain. Hence, Artificial Neural Networks [6] possess a surprising number of the brain's characteristics. For example, they learn from experience, generalize from previous examples to new ones, and abstract essential characteristics from inputs containing irrelevant data.
The glycemic index was first proposed by a group of researchers to classify foods containing carbohydrate according to their glycemic response [1, 2]. It indicates how quickly the blood glucose increases after ingestion of a food. Glycemic index is affected by many factors, such as fiber content, the amount of fat contained in the food, the type of sugar, cooking method, and food processing. The maturity of fruits can also affect its glycemic index, e.g., glycemic index of a fully ripe banana is much higher than that of an unripe banana.

2. Related works
Artificial Neural Networks [3, 5, 6] can modify their behaviour according to their environment. Given a set of inputs and the desired set of outputs, the two layer neural networks are trained to produce the desired output when the input is fed. In this research work, some of the GI values for some raw food items are taken, their contents, amount of nutrients are given as inputs, weight adjustments are given based on their amount of nutrients and the network is trained. After training, the network will be used for finding out GI values of food items which were not trained.
The input for the Neural Network is given along with some predetermined values of weights based on already derived algorithms or predetermined procedure. The weighted inputs from each neuron present in the layer feed its input to the subsequent layer neurons. Each neuron computes the summation of all weighted inputs which they receive from the previous layer neurons. If this algebraic sum of the inputs is more than a fixed value which is called as threshold value, then this neuron will emit an output of 1, 0 otherwise.

The GI value of food items are converted into binary numbers and that will be the correct and expected output. The output from the output layer is compared with the desired output. The difference between the present output and the desired output is calculated. The weight adjustments are made taking output difference based on the algorithms for this purpose or some Mathematical formula or predetermined procedure.
Again, the same input is given along with the new weights and the same procedure is followed. This is called training of the Neural Networks. This training process is repeated till the correct or nearly correct output is obtained. This training process is repeated for each training set of input and output. After full training of this Neural Network, if another input is given, it will automatically produce the correct output. The neural networks can modify their behaviour in response to their environment. The Neural Networks [5] self-adjust to produce consistent responses during training process. There are a wide variety of training algorithms have been developed. Each algorithm is having its own strengths and weaknesses.

2.1 Generalization and Abstraction
Once trained, a network's response can be to a degree, insensitive to minor variations in its input. This ability to see through noise and distortion to the pattern that lies within its limit is used for pattern recognition.
So, Artificial Neural Networks [5, 6] are capable of abstracting the essence of a set of inputs. For example, a network can be trained on a sequence of distorted versions of the letter A. After sufficient training, application of such a distorted example will cause the network to produce a perfectly formed letter. In one sense, it has learned to produce something that it has never seen before.

2.2 Artificial Neuron
The Artificial Neuron [6] is designed to mimic the first-order characteristics of the biological neuron. In this, set inputs are applied and the output is calculated as follows.

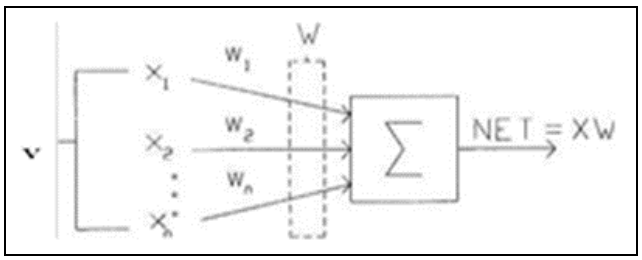

Fig 1: Structure of Artificial Neuron

$$NET = x_1 w_1 + x_2 w_2 + \ldots\ldots\ldots\ldots + x_n w_n \quad (1)$$

The Neuron adds all of the weighted inputs algebraically, producing an output that called as NET.

$$NET = XW \quad (2)$$

Activation Functions
The NF'I' signal is usually further processed by an activation function to produce the neuron's output signal, OUT. This may be a simple linear function

$$OUT = K(NET) \quad (3)$$

Where K is a constant, a threshold function,

OUT = 1 if NET > T
OUT = 0 otherwise (4)

Where 'T' is a constant threshold value or a function.

The concept of the glycemic index (GI) is well known among researchers and consumers. Much of this research is conducted to attempt to develop a reliable and rapid method for the determination of carbohydrate digestibility, and hence glycemic impact determination.

2.3 Glycemic Index (GI)
The glycemic index (GI) [1, 2] is a numerical system of measuring how much of a rise in circulating blood sugar a carbohydrate triggers - the higher the number, the greater the blood sugar response. So a low GI food will cause a small rise, while a high GI food will cause a high riseT.
Glycemic index (GI) is a numerical value assigned to foods based on their capability to increase the blood glucose levels after consumption. They are classified into high (≥70), moderate (between 69 and 55) and low (≤55) GI. The calculation of GI in foods introduces the concept of Glycemic Load (GL), which estimates how the quantity of carbohydrates in foods raises the blood glucose levels depending upon the type of carbohydrate present in that food.

3. Single-layer Feed Forward Network
It is the simplest and most basic architecture of ANN's [3, 5, 6]. It consists of only two layers- the input layer and the output layer. The input layer consists of 'm' input neurons connected to each of the 'n' output neurons. The connections carry weights w_{11} and so on. The input layer of the neurons doesn't conduct any processing they pass the i/p signals to the o/p neurons. The computations are performed in the output layer. So, though it has 2 layers of neurons, only one layer is performing the computation

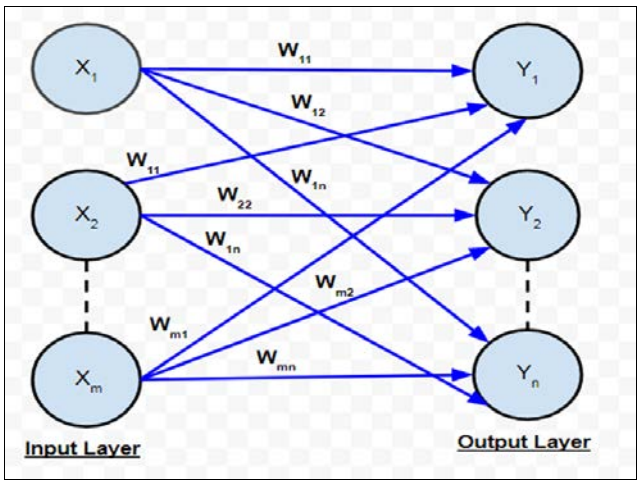

Fig 2: Architecture of Single-layer Feed Forward Network

This is the reason why the network is known as SINGLE layer. Also, the signals always flow from the input layer to the output layer. Hence, the network is known as FEED FORWARD**.** The net signal input to the output neurons is given by the signal output from each output neuron will depend on the activation function used.

4. Multilayer Feed forward Neural Networks

The multi-layer feed-forward network [3, 5, 6] is similar to the single-layer feed-forward network. But, there may be one or more intermediate layers of neurons between the input and the output layer. There may be more than two layers of neurons. So, the network is termed as multi-layer network**.** Each of the layers may have varying number of neurons. In the above diagram there are 'm' neurons in the input layer, 'n' neurons in the hidden layer and 'r' neurons in the output layer.

5. Characteristics of Neural Networks

- The Neural Networks possess mapping capabilities. That is, input patterns and the associated output patterns can be mapped.
- The Neural Networks learn by examples. Neural Networks can be imparted training.
- With known examples of problem that is input and the desired output pair. After training, when unknown instance of the problem is given, the Neural Network can identify new objects previously untrained.
- The Neural Networks have generalization capability. They can predict new outcomes from past trends.
- The Neural Networks are robust systems. They are fault tolerant. So, full patterns from incomplete, partial or noisy patterns can be recalled.
- Parallel processing of information at high speed and in a distributed manner is possible by Neural Networks.

6. Glycemic Index of Food Items (GI)

The GI [1, 2] is a value that ranks carbohydrates on a scale of 1 to 100 depends upon how much they raise blood sugar. If GI value of a food item is less, then it causes low blood sugar, whereas, high GI value of a food item causes high blood sugar.

Processed foods such as breads, cake, and chocolates have a high GI value. But, foods such as unrefined grains, non-starchy vegetables, and fruits have a lower GI.

Foods that are primarily fat or protein have a minimal impact on blood sugar levels. The GI of a specific food depends primarily on the quantity and type of carbohydrate it contains, but is also affected by the amount of the carbohydrate molecules within the food, the fat and protein content of the food, the amount of organic acids (or their salts) in the food, and whether it is cooked and, if so, how it is cooked. GI tables, which list many types of foods and their GIs, are available. A food is considered to have a low GI if it is 55 or less; high GI if 70 or more; and mid-range GI if 56 to 69.

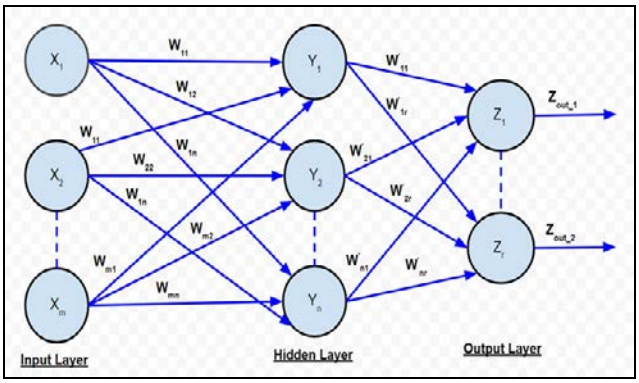

Fig 3: Architecture of Mulilayer Feed Forward Network

When persons have type 2 diabetes, the best way to control glucose levels is to eat foods with lower GI value which don't cause major blood sugar. Knowing the GI of the food items, can help to fine-tune the meals to keep the blood sugar within a normal range. Foods with a higher GI value will increase the blood sugar than foods with a lower GI. This research paper explains theoretically to find out the glycemic index of new raw food items. The glycemic index charts that show low GI, moderate GI, and high GI carbohydrates.

6.1 Glycemic Index Chart for Common Foods

The following charts highlight low, medium, and high GI foods.

Table 1: The GI values are classified into three ranges

Low GI	55 or less
Medium GI	56 to 69
High GI	70 to 100

Glycemic index values were found by a hard testing process using 10 or more people for each food. Researchers measured blood sugar levels of healthy volunteers before and two-hours after eating 50 grams of the same digestible carbohydrate (the test food). The points were then plotted on a graph.

Table 2: Low-GI (55 or Less) food items

Foods	GI
Apple	36
Apple juice	41
Banana	51
Barley	28
Dates	42
Ice cream	51
Mango	51
Orange	43
Orange juice	50

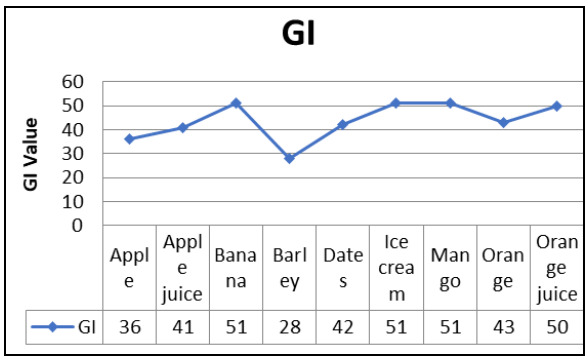

Fig 4: Low-GI (55 or Less) food items

At a separate date, the same 10 people consumed 50 grams of pure glucose (the reference food), and researchers again measured each person's glucose response and the points were plotted. Using this, the GI value of the tested food is calculated.

Table 3: Medium-GI (56 to 69) food items

Foods	GI
Popcorn	65
Potato chips	56

The major nutrients in our food are Carbohydrates, Proteins, fats, vitamins and minerals. In addition, food also contains dietary fibres and water. Though, there are different nutrients are present in our food items, but GI value mostly depend on the type and quantity of carbohydrate in it. GI value also depends on the other nutrients of food items. In our case, only raw food items are taken and therefore type of cooking is not considered.

Table 4: Medium-GI (56 to 69) food items

Foods	GI
Potatoes, instant mashed	87
Rice milk	86
Watermelon	76

7. Training and Learning of two layer Feed Forward Neural Networks for Finding out GI value of raw Food Items

Since, this research, deals with an innovative theoretical idea or method for finding out GI value, for easy understanding purpose, only the role of four important nutrients namely, carbohydrates, proteins, fats, vitamins and minerals collectively are assumed as key elements for GI value. Therefore, in the input layer of Neural Network, four neurons are taken, each one representing one key element.

Table 5: Weightage to nutrients

SL. No.	Nutrients	Amount
1	Carbohydrates	X1
2	Proteins	X2
3	Fats	X3
4	Vitamins and Minerals	X4

This is a supervised training in which every time the weight adjustments are made according to some predetermined procedure. Weight adjustments are given according to the amount of nutrients present in food items. Same time, above all, 40 to 50 times weighted input should be given to the neuron from carbohydrates because the major role of GI value is only from Carbohydrates.

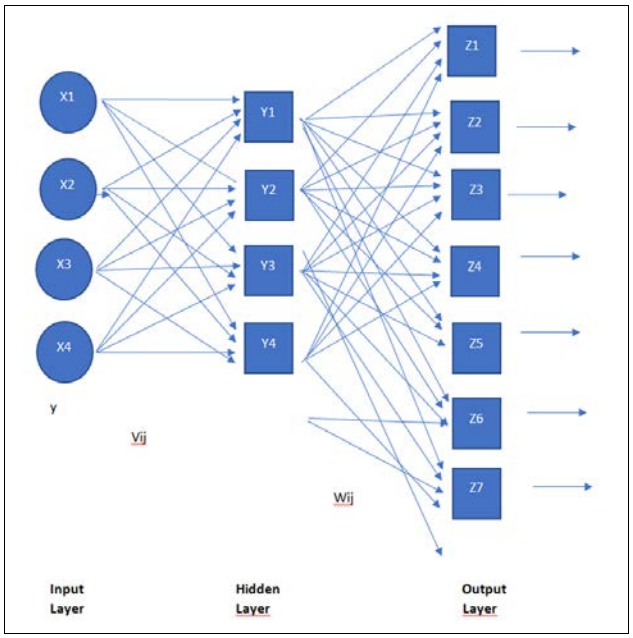

Fig 5: Two layer Feed Forward Neural Networks for Finding out GI value

Where Vij Weights between Input Layer and Hidden Layer and Wij Weights between Hidden Layer and Output Layer.
From the input layer, inputs are fed along with weights as per the predetermined procedure. The weighted inputs are fed to all the neurons in the hidden layer. The sum of weighted inputs they receive is more than that of the threshold value which is already fixed, the neuron will emit an output of 1, otherwise, 0.

Table 6: Weightage to nutrients

Sl. No.	Food Item	Carbohydrate	Protein	Fat	Vitamins, Minerals	GI Value	Output
1	Apple	C1	P1	F1	VM1	36	100100
2	Banana	C2	P2	F2	VM2	51	110011
3	Dates	C3	P3	F3	VM3	42	101010
4	Mango	C4	P4	F4	VM4	51	110011
5	Barley	C5	P5	F5	VM5	28	11100
6	Orange	C6	P6	F6	VM6	43	101011

The output from the hidden layer is given with weights to the neurons in the output layer. In the similar way, the output is calculated. This output is compared with the desired output. The difference between present output and desired output is calculated. This difference is used for the next weight adjustment. In this fashion, every time weight adjustments are made. This training process is repeated till the correct output is received.

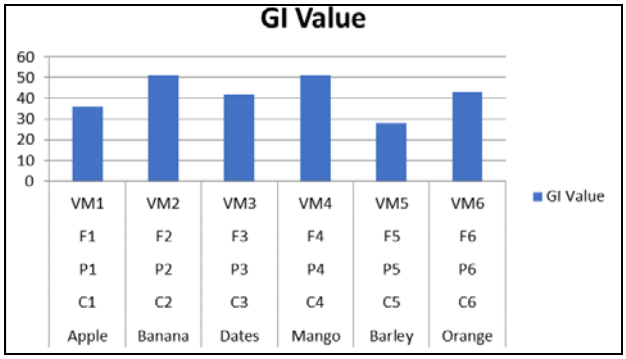

Fig 6: Nutrients contents of carbohydrates, proteins, fats, and combination of minerals and vitamins with GI value

The GI is a rating system that ranks carbohydrates on a scale of 1 to 100 based on how much they raise blood sugar. Each food item of 50 gm is taken, nutrients are measured and then it is taken for testing. So, the GI value will range from 1 to 100. Here, for the purpose of understanding the process of training of two layer neural networks, six input sets are taken. And, the nutrients contents of carbohydrates, proteins, fats, and combination of minerals and vitamins are assumed to have effect on GI value; their corresponding GI values are considered. Since, the value of GI varies from 1 to 100, to output the maximum value of 100, in the output layer there must be 7 output neurons.

7. Conclusion

This research work deals with an innovative idea for finding out GI value of raw food items. It deals with a method which is a theoretical idea only. In this research work, some of the GI values for some raw food items are taken, their contents, amount of nutrients are given as inputs, weight adjustments are given based on their amount of nutrients and the network is trained. After training, the network will

be used for finding out GI values of food items which were not trained.

But, with this idea, if it is proceeded according to the given procedure, it is well analysed assuming other nutrients of food items, and neural network is trained for a set of training pairs, it may give the correct result, that is, GI values of new food items which were untrained. An important thing is the GI values which are obtained from this neural network system must be compared with medical system of finding the GI values. This research work gives a way and an idea for finding out GI values using two layer artificial neural networks, but it should be medically proven

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