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University Of Diyala

College of science

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CHARACTER RECOGNITION USING ARTIFICIAL NEURAL NETWORK (ANN)

A PROJECT SUBMITTED TO THE DEPARTMENT OF COMPUTER science in THE COLLEGE OF science AS A PARTIAL FULFILLMENT OF THE REQUIRMENTS FOR THE DEGREE OF B.SC. IN COMPUTER science

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وزارة التعليم العالي والبحث العلمي

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كلية العلوم

قسم علوم الحاسوب

التعرف على الحروف باستخدام الشبكة العصبية الاصطناعية

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مشروع مقدم إلى قسم علوم الحاسوب في كلية العلوم كتنفيذ جزئي لمتطلبات

درجة البكالوريوس. في علوم الحاسوب

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1441 A.H

2020 A.D

بسم الله الرحمن الرحيم

((وَاللهُ أَخْرَجَكُم مِّن بُطُونِ أُمَّهَاتِكُمْ
لَا تَعْلَمُنَ شَيْئًا وَجَعَلَ لَكُمُ السَّمْعَ
وَالْأَبْصَارَ وَالْأَفْئِدَةَ لَعَلَّكُمْ تَشْكُرُونَ ٧٨
))

سورة النحل
(٧٨)

(صَدَقَ ٱللَّهُ ٱلْعَظِيمُ)

شكر وتقدير

مهما تقدمنا وفتحت امامنا الطرق و وصلنا الى كل ما نحلم به علينا ان نتذكر من كانو سبب في نجاحنا من ساندنا وأمسك بيدنا للاستمرار فمهما عَبرنا لهم فالكلمات قليلة فشُكرنا وتقديرنا الى من بذلوا ولم ينتظروا العطاء اساتذتنا الأفاضل.

أنْ قُلتَ شُكراً فشُكري لنْ يُوفيكَ حقاً سعيتَ فكانَ السعيُ مشكورا

الى مشرفنا

(م.د برهان مولان)

شكرنا وتقديرنا الى من كرمهم الله

وجعل منهم جسرا لعبور الأزمة

الى جيشنا الأبيض

الأهداء

الى المعلم الأول

الى من ارسل رحمة للعالمين

الى سيدنا وحبيبنا محمد (صلى الله عليه وعلى آله وصحبه وسلم)

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الى من كان برها حصنا لي من الشقاء

الى نبع الحنان

امي الغالية

الى من انحنا ظهره ليستقيم ظهري

الى من عرق جبينه لكي اواصل دراستي

الى من يحب لنا اكثر ما يحب لنفسه

ابي العزيز

كلمة حب وتقدير و تحية وفاء واخلاص تحية ملؤها كل معاني الأخوة الى من بهم يشد عضدي

الى اخوتي

الى من عرفتهم على كراسي الدراسة فاصبحوا اثمن ما املك

الى اصدقائي

الى من بدمائهم بقى علم دولتنا العزيز شامخا حرا ابيا

الى شهدائنا الأبرار

Abstract

Humans have the ability to recognize characters. For example, human can distinguish between different characters and recognize them easily as an a or a b and so on. Therefore, project is intended to develop a neural network system that is able to perform character recognition, particularly english alphabets. Neural network is a system inspired by human brain function; consists of neurons connected in parallel with the ability to learn. A basic design of neural network has input layer, hidden layer, and output layer. The use of neural network can improve the quality of recognition while achieving good performance. A total of 650 samples characters are used with 25 samples of each character. The performance of evaluation is divided to 80% of training and 20% for testing. Scaled conjugate gradient training function is used as this function can perform faster in pattern recognition as well as its small memory requirement. Two training methods are used. The first one is the gradient technique with 39 neurons in hidden layer. The second training method is geometric feature extraction with 35 neurons in hidden layer. Gradient technique and geometric feature extraction; both show an excellent recognition rate of 94.6% and 94.3% respectively. The output of recognized characters is shown in a .txt file.

الملخص

البشر لديهم القدرة على التعرف على الشخصيات. على سبيل المثال ، يمكن للإنسان التمييز بين الشخصيات المختلفة والتعرف عليها بسهولة على أنها أ أو ب وهكذا. لذلك ، يهدف المشروع إلى تطوير نظام شبكة عصبية قادر على أداء التعرف على الأحرف ، وخاصة الأبجدية الإنجليزية. الشبكة العصبية هي نظام مستوحى من وظيفة الدماغ البشري. يتكون من خلايا عصبية متصلة بالتوازي مع القدرة على التعلم. يحتوي التصميم الأساسي للشبكة العصبية على طبقة إدخال وطبقة مخفية وطبقة إخراج. يمكن أن يؤدي استخدام الشبكة العصبية إلى تحسين جودة التعرف مع تحقيق الأداء الجيد. يتم استخدام ما مجموعه ٦٥٠ عينة من الأحرف مع ٢٥ عينة من كل حرف. ينقسم أداء التقييم إلى ٨٠٪ من التدريب و ٢٠٪ للاختبار. يتم استخدام وظيفة التدرج المتدرج المتقارن لأن هذه الوظيفة يمكن أن تؤدي بشكل أسرع في التعرف على الأنماط وكذلك متطلبات الذاكرة الصغيرة. يتم استخدام طريقتين للتدريب. الأول هو تقنية التدرج مع ٣٩ خلية عصبية في طبقة مخفية. طريقة التدريب الثانية هي استخراج الميزة الهندسية مع ٣٥ الخلايا العصبية في طبقة مخفية. تقنية التدرج واستخراج الميزة الهندسية ؛ كلاهما يظهر معدل اعتراف ممتاز ٩٤,٦٪ و ٩٤,٣٪ على التوالي. يظهر إخراج الأحرف التي تم التعرف عليها في ملف .txt.

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Chapter one

introduction

1:1 introduction

Neural networks can be considered a new science that seeks to produce computers that operate according to the principle of the work human mind, as the human mind performs work through millions of neurons which branch into millions of neurons and through which knowledge about the external world is stored , where the neural network consists of a device that has a lot of processors linked in parallel ,

We may see some aspects of these networks see the light , where some of the devices containing a huge process consisting of small treatment units are distributed to the parallel that stores the practical knowledge to make it available to the user by adjusted the weights and nervous networks have provided some solutions in some areas some of them

1. Pattern recognition and image recognition
2. Ability to recognize distorted image
3. Completion of image that have been lost , such as the satellite image
4. Categories of ranking into a number of categories the students successful and classified if we took an example of a programming system that creates any quota in the traditional programs that will be done by introducing variables and call a special function, but in neural networks should input layer of the network input the number and show the value in otput layer then weight is adjusted and through the frequent training that the network can find the sale of numbers

If neural networks are a model simulates the neurons in humans and consists of nerves ,it is estimated to learn , conclusion and solve hard

problems, using the neural network we can solve all the problem that any programming language cannot be solve .

For example road monitoring system and image isolation , which can only be done in the neural network as well in the medical field

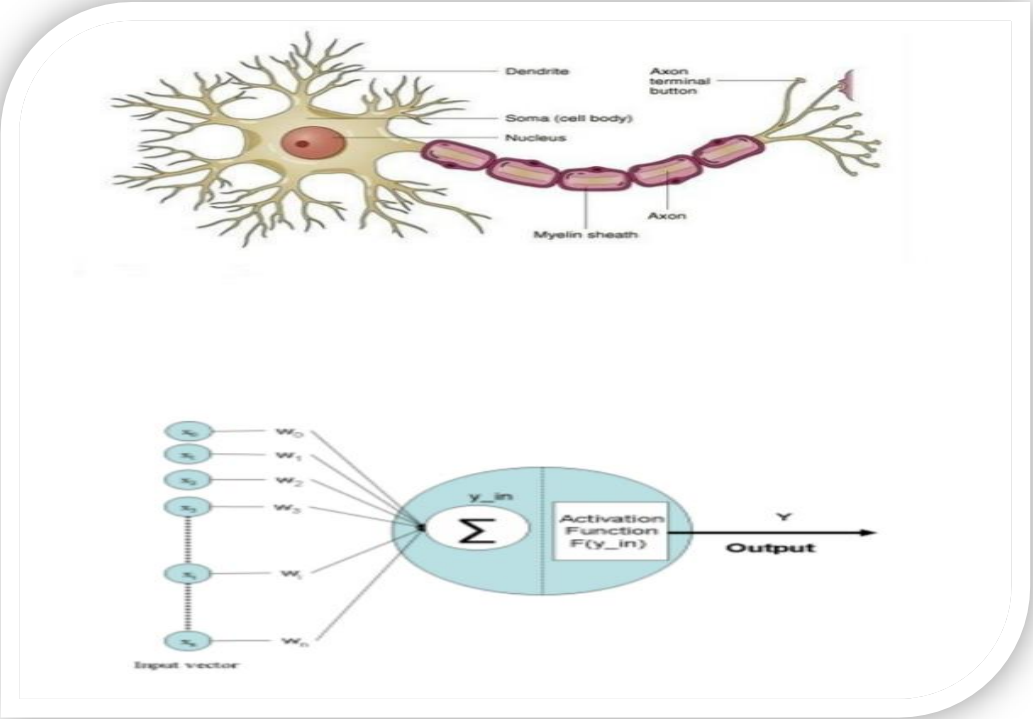


Figure (1:1) nerve cell in the human body and industrial nerve cell

Today, neural network has been a very popular computer tool used for solving lot of different practical problems. Neural network provides the best solutions to many problems in image recognition, natural language processing, and speech recognition. The basic idea of neural network is to simulate interconnected brain cells inside a computer so it can learn things all by itself, recognize patterns, and make decisions just like human way. One of the advantages of using neural network is the network learning. Network learning provides an efficient ability in recognition.

1:2 (neuronal in the human body) .VS (industrial neural) we can compare between the neuronal in the human body and the industrial neural

Dendrite: the necklace of the neuronal cell is the body of the outer world .

Body of the cell: officer for processing the input.

Nucleus: responsible for giving the signal.

Axon: it is transmitted by the transmission of sensory cells to body members.

Industrial nerve cell

Input of cell {x1,x2,x3,+……..+xn}

Weight {w1,w2,w3,+…..+wn}

A {activation faction }

Y {the result of faction }

It is also the manual of the unit of the introduction in world of the outside and is the five senses ,your ability to neutral network need to enter units and treatment unit that are subject to weights and are obtained through the appropriate reaction to each entry of the input network ,devices unit create input layer and process unit create hidden layer and output of network create output layer the network may contain one layer of the input layers to have more than one layer of processing layers the more hidden layers increased the complex network and took more time in learning process results for the best

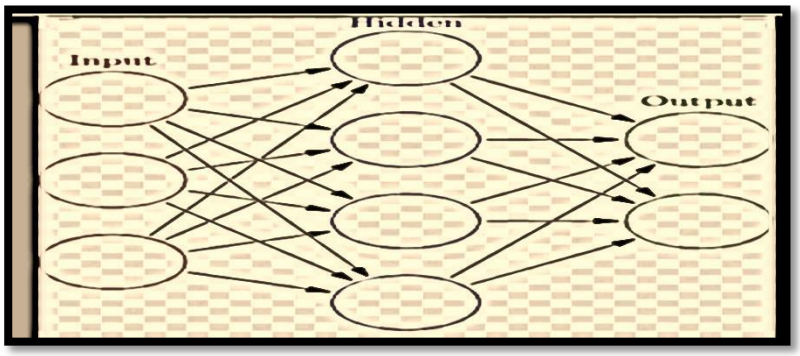


Figure (1:2) neural network

1:3 ***history***

Mcculloch_pitts neuron (1943)

Neurophysiologist warren mcculloch and mathematician waltre pitts wrote a paper on how neurons might work ,the activation function that is sum of input and find threshold

(a logical calculus of the ideas immanent in nervous system)

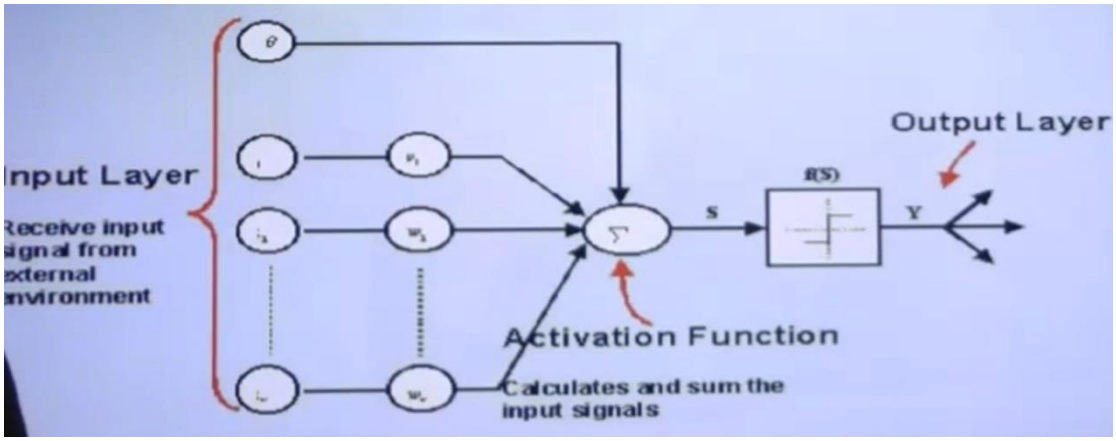


Figure (1:3) scheme mcculloch_pitts neuron

Hebb learning rule (1949)

Psychologist donald hebb wrote a book about how humans can learn , his work stated that neural pathways are strengthened each time they are used ,if two ….. Fire at the same time the connection between them is enhanced the change of weight between a neural (i) and neural(j)

Rosenblatt's perceptron (1957)

A supervised linear classifier invented by frank rosenblat

T mathematical definition

$$f(x) = \begin{cases} 1 \; if \; w * x + b \;\; x > 0 \\ 0 \quad \text{otherwise} \end{cases}$$

It was the first emergency of the neural network ,it was used as sulfate or adapted filters to eclectic of telephone lines and still used commercially for this purpose

Minsky &papert (1969)

They published a paper enumerating many of the flaws in neural networks ,they used the functionality of (xor) as an example of how the neural network fail ,if a model cannot solve a very simple problem .then we cannot use in the real world (*suggested to use multi_layer neural network.*)

1:4 *problems are solved by the neural network*

1. solve all the problems that are difficult to solve in programming languages.
2. raise the knees of the new staff under training can be raised as a nursing network as information that was entered by an Expert as in flying .
3. important the missing images part of them.
4. identify the distorted images.
5. reduce human sheets during statistical analysis.
6. resolve the problem of significant signatures in bank checks.
7. it is the most important problem in the security field by

   Identifying face .
8. identify the stuff on the street .
9. added to these the neural network convention of deaf and bust signal to written or print words

1:5 functions using in conversion process

1_threshold: the value extent it being zero or one .

2_linear:give the same values of the total number of signal.

3_segmode

Y= $\frac{1}{1+e^{-x}}$

Chapter two

Design neural network

2:1 ***design steps***

1. Choose the right shape
2. specify the primary values of weight
3. implement the feed_forward
4. implement the feed_backward
5. find the difference between the value of output and real values
6. modified the weights and repetition
7. apply the checkinto the neural stress of the network okay

2:2 together factorsg network displays

1. the network quality does not fit the application that is trained on it
2. number of processing units inappropriate
3. the weight that the network starts inappropriate
4. education rate is inappropriate
5. training category is not carefully selected
6. conversion base is inappropriate

2:3 feature of neural network

1. it can be applied in many different scientific fields
2. it's ability to solve many problem in the industrial field
3. an effective tool to configure mathematical models of issues
   In which the relationship between variables is unknown
4. because the process parallel be fact

2:4 the properties of neural network

1. (generalization) the network recognizes things that have not been Trained by those through the likely things they are being used in the Representation of the faction in the salary and the rest the previous Steps
2. (adaptivity) networks can change the weight in the links to Adapt to the surrounding environment and help them as

Emergency work

2:5 ***disadvantages of neural network***

1:data processing and training is taking a period of time

2:difficulty of determining the optimal number to process data

Through training

2:6 types of neural network

1) Feed forward neural network (FNN)

Of the simplest types and the least size , the data is going in one direction forward and no back path, it contains one hidden layer and sometimes it does not contain a hidden layer, it takes less time and is less efficient, the sigma function is used it is always used to recognize sounds, as well as computer vision and in self-driving cars, and one of its most important applications in some types of private television (convert voice to speech)that are used in public places as well as in hospitals to reduce noise

2) Radial basis function neural network (RBFNN)

Used in place of the sigma is a complex mathematical function that operates according to the distance between the center and the point widely used in classification and chronological functions

3) Self organizing map neural network (SOMNN)

It deals mainly with education without a supervisor and works according to the principle of dealing with a large amount of data and arranges it specifically during training and an example of its use in the amazon website as there are more than 2 million subscribers and each subscriber has data such as age, profession and others arranged according to the form a certain used in maps, navigation, water and oil exploration, and data analysis

4)Frequent neural network(FNN)

Its idea depends on feeding the entrance and the hidden networks, but rather an appropriate outlet for any use of prediction. For example, if we wanted to search for a topic in youtube at the beginning, this topic will be considered as an entry that deals with the hidden layer, then we get the output from the output layer, this output is an input at the time next in the list of suggested videos as well as in the google search engine type only the beginning of the word and it gives suggestions

5)Convolution neural network(CNN)

Feed the input with the image, and thus divide the image by wrapping layers and analyze the image to reach the appropriate algorithm mainly used in analyzing images and videos and in identifying faces and medical uses such as taking a picture of the body and identifying skin diseases

6)Modular neural network(MNN)

It works on having a different number of neural networks that work in parallel side by side and is characterized by great speed with big data used in financial and economic analyzes, reading letters and biological uses

Chapter three

teaching neural networ

3:1 teaching neural network

The neural network learns by giving it a set of data that must be carefully selected, because that will contribute to the speed of the network learning. This group is called a training class.

Network learning methods are divided into two parts

1. Supervised learning it is the most common way in the learning process and works according to the idea of presenting training data in front of the network in the form of a pair of shapes, the entrance and the target

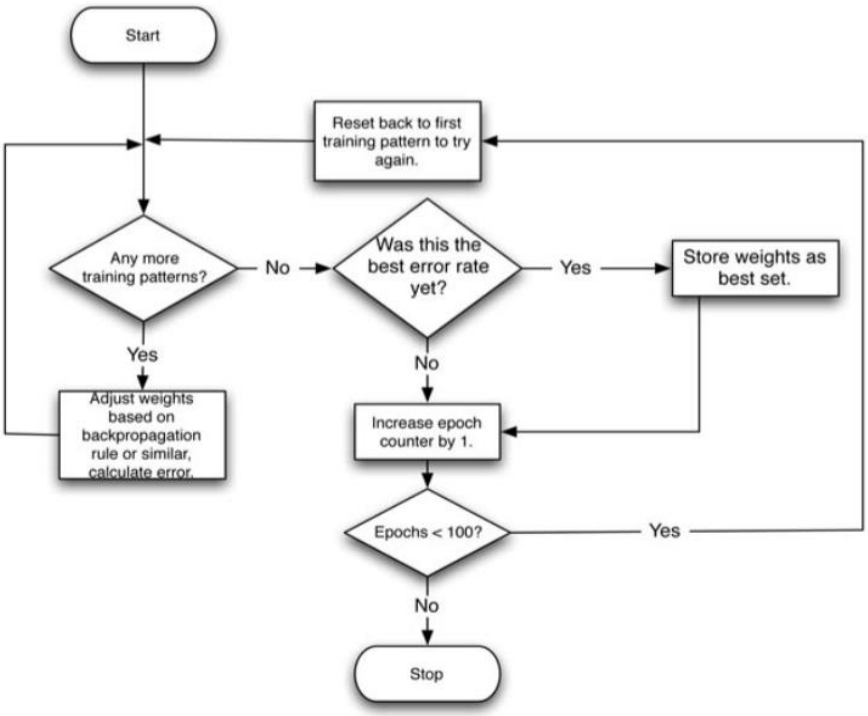


figure (3:1) Supervised learning

2. Un supervised learning this method works according to the inputs only without resorting to displaying the target on the network. Sometimes this method is called the self-learning method. The network predicts learning methods on the basis of its ability to discover the distinctive characteristics of what is presented to it and its ability to develop an internal representation of these forms without prior knowledge of what should i have to produce it

$A_i(x_j\text{-}c(t_j+w_{ji}\ old=w_{ji}\ new)$

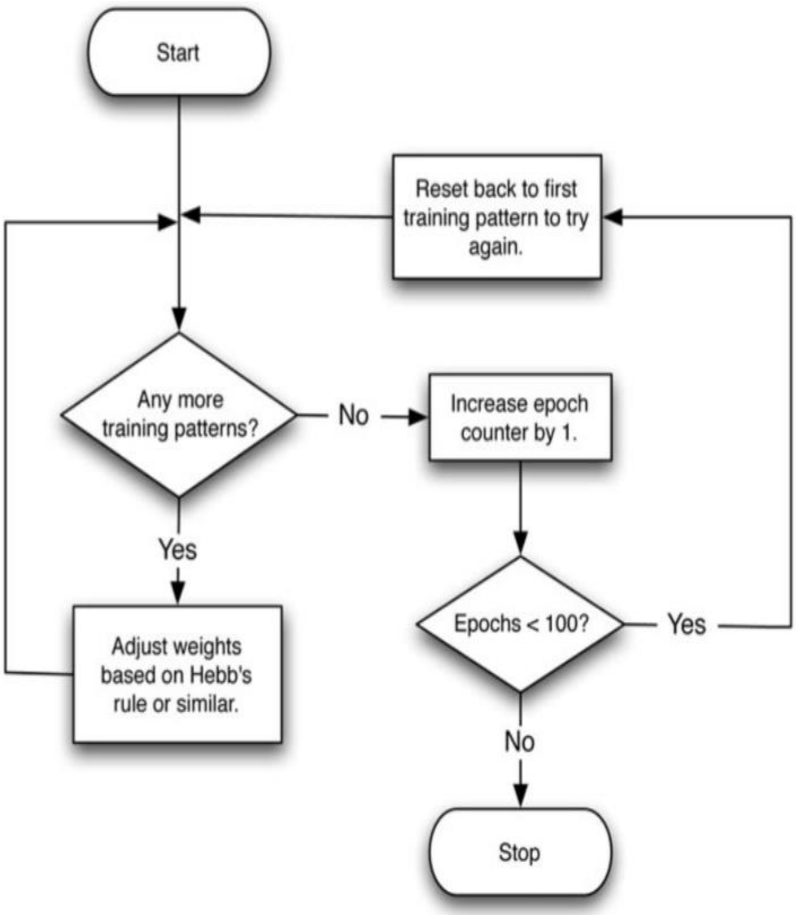


figure (3:2) UN Supervised learning

3:2 it is common to all types of neural network

1. Set of simple processing unit.
2. Patten of connectivity.
3. Propagate signal
4. Combining input signal.
5. Calculating output signal.
6. Learning rule to adapt weight.

3:3 *classification of neural network*

We can classification neural network by number of layers

1:(perceptron) it is the simplest species, does not contain a

Hidden layer

2:multi_contract contain (input layer and hidden layer and

Output layer) extensively famous

The most important application of the neural network is the conversion of book and documents printed to electronic copies for easy storage and handling

,

Chapter four

ALGORITHM

AND

CODE IN MATLAB

4:1 used to adjust weights in the training phase the algorithms

used to recognize letters can be divided into three categories

1. Image before processing.
2. Feature extraction.
3. Category

4:2 it is used as a sequence and helps the presets for the image to make the extraction of smooth features

1. Feed forward

There is no modification of the weights, which is represented by the width of the input shape of the network, after which each element of the treatment layer is allocated to one of the components of the beam, the input layer is spread, then a front diffusion occurs

2. Back propagation

It is the stage of adjusting the weights of the network, and it is considered a gradual regression algorithm(gradient descent algorithm) that allows the network weights to move to the negative side of the performance tracker. Its role is due to the way in which the inclination of the multiple non-linear network blocks is calculated, where in one of the stages of education the signal is redeployed from the output to the input in a way reverse, during which network weights are adjusted, and the algorithm for one iteration can be represented as follows

(xk+1=xk –ak*gk)

Xk (beam weights and front biases)

Ak (education rate)

Gk (the current tendency)

4:3there are two ways to calculate progressive regression

1. Incremental mode

According to this method, the tendency is calculated and then the weights are adjusted after each income given to the network

2. Batch mode

According to this pattern, the network provides all the rays of income before the process of updating the weights, and therefore we can say that the weights and biases in this method are adjusted after providing the network with the entire training set as the tendency calculated in each training example are added to each other to determine the changes in weights and biases

4:4 mathematical equation

(z=x*w)……(1:4)

[z(output) x (input) w (weight)]

w_{jk}^{i}……...(2:4)

[i(number of layer) j (cell of begin) k(cell of end)]

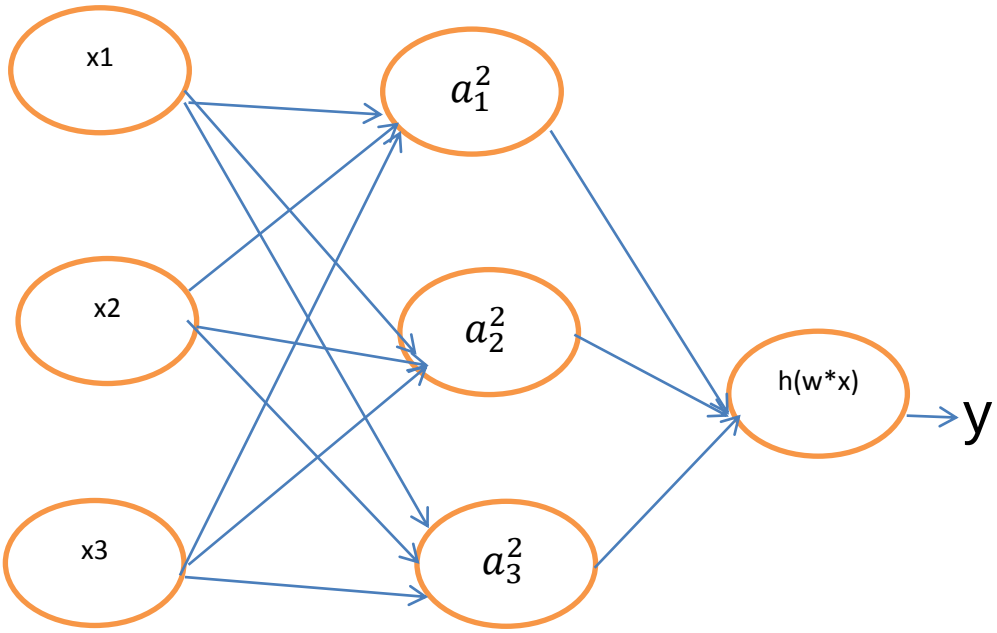


figure (4:1) neural network

$A^2{}_1 = g(W_{10}^1\ X_0 + W_{11}^1\ X_1 + W_{12}^1\ X_2 + W_{13}^1\ X_3)$.....(3:4)

$A^2{}_2 = g(W_{20}^1\ X_0 + W_{21}^1\ X_1 + W_{22}^1\ X_2 + W_{23}^1\ X_3)$.....(4:4)

$A^2{}_3 = g(W_{30}^1\ X_0 + W_{31}^1\ X_1 + W_{32}^1\ X_2 + W_{33}^1\ X_3)$.....(5:4)

$H(wx) = a_1^3 = g(w_{10}^2 a_{10}^2 + w_{11}^2 a_1^2 + w_{12}^2 a_2^2 + w_{13}^2 a_3^2)$.....(6:4)

$$\begin{bmatrix} W_{10}^1 & W_{11}^1 & W_{12}^1 & W_{13}^1 \\ W_{20}^1 & W_{21}^1 & W_{22}^1 & W_{23}^1 \\ W_{30}^1 & W_{31}^1 & W_{32}^1 & W_{33}^1 \end{bmatrix}$$

$$[w_{10}^2 a_{10}^2 \quad w_{11}^2 a_1^2 \quad w_{12}^2 a_2^2 \quad w_{13}^2 a_3^2]$$

Error equation

$$J(w) = -\frac{1}{m}\sum_{i=1}^{m}\sum_{k=1}^{k}[y_k^i \ \mathrm{Log}\left(ch * w\left(x^i\right)\right)_K +$$

$$\left(_{1-}y_k^i\right)\mathrm{Log}(1-(hw\left(x^i\right))_K)] + \frac{y}{2m}$$

$$\sum_{l=1}^{l-1}\sum_{i=1}^{si}\sum_{j=1}^{si+1}(w_{j,i})^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7{:}4)$$

K(number of output)

2m(the number of elements of the sample)

Si+1(number of unit output)

Cost (i) $\approx (\mathrm{hw}(x^i) - y^i)^2$ .....(8:4)

If it becomes zero, it means high accuracy

4:5 sample examination cases and same example

True positive (TP)	The result was that there was a specific object and that object actually existed
True negative (TN)	The result determined that a particular object exists and that this object does not exist
False positive(FP)	The result is that no particular object exists but that object exists
False negative(FN)	The result is that no particular object exists but this object does exist

Example(1) in perceptron (and) gate

G(z)=$\frac{1}{1+e^{-z}}$ ……..(9:4)

hw(x)=g(-30+20$x_1 + 20x_2$)

(a=0&b=0), [-30] , $\frac{1}{1+e^{30}}$=0

(a=0&b=1), [-10] , $\frac{1}{1+e^{10}}$=0

(a=1&b=0), [-10] , $\frac{1}{1+e^{10}}$=0

(a=1&b=1), [10] , $\frac{1}{1+e^{-10}}$=1.

Example(2) in feed for word (XOR)

Y_1=-10+20$x_1 + 20x_2$

Y_2=30-20$x_1 - 20x_2$

Z=-30+20$Y_1 + 20Y_2$

(a=0&b=0),[Y_1=-10=0, Y_2=30=1,z=-10=0]

(a=0&b=1),[Y_1=10=1, Y_2=10=1,z=10=1]

(a=1&b=0),[Y_1=10=1, Y_2=10=1,z=10=1]

(a=1&b=1),[Y_1=30=1, Y_2=-10=0,z=-10=0]

example (3) neural network abut square

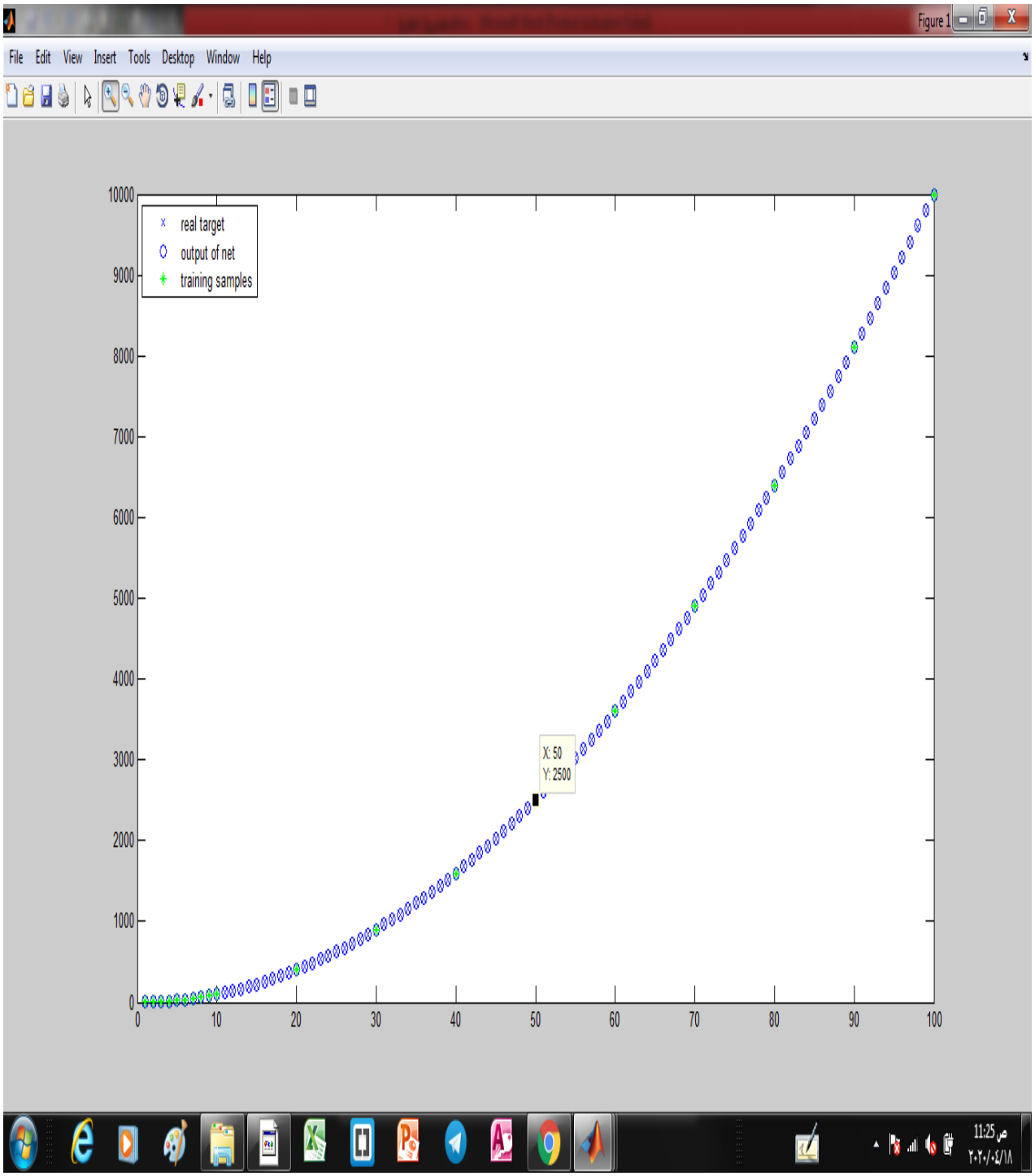


figure (1:4) result of example (3)

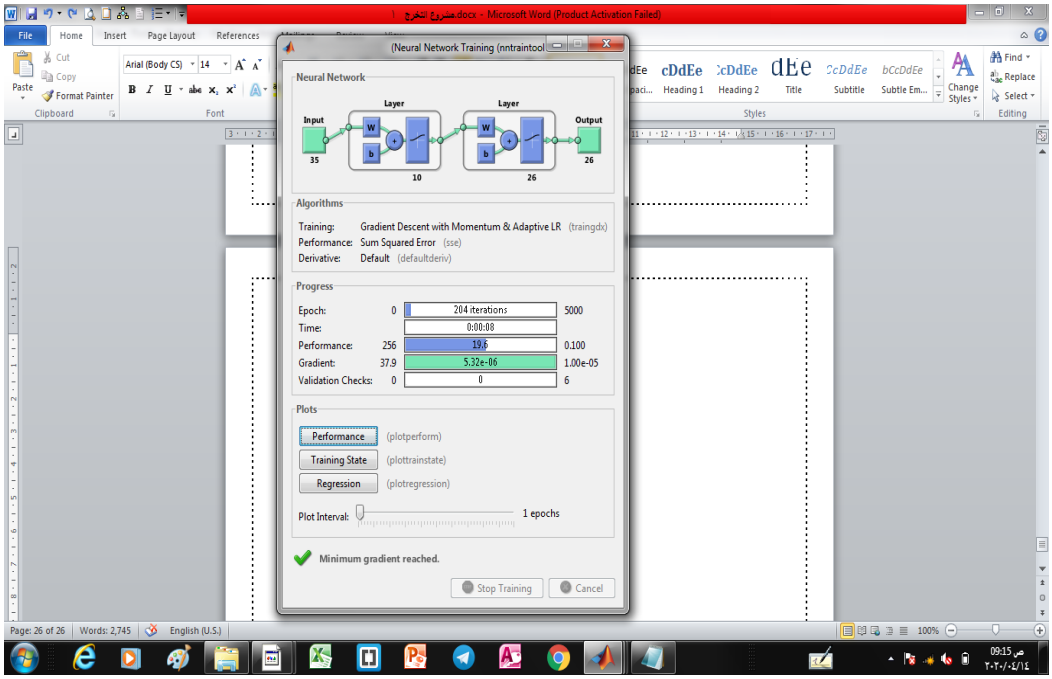


figure (2:4) result code in matlab

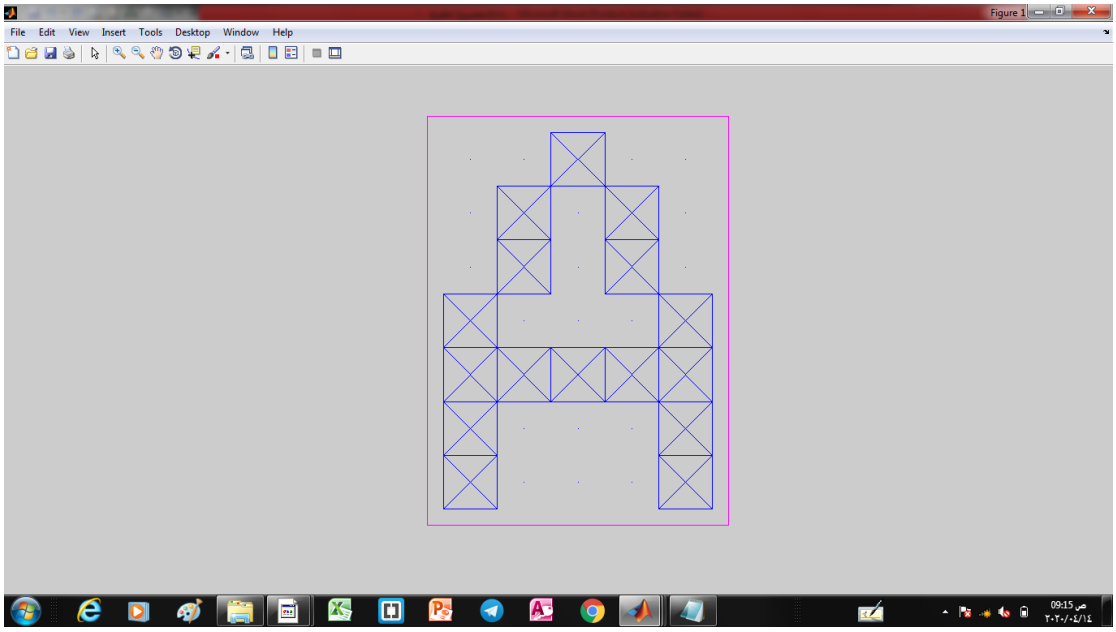


figure (3:4) result example 1 code in matlab

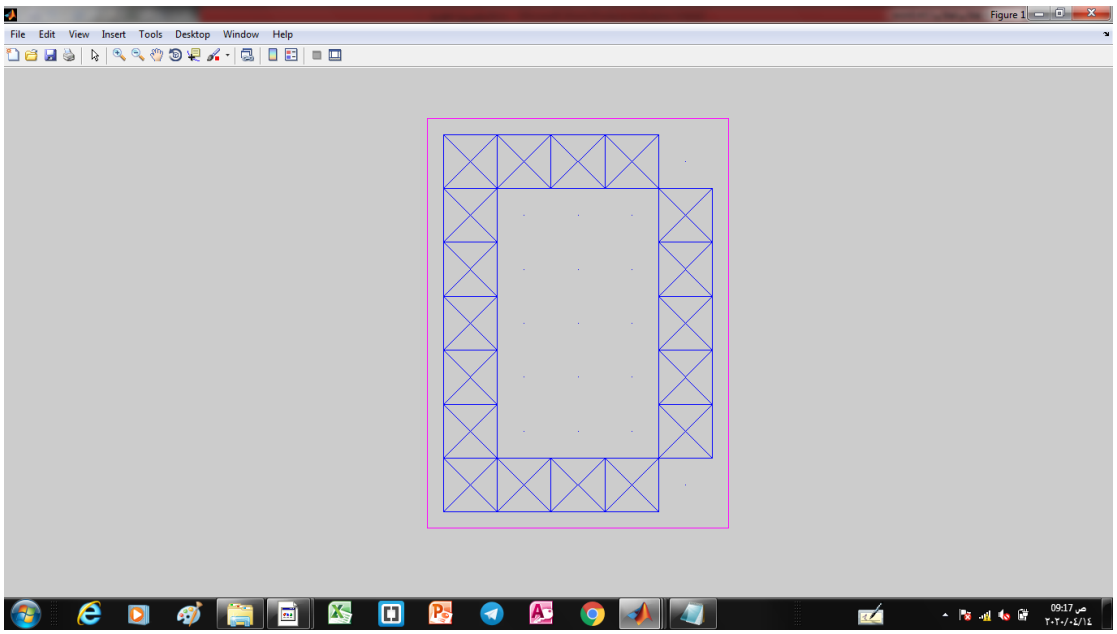


figure (4:4) result example 2 code in matlab

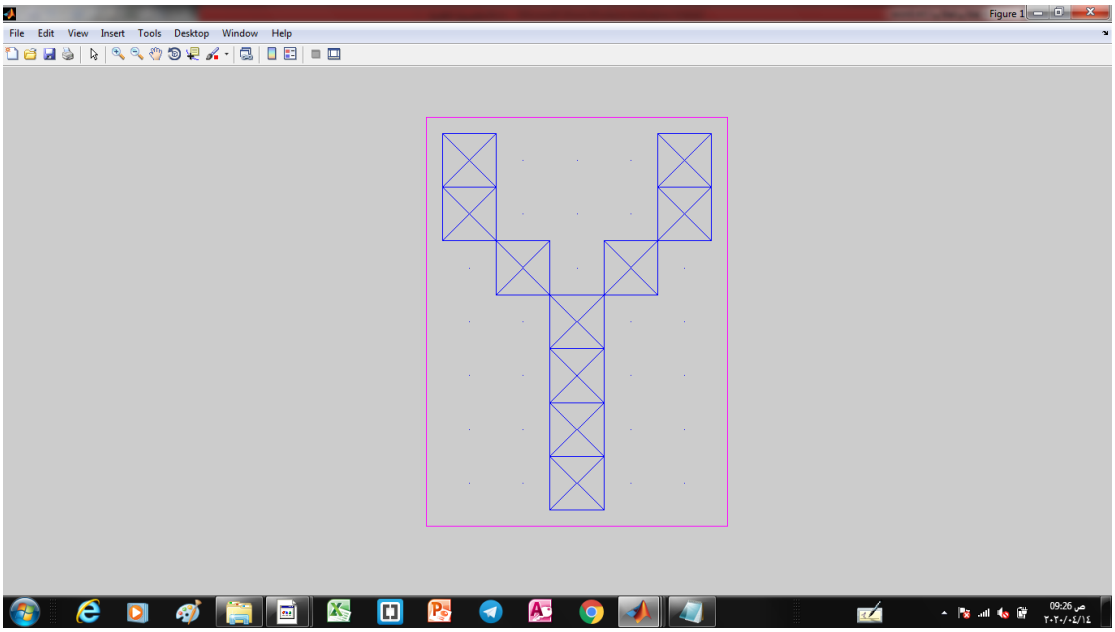
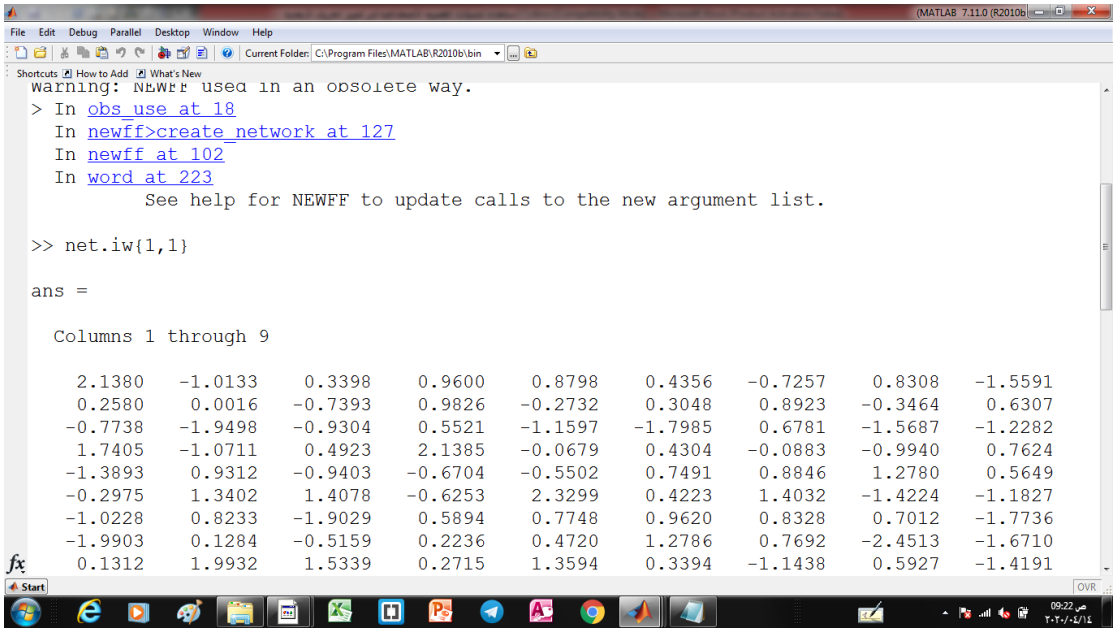
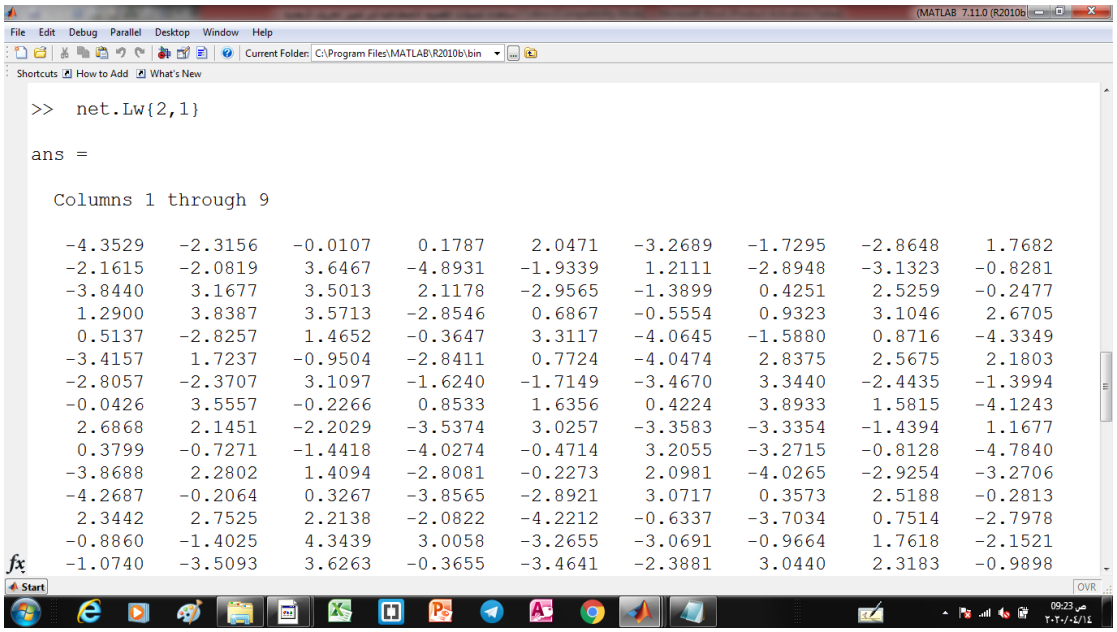


figure (5:4) result example 3 code in matlab



```
Warning: NEWFF used in an obsolete way.
> In obs_use at 18
  In newff>create_network at 127
  In newff at 102
  In word at 223
          See help for NEWFF to update calls to the new argument list.

>> net.iw{1,1}

ans =

  Columns 1 through 9

    2.1380   -1.0133    0.3398    0.9600    0.8798    0.4356   -0.7257    0.8308   -1.5591
    0.2580    0.0016   -0.7393    0.9826   -0.2732    0.3048    0.8923   -0.3464    0.6307
   -0.7738   -1.9498   -0.9304    0.5521   -1.1597   -1.7985    0.6781   -1.5687   -1.2282
    1.7405   -1.0711    0.4923    2.1385   -0.0679    0.4304   -0.0883   -0.9940    0.7624
   -1.3893    0.9312   -0.9403   -0.6704   -0.5502    0.7491    0.8846    1.2780    0.5649
   -0.2975    1.3402    1.4078   -0.6253    2.3299    0.4223    1.4032   -1.4224   -1.1827
   -1.0228    0.8233   -1.9029    0.5894    0.7748    0.9620    0.8328    0.7012   -1.7736
   -1.9903    0.1284   -0.5159    0.2236    0.4720    1.2786    0.7692   -2.4513   -1.6710
    0.1312    1.9932    1.5339    0.2715    1.3594    0.3394   -1.1438    0.5927   -1.4191
```

figure (6:4) Weights between the input layer and the hidden layer



```
>>  net.Lw{2,1}

ans =

  Columns 1 through 9

   -4.3529   -2.3156   -0.0107    0.1787    2.0471   -3.2689   -1.7295   -2.8648    1.7682
   -2.1615   -2.0819    3.6467   -4.8931   -1.9339    1.2111   -2.8948   -3.1323   -0.8281
   -3.8440    3.1677    3.5013    2.1178   -2.9565   -1.3899    0.4251    2.5259   -0.2477
    1.2900    3.8387    3.5713   -2.8546    0.6867   -0.5554    0.9323    3.1046    2.6705
    0.5137   -2.8257    1.4652   -0.3647    3.3117   -4.0645   -1.5880    0.8716   -4.3349
   -3.4157    1.7237   -0.9504   -2.8411    0.7724   -4.0474    2.8375    2.5675    2.1803
   -2.8057   -2.3707    3.1097   -1.6240   -1.7149   -3.4670    3.3440   -2.4435   -1.3994
   -0.0426    3.5557   -0.2266    0.8533    1.6356    0.4224    3.8933    1.5815   -4.1243
    2.6868    2.1451   -2.2029   -3.5374    3.0257   -3.3583   -3.3354   -1.4394    1.1677
    0.3799   -0.7271   -1.4418   -4.0274   -0.4714    3.2055   -3.2715   -0.8128   -4.7840
   -3.8688    2.2802    1.4094   -2.8081   -0.2273    2.0981   -4.0265   -2.9254   -3.2706
   -4.2687   -0.2064    0.3267   -3.8565   -2.8921    3.0717    0.3573    2.5188   -0.2813
    2.3442    2.7525    2.2138   -2.0822   -4.2212   -0.6337   -3.7034    0.7514   -2.7978
   -0.8860   -1.4025    4.3439    3.0058   -3.2655   -3.0691   -0.9664    1.7618   -2.1521
   -1.0740   -3.5093    3.6263   -0.3655   -3.4641   -2.3881    3.0440    2.3183   -0.9898
```

figure (7:4) Weights between the hidden layer and the output layer

4:6 Conclusion and recommendations

1_ We created a front grid with a backward spread and trained it to distinguish the Latin letters, and after the training the network was able to recognize the letters even in the presence of jamming.

2_We recommend the establishment of a frontal neural network with an inverse spread in distinguishing Arabic letters

3- We recommend increasing the number of cells in the hidden layer and its effect on learning the grid and distinguishing it from letters with confusion.

References

1. Li, Fuliang ; Gao, Shuangxi, "Character Recognition System Based on Back-Propagation Neural Network," Machine Vision and Human-Machine Interface (MVHI), 2010 International Conference on , vol., no., pp.393,396, 24-25 April 2010.
2. RajbalaTokas, ArunaBhadu, "A comparative analysis of feature extraction techniques for handwritten character recognition", International Journal of Advanced Technology and Engineering Research, Volume 2, Issue 4, pp. 215-219, July 2012
3. Tirtharaj Dash, Time efficient approach to onine hand writtencharacter recognition using associative memory net International 49 Journal of Computing and Business Research, Volume 3 Issue 3September 2012
4. R.Tokas, A.Bhadu, “A Comparative Analysis Of Feature Extraction Techniques For Handwritten Character Recognition”, International Journal of Advanced Technology & Engineering Research (IJATER), July 2012, pp. 215-218.
5. M. Zafar, D. Mohamad, M.M. Anwar, “Recognition of Online Isolated Handwritten Characters by Back propagation Neural Nets Using SubCharacter Primitive Features”, IEEE Multitopic Conference (INMIC), 2006, pp. 157 – 162
6. N. Friedman, D. Geiger, M. Goldszmidt, “Bayesian Network Classifiers, Machine learning, 1997,pp.131-163.
7. Sutton, Richard S. and Barto, Andrew G., Reinforcement Learning: An Introduction, MIT Press, Cambridge, MA, 1998.
8. Hand printed Symbol Recognition System, Ptrttern Recognition, Vol. 21 No.2, pp. 91 - 118, I988
9. Rosenfeld,A. and Kak, A.C., Digital Image Processing, Academic Press Inc., 2nd. Ed., 1993 Simon,
10. C-L. Liu and K. Marukawa, “Normalization Ensemble for Handwritten Character Recognition”, The Ninth International Workshop on Frontiers in Handwriting Recognition (IWFHR 9), Tokyo, Japan, pp. 69-74, 2004