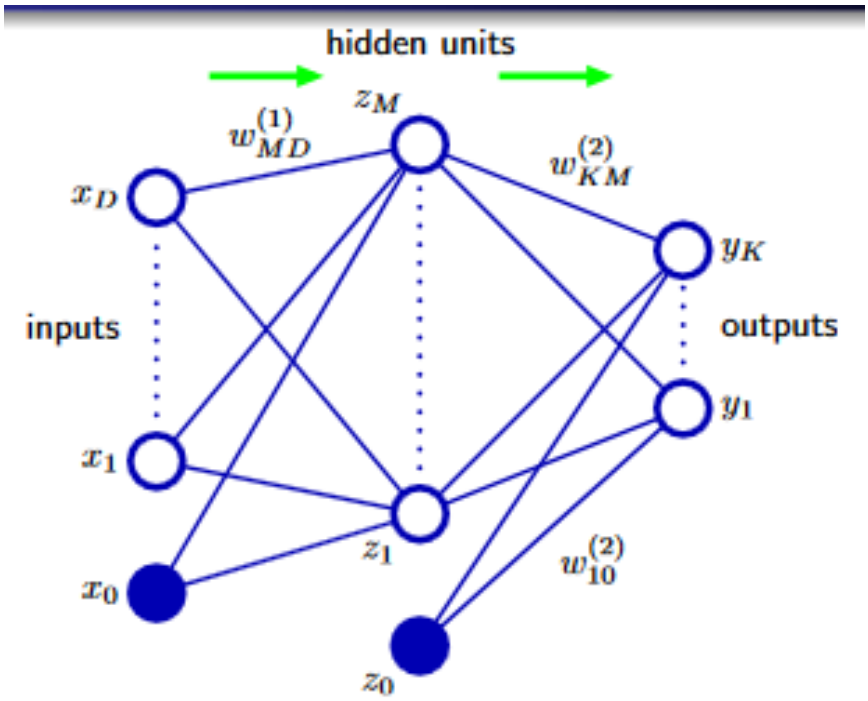
ΜΗΧΑΝΙΚΗ ΜΑΘΗΣΗ

ΕΡΓΑΣΙΑ 1Η ΑΚΑΔΗΜΑΙΚΟ ΕΤΟΣ : 2018-2019

ΦΟΙΤΗΤΗΣ: ΙΑΚΩΒΟΣ ΕΥΔΑΙΜΩΝ 3130059



Αρχικά, θα αναλύσουμε και θα ορίσουμε κάποιες νέες και κάποιες ήδη υπάρχουσες παραμέτρους. Ξεκινώντας από το input layer έχουμε κάθε παράδειγμα x_n του train set όπου κάθε feature κάθε παραδείγματος x_{nd} με $1 \leq d \leq D$ γνωρίζουμε ότι πολλαπλασιάζεται με το κατάλληλο βάρος $w_{j,i}^{(1)}$. Το άθροισμα του γινομένου όλων των χαρακτηριστικών ενός παραδείγματος με τα βάρη τους $w_{j,i}^{(1)}$ δίνονται σαν είσοδο σε κάθε νευρώνα j του hidden layer του νευρωνικού δικτύου. Με λίγα λόγια η είσοδος κάθε νευρώνα j του hidden layer του νευρωνικού δικτύου είναι της μορφής : $\sum_{i=1}^{D} w_{ji}^{(1)} x_i + w_{j0}^{(1)}$= a (το οποίο θα το συμβολίζουμε ως a). Κατ' επέκταση, για όλους τους νευρώνες του hidden layer ισχύει ότι : $\sum_{j=1}^{M}(\sum_{i=1}^{D} w_{ji}^{(1)} x_i + w_{j0}^{(1)} x_0)$. Έπειτα, κάθε νευρώνας j του hidden layer παίρνει την είσοδό του a_j = $w_{j,0}^{(1)}x_0+w_{j,1}^{(1)}x_1+w_{j,2}^{(1)}x_2+\cdots+w_{j,i}^{(1)}\ x_i+\cdots+w_{j,d}^{(1)}\ x_d$ για κάθε παράδειγμα x_n και την "δίνει" σαν όρισμα σε μία συνάρτηση ενεργοποίησης h. Για τους

σκοπούς της εργασίας έχουμε τρεις διαφορετικές συναρτήσεις ενεργοποίησης που θα πρέπει να χρησιμοποιήσουμε. Έχουμε τις εξής :

- h(a) = log(1 +e^a)
- h(a) = $\frac{e^a - e^{-a}}{e^a + e^{-a}}$
- h(a) = cos(a)

Η τιμή $z_j = h\left(\left(w_j^{(1)}\right)^T x_n\right)$ με 0 ≤ j ≤ M, που μας δίνει η συνάρτηση ενεργοποίησης πολλαπλασιάζεται με ένα νέο βάρος $w_{jk}^{(2)}$ (0 ≤ j ≤ M, 1 ≤k ≤ K). Το άθροισμα του γινομένου όλων των z_j με τα βάρη τους $w_{k,j}^{(2)}$ δίνονται σαν είσοδο σε κάθε νευρώνα k του output layer του νευρωνικού δικτύου. Με λίγα λόγια η είσοδος κάθε νευρώνα k του output layer του νευρωνικού δικτύου είναι της μορφής : $\sum_{j=1}^{M} w_{kj}^{(2)} z_j + w_{k0}^{(2)} = s_k$ (το οποίο θα το συμβολίζουμε ως s). Κατ' επέκταση, για όλους τους νευρώνες του hidden layer ισχύει ότι : $\sum_{k=1}^{K}(\sum_{j=1}^{M} w_{kj}^{(2)} z_j + w_{k0}^{(2)} z_0)$. Έπειτα, κάθε νευρώνας k του output layer παίρνει την είσοδό του $s_k = w_{k,0}^{(2)} z_0 + w_{k,1}^{(2)} z_1 + w_{2,j}^{(2)} z_2 + \cdots + w_{k,j}^{(2)} z_j + \cdots + w_{k,m}^{(2)} z_m$. Σε κάθε ένα από τα ζυγισμένα αθροίσματα s_k, τα οποία δίνονται σαν είσοδο στο output layer, εφαρμόζεται μια συνάρτηση ενεργοποίησης $y_{n_k} = \frac{e^{\left(w_k^{(2)}\right)^T z_n}}{\sum_{j=1}^{k} e^{\left(w_j^{(2)}\right)^T z_n}}$ (softmax) όπου το αποτέλεσμα που παίρνουμε από αυτή την συνάρτηση ενεργοποίησης αποτελεί την πιθανότητα ένα παράδειγμα να ανήκει σε μία από τις k κατηγορίες. Κατά την εκπαίδευση για να βρούμε τα κατάλληλα βάρη που θα ικανοποιούν το μοντέλο μας, πρέπει να χρησιμοποιήσουμε την τεχνική του backpropagation σε συνδυασμό με τον αλγόριθμο της στοχαστικής ανάβασης κλίσης. Για να πετύχουμε την εκτίμηση των βαρών πρέπει να μεγιστοποιήσουμε την συνάρτηση κόστους. Οπότε χρειάζεται να βρούμε τις μερικές παραγώγους της συνάρτησης κόστους για τις παραμέτρους $W^{(2)}$ και τις μερικές παραγώγους της συνάρτησης κόστους για τις παραμέτρους $W^{(1)}$.

Ο τύπος της συνάρτησης κόστους E(w)= $\sum_{n=1}^{N}\sum_{k=1}^{K} t_{nk} log(y_{nk}) - \frac{\lambda}{2}\|w\|^2$ (1.1). Εφαρμόζοντας τον τύπο της $y_{n_k} = \frac{e^{\left(w_k^{(2)}\right)^T z_n}}{\sum_{j=1}^{k} e^{\left(w_j^{(2)}\right)^T z_n}}$ στον τύπο (1.1),

τότε ο (1.1)=> $E(W) = \sum_{n=1}^{N}\left[\left(\sum_{k=1}^{K} t_{nk}\left(w_k^{(2)}\right)^T z_n\right) - \log\left(\sum_{j=1}^{K} e^{\left(w_j^{(2)}\right)^T z_n}\right)\right] - \frac{\lambda}{2}\|w\|^2 = E_y(W)$ (1.2).

Ο τύπος (1.2) δηλαδή ο $E_y(W)$ ουσιαστικά είναι ο τύπος E(W) στον οποίο όπου είχαμε την συνάρτηση y_{n_k} έχουμε θέσει τον τύπο της. Χρησιμοποιώντας τον τύπο (1.2), δηλαδή τον E_y, βρίσκουμε την μερική παράγωγο για τις παραμέτρους $W^{(2)}$, δηλαδή για κάθε βάρος $w_{i,j}^{(2)}$ από έναν νευρώνα i του κρυφού επιπέδου προς έναν νευρώνα j του επιπέδου εξόδου του νευρωνικού δικτύου έχουμε ότι: $\frac{\partial E_y}{\partial w_{k,j}^{(2)}} = \frac{\partial E_y}{\partial s_k}\frac{\partial s_k}{\partial w_{k,j}^{(2)}} = \frac{\partial E_y}{\partial s_k} z_n$. Δεν χρειάζεται να βρούμε το $\frac{\partial E}{\partial y}\frac{\partial y}{\partial s_k}$ καθώς έχουμε την εξίσωση E_y όπου είναι το ανάπτυγμα η E(W) έχοντας αντικαταστήσει όπου έχουμε y_{nk} τον τύπο της y_{nk}. Αντ' αυτού, πρέπει να βρούμε το $\frac{\partial E_y}{\partial s_j}$ κατευθείαν. Οπότε, $\frac{\partial E_y}{\partial w_{k,j}^{(2)}} = \frac{\partial E_y}{\partial s_k} z_n = (t_{nk} - \frac{e^{\left(w_k^{(2)}\right)^T z_n}}{\sum_{j=1}^{K} e^{\left(w_j^{(2)}\right)^T z_n}}) z_n = (T-Y)^T Z$. Προσθέτουμε στον τύπο επίσης και όρο της κανονικοποίησης, του οποίου η παράγωγος είναι $\lambda W^{(2)}$. Οπότε ο τελικός μας τύπος είναι $(T-Y)^T Z - \lambda W^{(2)}$, όπου T είναι ένας $N_b \times K$ πίνακας με όλα τα δεδομένα εξόδου για το minibatch δεδομένων μεγέθους N_b, δηλαδή τέτοιος ώστε $[T]_{nk}=t_{nk}$, Y είναι ο αντίστοιχος $N_b \times K$ πίνακας που αποθηκεύει τις τιμές των softmax πιθανοτήτων, δηλαδή $[Y]_{nk}=y_{nk}$ και Z είναι ο $N_b \times (M+1)$ πίνακας στον οποίο αποθηκεύουμε τα διανύσματα z_n των εξόδων του κρυμμένου επιπέδου. Επόμενό μας βήμα είναι να βρούμε την μερική παράγωγο για τις παραμέτρους $W^{(1)}$ χρησιμοποιώντας και πάλι τον τύπο E_y. Η μερική παράγωγος για τις παραμέτρους $W^{(1)}$ έχει ως εξής:

$\frac{\partial E_y}{\partial w_{j,i}^{(1)}} = \frac{\partial E_y}{\partial a_j}\frac{\partial a_j}{\partial w_{j,i}^{(1)}} = \frac{\partial E_y}{\partial s_j} x_i$. Έπειτα, το $\frac{\partial E_y}{\partial a_j} = \frac{\partial E_y}{\partial z_j}\frac{\partial z_j}{\partial a_j}$ (2). Το $z_j = h\left(\left(w_j^{(1)}\right)^T x_n\right)$, όπου h(●) είναι η activation function του hidden layer και για την άσκησή μας έχουμε 3 υποψήφιες συναρτήσεις ενεργοποίησης. Οπότε πρέπει να βρούμε την σχέση (2) για τρεις διαφορετικές περιπτώσεις.

Πρώτον, αν h(a) = log(1 +e^a) (softplus) τότε η (2) => $\frac{\partial E_y}{\partial z_j}\frac{e^a}{1+e^a}$ και $\frac{\partial E_y}{\partial z_j} = \sum_{k=1}^{K}\frac{\partial E_y}{\partial s_k}\frac{\partial s_k}{\partial z_j} = \sum_{k=1}^{K}\frac{\partial E_y}{\partial s_k} w_{k,j}^{(2)} = \frac{\partial E_y}{\partial S} W^{(2)}$ όπου $\frac{\partial E_y}{\partial S} = T - Y$. Άρα, $\frac{\partial E_y}{\partial z_j} = (T-Y)\, W^{(2)}$ και κατά συνέπεια, $\frac{\partial E_y}{\partial w_{j,i}^{(1)}} = \left((T-Y)\, W^{(2)}\, \frac{e^a}{1+e^a}\right)^T x_i$, οπότε γενικότερα ο τύπος των μερικών παραγώγων προσθέτοντας και τον όρο της κανονικοποίησης είναι : $\frac{\partial E_y}{\partial W^{(1)}} = \left((T-Y)\, W^{(2)}\, \frac{e^a}{1+e^a}\right)^T X -$

$\lambda W^{(1)}$ ή $\frac{\partial E_y}{\partial W^{(1)}} = \left((T-Y)\,W^{(2)}\,\frac{1}{1+e^{-a}}\right)^T X - \lambda W^{(1)}$, όπου T είναι ένας $N_b \times K$ πίνακας με όλα τα δεδομένα εξόδου για το minibatch δεδομένων μεγέθους N_b, δηλαδή τέτοιος ώστε $[T]_{nk} = t_{nk}$, Y είναι ο αντίστοιχος $N_b \times K$ πίνακας που αποθηκεύει τις τιμές των softmax πιθανοτήτων, δηλαδή $[Y]_{nk}=y_{nk}$, $W^{(2)}$ είναι ο K×M (έχουμε εξαιρέσει την στήλη των bias δηλαδή τα $w_{k,0}^{(2)}$ ώστε να μην έχουμε θέματα με τις διαστάσεις των πινάκων κατά τους πολλαπλασιασμούς πινάκων) πίνακας στον οποίο αποθηκεύουμε τα διανύσματα $w_{k,j}{}^{(2)}$ των βαρών που πολλαπλασιάζονται με τις εξόδους του κρυμμένου επιπέδου και X είναι ο $N_b \times (D+1)$.

Δεύτερον, αν h(a) = $\frac{e^a - e^{-a}}{e^a + e^{-a}}$ (tanh) τότε η (2) => $\frac{\partial E_y}{\partial z_j}\left(1 - \left(\frac{e^a - e^{-a}}{e^a + e^{-a}}\right)^2\right) = \frac{\partial E_y}{\partial z_j}\left(1 - h^2(a)\right)$ και $\frac{\partial E_y}{\partial z_j} = \sum_{k=1}^{K} \frac{\partial E_y}{\partial s_k}\frac{\partial s_k}{\partial z_j} = \sum_{k=1}^{K} \frac{\partial E_y}{\partial s_k} w_{k,j}^{(2)} = \frac{\partial E_y}{\partial S} W^{(2)}$ $όπου$ $\frac{\partial E_y}{\partial S} = T - Y.$ Άρα, $\frac{\partial E_y}{\partial z_j} = (T-Y)\,W^{(2)}$ και κατά συνέπεια, $\frac{\partial E_y}{\partial w_{j,i}{}^{(1)}} = \left((T-Y)\,W^{(2)}\left(1 - \left(\frac{e^a - e^{-a}}{e^a + e^{-a}}\right)^2\right)\right)^T x_i$, οπότε γενικότερα ο τύπος των μερικών παραγώγων προσθέτοντας και τον όρο της κανονικοποίησης είναι : $\frac{\partial E_y}{\partial W^{(1)}} = \left((T-Y)\,W^{(2)}\left(1 - \left(\frac{e^a - e^{-a}}{e^a + e^{-a}}\right)^2\right)\right)^T X - \lambda W^{(1)}$, όπου T είναι ένας $N_b \times K$ πίνακας με όλα τα δεδομένα εξόδου για το minibatch δεδομένων μεγέθους N_b, δηλαδή τέτοιος ώστε $[T]_{nk} = t_{nk}$, Y είναι ο αντίστοιχος $N_b \times K$ πίνακας που αποθηκεύει τις τιμές των softmax πιθανοτήτων, δηλαδή $[Y]_{nk}=y_{nk}$, $W^{(2)}$ είναι ο K×M (έχουμε εξαιρέσει την στήλη των bias δηλαδή τα $w_{k,0}^{(2)}$ ώστε να μην έχουμε θέματα με τις διαστάσεις των πινάκων κατά τους πολλαπλασιασμούς πινάκων) πίνακας στον οποίο αποθηκεύουμε τα διανύσματα $w_{k,j}{}^{(2)}$ των βαρών που πολλαπλασιάζονται με τις εξόδους του κρυμμένου επιπέδου και X είναι ο $N_b \times (D+1)$.

Τρίτον, αν h(a) = cos(a) τότε η (2) => $\frac{\partial E_y}{\partial z_j}(-\sin(a))$ και $\frac{\partial E_y}{\partial z_j} = \sum_{k=1}^{K} \frac{\partial E_y}{\partial s_k}\frac{\partial s_k}{\partial z_j} = \sum_{k=1}^{K} \frac{\partial E_y}{\partial s_k} w_{k,j}^{(2)} = \frac{\partial E_y}{\partial S} W^{(2)}$ $όπου$ $\frac{\partial E_y}{\partial S} = T - Y.$ Άρα, $\frac{\partial E_y}{\partial z_j} = (T-Y)\,W^{(2)}$ και κατά συνέπεια, $\frac{\partial E_y}{\partial w_{j,i}{}^{(1)}} = \left((T-Y)\,W^{(2)}\left(-\sin(a)\right)\right)^T x_i$, οπότε γενικότερα ο τύπος των μερικών

παραγώγων προσθέτοντας και τον όρο της κανονικοποίησης είναι : $\frac{\partial E_y}{\partial W^{(1)}} = ((T-Y)\,W^{(2)}\,(-\sin(a))\,)^T X - \lambda W^{(1)}$, όπου T είναι ένας $N_b \times K$ πίνακας με όλα τα δεδομένα εξόδου για το minibatch δεδομένων μεγέθους N_b, δηλαδή τέτοιος ώστε $[T]_{nk} = t_{nk}$, Y είναι ο αντίστοιχος $N_b \times K$ πίνακας που αποθηκεύει τις τιμές των softmax πιθανοτήτων, δηλαδή $[Y]_{nk}=y_{nk}$, $W^{(2)}$ είναι ο $K \times M$ (έχουμε εξαιρέσει την στήλη των bias δηλαδή τα $w_{k,0}^{(2)}$ ώστε να μην έχουμε θέματα με τις διαστάσεις των πινάκων κατά τους πολλαπλασιασμούς πινάκων) πίνακας στον οποίο αποθηκεύουμε τα διανύσματα $w_{k,j}^{(2)}$ των βαρών που πολλαπλασιάζονται με τις εξόδους του κρυμμένου επιπέδου και X είναι ο $N_b \times (D+1)$.

Σημαντικές πληροφορίες

Για λόγους απλούστευσης τα print screens που φαίνονται παραπάνω δεν ζητάνε από τον χρήστη να επιλέξει όσα του ζητούνται κατά το τελικό project. Επίσης, κάποια print screens ίσως διαφέρουν από τα άλλα καθώς σε ορισμένα δεν θα υπάρχει το Training accuracy καθώς προστέθηκε αργότερα. Επιπλέον, θα ήθελα να προσθέσω ότι η εργασία διεκπεραιώθηκε μέσω του IDE PyCharm. Τέλος, θα ήθελα να επισημάνω ότι ο κώδικας έχει δομηθεί έτσι ώστε το dataset mnist να βρίσκεται μέσα στο path Data\mnist και το dataset cifar 10 να βρίσκεται στο path Data\cifar-10 του Project μου ώστε να μπορούν να φορτωθούν. Και στα δύο μονοπάτια πρέπει να βρίσκονται μόνο τα αρχεία με τα δεδομένα του κάθε dataset.

ΠΑΡΑΔΕΙΓΜΑΤΑ ΕΦΑΡΜΟΓΗΣ ΤΟΥ ΣΥΣΤΗΜΑΤΟΣ

Τα παραδείγματα παρουσιάζονται παρακάτω μέσω print screens. Κάθε παράδειγμα απαρτίζεται από δύο print screens, όπου στο 1ο αναφέρεται το dataset που χρησιμοποιεί το σύστημα, το learning rate, το λ (όρο κανονικοποίησης) που επιλέγεται, η συνάρτηση ενεργοποίησης, το μέγεθος των mini batches καθώς και οι εποχές(δηλαδή οι φορές όπου γίνεται εκπαίδευση πάνω σε ολόκληρο το dataset). Το 2ο print screen αφορά το accuracy score που έχει το μοντέλο μας αφού εκπαιδευτεί πάνω στα test data και στα περισσότερα παραδείγματα και στα train data.

- Για το dataset MNIST έχουμε τα εξής παραδείγματα:

Παράδειγμα 1:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.01
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Test accuracy : 96.870000 %
```

Παράδειγμα 2:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.1
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 11.236667 %
Test accuracy : 11.350000 %
```

Παράδειγμα 3:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
Test accuracy : 97.200000 %
```

Παράδειγμα 4:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.01
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 95.835000 %
Test accuracy : 95.410000 %
```

Παράδειγμα 5:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 98.388333 %
Test accuracy : 97.430000 %
```

Παράδειγμα 6:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Train accuracy : 98.250000 %
Test accuracy : 97.340000 %
```

Παράδειγμα 7:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.00001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Train accuracy : 92.528333 %
Test accuracy : 92.560000 %
```

Παράδειγμα 8:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Train accuracy : 97.821667 %
Test accuracy : 97.160000 %
```

Παράδειγμα 9:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Train accuracy : 99.060000 %
Test accuracy : 98.000000 %
```

Παράδειγμα 10:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 91.981667 %
Test accuracy : 92.210000 %
```

Παράδειγμα 11:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.01
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 99.355000 %
Test accuracy : 97.680000 %
```

Παράδειγμα 12:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.01
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 99.746667 %
Test accuracy : 97.840000 %
```

Παράδειγμα 13:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.01
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 99.965000 %
Test accuracy : 98.000000 %
```

Παράδειγμα 14:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 95.166667 %
Test accuracy : 95.170000 %
```

Παράδειγμα 15:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 99.655000 %
Test accuracy : 98.140000 %
```

Παράδειγμα 16:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:100
Train accuracy : 99.900000 %
Test accuracy : 98.200000 %
```

Παράδειγμα 17:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:200
Train accuracy : 99.748333 %
Test accuracy : 98.260000 %
```

Παράδειγμα 18:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:100
Train accuracy : 99.000000 %
Test accuracy : 97.830000 %
```

Παράδειγμα 19:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
Train accuracy : 99.580000 %
Test accuracy : 98.080000 %
```

Παράδειγμα 20:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.773333 %
Test accuracy : 98.060000 %
```

Παράδειγμα 21:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.345000 %
Test accuracy : 97.960000 %
```

Παράδειγμα 22:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 99.891667 %
Test accuracy : 98.090000 %
```

Παράδειγμα 23:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.945000 %
Test accuracy : 98.180000 %
```

Παράδειγμα 24:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:100
Train accuracy : 99.620000 %
Test accuracy : 98.080000 %
```

Παράδειγμα 25:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.781667 %
Test accuracy : 98.320000 %
```

Παράδειγμα 26:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 98.853333 %
Test accuracy : 97.750000 %
```

Παράδειγμα 27:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.365000 %
Test accuracy : 97.950000 %
```

Παράδειγμα 28:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.970000 %
Test accuracy : 98.450000 %
```

Παράδειγμα 29:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.398333 %
Test accuracy : 97.790000 %
```

Παράδειγμα 30:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.05
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.843333 %
Test accuracy : 98.250000 %
```

Παράδειγμα 31:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.01
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:300
```

```
Train accuracy : 37.396667 %
Test accuracy : 36.730000 %
```

Παράδειγμα 32:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.01
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 96.690000 %
Test accuracy : 96.370000 %
```

Παράδειγμα 33:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.01
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 92.088333 %
Test accuracy : 91.900000 %
```

Παράδειγμα 34:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 98.821667 %
Test accuracy : 97.690000 %
```

Παράδειγμα 35:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.p
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
```

```
Train accuracy : 99.363333 %
Test accuracy : 98.080000 %
```

Παράδειγμα 36:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.735000 %
Test accuracy : 98.290000 %
```

Παράδειγμα 37:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.001
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 100.000000 %
Test accuracy : 98.120000 %
```

Παράδειγμα 38:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.p
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 98.696667 %
Test accuracy : 97.660000 %
```

Παράδειγμα 39:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.718333 %
Test accuracy : 98.260000 %
```

Παράδειγμα 40:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.316667 %
Test accuracy : 98.010000 %
```

Παράδειγμα 41:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.001
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.975000 %
Test accuracy : 97.810000 %
```

Παράδειγμα 42:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.001
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 100.000000 %
Test accuracy : 98.250000 %
```

Παράδειγμα 43:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.00006
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 98.920000 %
Test accuracy : 97.790000 %
```

Παράδειγμα 44:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.00006
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 96.720000 %
Test accuracy : 96.330000 %
```

Παράδειγμα 45:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.00006
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 97.910000 %
Test accuracy : 97.160000 %
```

Παράδειγμα 46:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.00006
Enter the term of regularization:0.001
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 99.303333 %
Test accuracy : 97.860000 %
```

Παράδειγμα 47:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.00006
Enter the term of regularization:0.001
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 98.421667 %
Test accuracy : 97.420000 %
```

Παράδειγμα 48:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:300
Enter the learning rate:0.00006
Enter the term of regularization:0.001
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
Train accuracy : 97.351667 %
Test accuracy : 96.660000 %
```

- Για το dataset CIFAR-10 έχουμε τα εξής παραδείγματα:

Παράδειγμα 1:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Do you want to use cross-validation(Yes/No):no
Enter the number of hidden neurons:100
Enter the learning rate:0.1
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epoches:100
Test accuracy : 10.000000 %
```

Παράδειγμα 2:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:500
Enter the learning rate:0.0001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
Test accuracy : 49.810000 %
```

Παράδειγμα 3:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:100
Test accuracy : 42.330000 %
```

Παράδειγμα 4:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.0001
Enter the term of regularization:0.5
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 53.636000 %
Test accuracy : 48.200000 %
```

Παράδειγμα 5:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.00001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 48.334000 %
Test accuracy : 46.170000 %
```

Παράδειγμα 6:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 61.348000 %
Test accuracy : 50.170000 %
```

Παράδειγμα 7:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.01
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 58.184000 %
Test accuracy : 46.260000 %
```

Παράδειγμα 8:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.5
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 40.332000 %
Test accuracy : 37.870000 %
```

Παράδειγμα 9:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 47.346000 %
Test accuracy : 41.190000 %
```

Παράδειγμα 10:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:200
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 32.220000 %
Test accuracy : 15.250000 %
```

Παράδειγμα 11:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 48.348000 %
Test accuracy : 40.890000 %
```

Παράδειγμα 12:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 52.870000 %
Test accuracy : 45.220000 %
```

Παράδειγμα 13:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Train accuracy : 37.148000 %
Test accuracy : 19.000000 %
```

Παράδειγμα 14:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML_ASS1/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Do you want to use visualize dataset?(Yes/No):no
Do you want to use cross-validation?(Yes/No):no
Enter the number of hidden neurons:100
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Test accuracy : 41.940000 %
```

Παράδειγμα 15:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML_ASS1/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Do you want to use visualize dataset?(Yes/No):no
Do you want to use cross-validation?(Yes/No):ni
Enter the number of hidden neurons:100
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Test accuracy : 42.560000 %
```

Παράδειγμα 16:

```
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Do you want to use visualize dataset?(Yes/No):no
Do you want to use cross-validation?(Yes/No):no
Enter the number of hidden neurons:100
Enter the learning rate:0.001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:100
Enter the number of epochs:100
```

```
Test accuracy : 14.330000 %
```

Παράδειγμα 17:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML_ASS1/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Do you want to use visualize dataset?(Yes/No):no
Do you want to use cross-validation?(Yes/No):no
Enter the number of hidden neurons:100
Enter the learning rate:0.0001
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:100
```

```
Test accuracy : 50.490000 %
```

Παράδειγμα 18:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):cos
Enter the size of every batch:200
Enter the number of epochs:200
```

```
Train accuracy : 44.026000 %
Test accuracy : 15.150000 %
```

Παράδειγμα 19:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):tanh
Enter the size of every batch:200
Enter the number of epochs:200
```

```
Train accuracy : 45.342000 %
Test accuracy : 36.760000 %
```

Παράδειγμα 20:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):cifar
Enter the number of hidden neurons:300
Enter the learning rate:0.0005
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:200
Enter the number of epochs:200
```

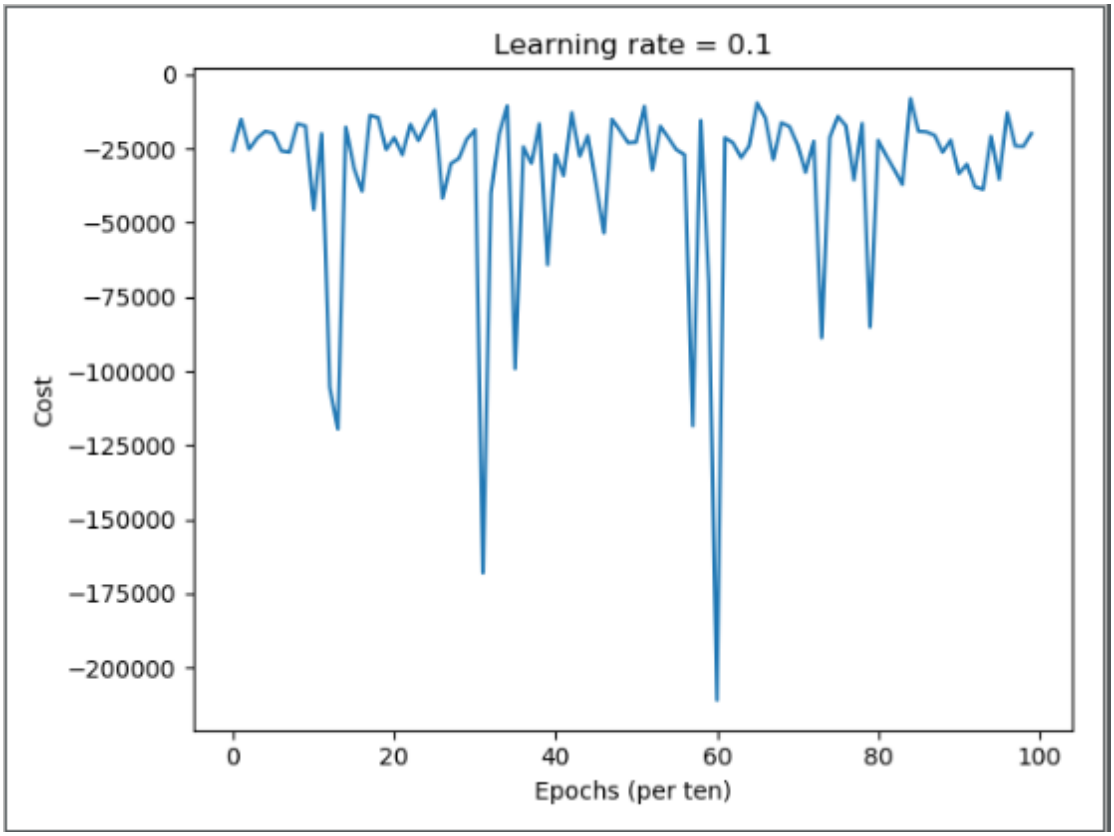
```
Train accuracy : 56.854000 %
Test accuracy : 47.090000 %
```

Γενικά παρατηρείται ότι δεν έχουμε υπερεκπαίδευση. Με learning rate = 0.1 και τα δύο dataset παρουσιάζουν μικρό σκορ κατά την πρόβλεψη του test set καθώς κατά την εκπαίδευση παρατηρείται κιόλας η cost function να είναι πολύ μικρή και ενώ βελτιώνεται μετά τις 40-60 εποχές αρχίζει πάλι να μειώνεται. Γενικός που συμβαίνει καθώς είναι μεγάλη η δοσμένη τιμή για το learning rate και για αυτό το λόγο . Το συγκεκριμένο φαινόμενο φαίνεται και από την γραφική παράσταση της cost function ανά εποχή που υπάρχει παρακάτω.

Για το dataset mnist και με τα εξής χαρακτηριστικά:

```
C:\Users\IAKOVOS\AppData\Local\Programs\Python\Python36\python.exe C:/Users/IAKOVOS/PycharmProjects/ML/Main.py
Enter the name of dataset which you want to explore(CHOICES: mnist or cifar):mnist
Enter the number of hidden neurons:100
Enter the learning rate:0.1
Enter the term of regularization:0.1
Enter which activation function you want to use(softplus/tanh/cos):softplus
Enter the size of every batch:100
Enter the number of epochs:100
```

Έχουμε:



Με τα ίδια χαρακτηριστικά αλλά για το dataset cifar-10 έχουμε: