Arhitektura 1

```
    model.cuda()
Net(
  (network): Sequential(
    (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU()
    (2): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (3): Conv2d(32, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (4): ReLU()
    (5): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (6): Flatten(start_dim=1, end_dim=-1)
    (7): Linear(in_features=4096, out_features=1024, bias=True)
    (8): ReLU()
    (9): Linear(in_features=1024, out_features=512, bias=True)
    (10): ReLU()
    (11): Linear(in_features=512, out_features=10, bias=True)
  )
)
```

Rezultati treniranja obucavajuci skup i validacioni skup

```
Epoch: 1        Training Loss: 1.044767         Validation Loss: 0.208014
Validation loss decreased (inf --> 0.208014).  Saving model ...
Epoch: 2        Training Loss: 0.709225         Validation Loss: 0.182042
Validation loss decreased (0.208014 --> 0.182042).  Saving model ...
Epoch: 3        Training Loss: 0.516735         Validation Loss: 0.174881
Validation loss decreased (0.182042 --> 0.174881).  Saving model ...
Epoch: 4        Training Loss: 0.340460         Validation Loss: 0.191083
Epoch: 5        Training Loss: 0.203494         Validation Loss: 0.232354
Epoch: 6        Training Loss: 0.138557         Validation Loss: 0.263622
Epoch: 7        Training Loss: 0.103955         Validation Loss: 0.316084
Epoch: 8        Training Loss: 0.086159         Validation Loss: 0.341103
Epoch: 9        Training Loss: 0.073901         Validation Loss: 0.371545
Epoch: 10       Training Loss: 0.072510         Validation Loss: 0.374595
```

Rezultati na test skupu

```
Test Loss: 0.884072

Test Accuracy of airplane: 71% (716/1000)
Test Accuracy of automobile: 78% (785/1000)
Test Accuracy of  bird: 61% (616/1000)
Test Accuracy of   cat: 47% (479/1000)
Test Accuracy of  deer: 60% (600/1000)
Test Accuracy of   dog: 69% (695/1000)
Test Accuracy of  frog: 78% (785/1000)
Test Accuracy of horse: 81% (819/1000)
Test Accuracy of  ship: 75% (757/1000)
Test Accuracy of truck: 76% (766/1000)

Test Accuracy (Overall): 70% (7018/10000)
```

Arhitektura 2

```
Net(
  (network): Sequential(
    (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU()
    (2): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (3): Conv2d(32, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (4): ReLU()
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU()
    (7): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (8): Flatten(start_dim=1, end_dim=-1)
    (9): Linear(in_features=8192, out_features=4096, bias=True)
    (10): ReLU()
    (11): Linear(in_features=4096, out_features=1024, bias=True)
    (12): ReLU()
    (13): Linear(in_features=1024, out_features=10, bias=True)
  )
)
```

Rezultati treniranja obucavajuci skup i validacioni skup

```
Epoch: 1        Training Loss: 1.123275         Validation Loss: 0.225919
Validation loss decreased (inf --> 0.225919).  Saving model ...
Epoch: 2        Training Loss: 0.773582         Validation Loss: 0.191445
Validation loss decreased (0.225919 --> 0.191445).  Saving model ...
Epoch: 3        Training Loss: 0.557573         Validation Loss: 0.175375
Validation loss decreased (0.191445 --> 0.175375).  Saving model ...
Epoch: 4        Training Loss: 0.355458         Validation Loss: 0.193759
Epoch: 5        Training Loss: 0.194703         Validation Loss: 0.235016
Epoch: 6        Training Loss: 0.124595         Validation Loss: 0.264791
Epoch: 7        Training Loss: 0.102577         Validation Loss: 0.320402
Epoch: 8        Training Loss: 0.082957         Validation Loss: 0.346072
Epoch: 9        Training Loss: 0.081936         Validation Loss: 0.351864
Epoch: 10       Training Loss: 0.074376         Validation Loss: 0.378298
```

Rezultati na test skupu

```
Test Loss: 0.881347

Test Accuracy of airplane: 77% (777/1000)
Test Accuracy of automobile: 86% (860/1000)
Test Accuracy of  bird: 57% (571/1000)
Test Accuracy of   cat: 48% (483/1000)
Test Accuracy of  deer: 55% (558/1000)
Test Accuracy of   dog: 63% (639/1000)
Test Accuracy of  frog: 82% (827/1000)
Test Accuracy of horse: 78% (788/1000)
Test Accuracy of  ship: 72% (728/1000)
Test Accuracy of truck: 80% (808/1000)

Test Accuracy (Overall): 70% (7039/10000)
```

Arhitektura 3

```
Net(
  (network): Sequential(
    (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU()
    (2): Conv2d(32, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU()
    (7): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU()
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (10): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (11): ReLU()
    (12): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (13): Flatten(start_dim=1, end_dim=-1)
    (14): Linear(in_features=8192, out_features=1024, bias=True)
    (15): ReLU()
    (16): Linear(in_features=1024, out_features=10, bias=True)
  )
)
```

Rezultati treniranja obucavajuci skup i validacioni skup

```
Epoch: 1          Training Loss: 1.145415          Validation Loss: 0.214983
Validation loss decreased (inf --> 0.214983).  Saving model ...
Epoch: 2          Training Loss: 0.725920          Validation Loss: 0.167171
Validation loss decreased (0.214983 --> 0.167171).  Saving model ...
Epoch: 3          Training Loss: 0.538220          Validation Loss: 0.147429
Validation loss decreased (0.167171 --> 0.147429).  Saving model ...
Epoch: 4          Training Loss: 0.392557          Validation Loss: 0.146082
Validation loss decreased (0.147429 --> 0.146082).  Saving model ...
Epoch: 5          Training Loss: 0.272783          Validation Loss: 0.170118
Epoch: 6          Training Loss: 0.192102          Validation Loss: 0.192334
Epoch: 7          Training Loss: 0.147872          Validation Loss: 0.209446
Epoch: 8          Training Loss: 0.128645          Validation Loss: 0.234868
Epoch: 9          Training Loss: 0.121732          Validation Loss: 0.251060
Epoch: 10         Training Loss: 0.105826          Validation Loss: 0.270742
```

Rezultati na test skupu

```
Test Loss: 0.763663

Test Accuracy of airplane: 79% (794/1000)
Test Accuracy of automobile: 88% (887/1000)
Test Accuracy of  bird: 68% (686/1000)
Test Accuracy of   cat: 55% (551/1000)
Test Accuracy of  deer: 60% (607/1000)
Test Accuracy of   dog: 69% (699/1000)
Test Accuracy of  frog: 81% (815/1000)
Test Accuracy of horse: 82% (826/1000)
Test Accuracy of  ship: 87% (870/1000)
Test Accuracy of truck: 81% (819/1000)

Test Accuracy (Overall): 75% (7554/10000)
```

Komentar:

Pocetna arhitektura sadrzi 5 slojeva: 2 konvoluciona i 3 skroz povezana sloja i za tako mali broj parametara neuralne mreze daje jako dobre rezultate. Ova arhitektura zbog malog broja parametara se jako brzo obuci potrebno je svega 3 epohe nakon cega ulazi preobucavanje, odnosno u „overfit". Kao zastita od preobucavanja koriste se dropout slojevi na skroz povezanim slojevima, na svim arhitekturama. Kao posledica malog broja parametara ne moze se ocekivati velika moc klasifikacije mreze, ali 70% na testirajucem skupu je dobar rezultat.

Druga po redu testirana arhitekura ima 3 konvoluciona i 3 skroz povezana sloja sto nije veliko povecanje u smislu broja parametara sto ne donosi nikave promene u smislu rezultata.

Poslednja arhitektura ima 5 konvolucionih slojeva i 2 skroz povezana sloja i daje tacnost na trestirajucem skupu od 75% sto je bolji rezultat, ali je u smislu testiranja broj epoha povecao na 4 sto je ocekivano ponasanje nakon cega se ulazi u oblast preobucavanja.

Preobucavanje modela se prepoznaje tako sto kriterijumska funkcija na validacionom skupu nakon opadanja pocne da raste umesto da opada.

Za inicijalna podesavanja i obucavanja je koriscen CPU Intel I7 procesor, obucavanje ovih modela na CPU je trajalo oko 60min, za zavrsna obucavanja koristen Google Colab koji nudi besplatne graficke karice na svojim Cloud serverima na kojima se vreme obucavanja drasticno smanjuje na do 10ak minuta.