

When img2obj was used to train the CNN with the CIFAR-100 dataset, the training time was 28.8 seconds per epoch. Following are the accuracies obtained:

Epochs	Accuracy (%)
20	25.81
60	31.97

When both the fully connected neural network (img2num_hw4) and the convolutional neural network (img2num) were trained with MNIST data, following were the accuracies obtained:

Epochs	Accuracy with conv NN (%)	Accuracy with fully connected NN (%)
1	86.25	89.93
5	97.86	93.21
10	98.49	95.51
15	98.63	96.42
20	98.39	96.94

It took 25 seconds per epoch to train the convolutional neural network with MNIST, while it took only 8.09 seconds per epoch to train the fully connected neural network with MNIST data. The additional time taken to train a CNN is worth the trouble because a CNN gives much better accuracy than the fully connected NN in all cases, except when it is trained with one epoch, which is usually not the case. In the cases of both neural networks, the accuracy converges reasonably at 20 epochs.

Notes:

- 1) The file img2num_hw4.py that contains the fully connected network (from hw 4) does not comply with the API mentioned in the homework document. The classes in the files img2num.py and img2obj.py comply with the given API.

Appendix A: CIFAR-100 training accuracies with 20 and 60 epochs

20 epochs: accuracy: 0.2581: 9.6 mins

Accuracy per class:

beaver : 0.34

dolphin : 0.36

otter : 0.2

seal : 0.13

whale : 0.12

aquarium fish : 0.26

flatfish : 0.19

ray : 0.35

shark : 0.19

trout : 0.31

orchids : 0.03

poppies : 0.14

roses : 0.2

sunflowers : 0.09

tulips : 0.24

bottles : 0.21

bowls : 0.28

cans : 0.43

cups : 0.26

plates : 0.1

apples : 0.59

mushrooms : 0.45

oranges : 0.15

pears : 0.34

sweet peppers : 0.61

clock : 0.03

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BME 595 HW05

computer keyboard : 0.22

lamp : 0.13

telephone : 0.12

television : 0.21

bed : 0.45

chair : 0.26

couch : 0.13

table : 0.18

wardrobe : 0.14

bee : 0.25

beetle : 0.29

butterfly : 0.2

caterpillar : 0.17

cockroach : 0.26

bear : 0.26

leopard : 0.44

lion : 0.34

tiger : 0.37

wolf : 0.09

bridge : 0.1

castle : 0.08

house : 0.61

road : 0.59

skyscraper : 0.09

cloud : 0.05

forest : 0.17

mountain : 0.37

plain : 0.52

sea : 0.25

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camel : 0.05

cattle : 0.35

chimpanzee : 0.21

elephant : 0.36

kangaroo : 0.24

fox : 0.69

porcupine : 0.34

possum : 0.34

raccoon : 0.26

skunk : 0.03

crab : 0.03

lobster : 0.15

snail : 0.23

spider : 0.56

worm : 0.5

baby : 0.28

boy : 0.62

girl : 0.05

man : 0.16

woman : 0.15

crocodile : 0.57

dinosaur : 0.56

lizard : 0.07

snake : 0.11

turtle : 0.04

hamster : 0.0

mouse : 0.24

rabbit : 0.68

shrew : 0.14

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squirrel : 0.16

maple : 0.46

oak : 0.38

palm : 0.15

pine : 0.06

willow : 0.3

bicycle : 0.18

bus : 0.46

motorcycle : 0.06

pickup truck : 0.13

train : 0.47

lawn-mower : 0.27

rocket : 0.2

streetcar : 0.29

tank : 0.05

tractor : 0.24

60 epochs: accuracy: 0.3197: 35 mins

Accuracy per class:

beaver : 0.54

dolphin : 0.42

otter : 0.19

seal : 0.17

whale : 0.1

aquarium fish : 0.25

flatfish : 0.25

ray : 0.42

shark : 0.3

trout : 0.44

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orchids : 0.16

poppies : 0.09

roses : 0.33

sunflowers : 0.3

tulips : 0.21

bottles : 0.13

bowls : 0.31

cans : 0.56

cups : 0.3

plates : 0.18

apples : 0.61

mushrooms : 0.52

oranges : 0.24

pears : 0.52

sweet peppers : 0.64

clock : 0.15

computer keyboard : 0.19

lamp : 0.22

telephone : 0.51

television : 0.26

bed : 0.27

chair : 0.29

couch : 0.24

table : 0.34

wardrobe : 0.22

bee : 0.18

beetle : 0.31

butterfly : 0.3

caterpillar : 0.07

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cockroach : 0.43

bear : 0.26

leopard : 0.56

lion : 0.31

tiger : 0.27

wolf : 0.08

bridge : 0.17

castle : 0.14

house : 0.55

road : 0.51

skyscraper : 0.5

cloud : 0.08

forest : 0.28

mountain : 0.51

plain : 0.55

sea : 0.45

camel : 0.11

cattle : 0.37

chimpanzee : 0.23

elephant : 0.48

kangaroo : 0.28

fox : 0.7

porcupine : 0.45

possum : 0.46

raccoon : 0.32

skunk : 0.11

crab : 0.1

lobster : 0.29

snail : 0.29

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spider : 0.67

worm : 0.56

baby : 0.23

boy : 0.54

girl : 0.05

man : 0.31

woman : 0.17

crocodile : 0.52

dinosaur : 0.64

lizard : 0.13

snake : 0.12

turtle : 0.34

hamster : 0.1

mouse : 0.25

rabbit : 0.59

shrew : 0.29

squirrel : 0.19

maple : 0.38

oak : 0.34

palm : 0.35

pine : 0.18

willow : 0.36

bicycle : 0.25

bus : 0.41

motorcycle : 0.17

pickup truck : 0.18

train : 0.75

lawn-mower : 0.44

rocket : 0.23

streetcar : 0.35

tank : 0.03

tractor : 0.28

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Appendix B: MNIST accuracies when trained with a convolutional neural network

1 epoch: accuracy: 0.8625

Accuracy per class:

one : 0.957

two : 0.952

three : 0.858

four : 0.788

five : 0.872

six : 0.776

seven : 0.92

eight : 0.86

nine : 0.819

ten : 0.821

5 epochs: accuracy: 0.97856

Accuracy per class:

one : 0.99

two : 0.993

three : 0.984

four : 0.983

five : 0.98

six : 0.981

seven : 0.983

eight : 0.971

nine : 0.955

ten : 0.966

10 epochs: accuracy: 0.9849

Accuracy per class:

one : 0.988

two : 0.989

three : 0.994

four : 0.993

five : 0.987

six : 0.981

seven : 0.979

eight : 0.981

nine : 0.984

ten : 0.973

15 epochs: accuracy: 0.9863

Accuracy per class:

one : 0.996

two : 0.997

three : 0.979

four : 0.994

five : 0.994

six : 0.987

seven : 0.988

eight : 0.983

nine : 0.984

ten : 0.961

20 epochs: accuracy: 0.9839

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Accuracy per class:

one : 0.997

two : 0.999

three : 0.988

four : 0.981

five : 0.994

six : 0.981

seven : 0.975

eight : 0.992

nine : 0.984

ten : 0.948

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Appendix C: MNIST accuracies when trained with a regular fully connected neural network

1 epoch: accuracy: 0.8993

Accuracy per class:

one : 0.977

two : 0.967

three : 0.857

four : 0.871

five : 0.896

six : 0.846

seven : 0.955

eight : 0.87

nine : 0.852

ten : 0.902

5 epochs: accuracy: 0.9321

Accuracy per class:

one : 0.977

two : 0.971

three : 0.886

four : 0.916

five : 0.928

six : 0.907

seven : 0.963

eight : 0.929

nine : 0.926

ten : 0.918

10 epochs: accuracy: 0.9551

Accuracy per class:

one : 0.984

two : 0.978

three : 0.957

four : 0.945

five : 0.964

six : 0.942

seven : 0.973

eight : 0.953

nine : 0.939

ten : 0.916

15 epochs: accuracy: 0.9642

Accuracy per class:

one : 0.985

two : 0.986

three : 0.959

four : 0.977

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five : 0.949

six : 0.97

seven : 0.968

eight : 0.953

nine : 0.948

ten : 0.947

20 epochs: accuracy: 0.9694

Accuracy per class:

one : 0.984

two : 0.99

three : 0.967

four : 0.979

five : 0.963

six : 0.963

seven : 0.967

eight : 0.962

nine : 0.965

ten : 0.954
