In [ ]:
```
# This mounts your Google Drive to the Colab VM.
from google.colab import drive
drive.mount('/content/drive')

# TODO: Enter the foldername in your Drive where you have saved the unzipped
# assignment folder, e.g. 'cs6353/assignments/assignment2/'
FOLDERNAME = 'CS6353/Assignments/assignment2/assignment2/'
assert FOLDERNAME is not None, "[!] Enter the foldername."

# Now that we've mounted your Drive, this ensures that
# the Python interpreter of the Colab VM can load
# python files from within it.
import sys
sys.path.append('/content/drive/My Drive/{}'.format(FOLDERNAME))

# This downloads the CIFAR-10 dataset to your Drive
# if it doesn't already exist.
%cd /content/drive/My\ Drive/$FOLDERNAME/cs6353/datasets/
!bash get_datasets.sh
%cd /content/drive/My\ Drive/$FOLDERNAME

# Install requirements from colab_requirements.txt
# TODO: Please change your path below to the colab_requirements.txt file
! python -m pip install -r /content/drive/My\ Drive/$FOLDERNAME/colab_requirements.txt
```

```
Mounted at /content/drive
/content/drive/My Drive/CS6353/Assignments/assignment2/assignment2/cs6353/datasets
--2024-09-29 21:35:39--  http://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
Resolving www.cs.toronto.edu (www.cs.toronto.edu)... 128.100.3.30
Connecting to www.cs.toronto.edu (www.cs.toronto.edu)|128.100.3.30|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 170498071 (163M) [application/x-gzip]
Saving to: ‘cifar-10-python.tar.gz’

cifar-10-python.tar 100%[===================>] 162.60M  44.0MB/s    in 3.9s

2024-09-29 21:35:43 (41.7 MB/s) - ‘cifar-10-python.tar.gz’ saved [170498071/17049807
1]

cifar-10-batches-py/
cifar-10-batches-py/data_batch_4
cifar-10-batches-py/readme.html
cifar-10-batches-py/test_batch
cifar-10-batches-py/data_batch_3
cifar-10-batches-py/batches.meta
cifar-10-batches-py/data_batch_2
cifar-10-batches-py/data_batch_5
cifar-10-batches-py/data_batch_1
/content/drive/My Drive/CS6353/Assignments/assignment2/assignment2
Requirement already satisfied: anyio==3.7.1 in /usr/local/lib/python3.10/dist-package
s (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_
requirements.txt (line 1)) (3.7.1)
Collecting appnope==0.1.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 2))
  Downloading appnope-0.1.3-py2.py3-none-any.whl.metadata (1.2 kB)
Requirement already satisfied: argon2-cffi==23.1.0 in /usr/local/lib/python3.10/dist-
packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment
2//colab_requirements.txt (line 3)) (23.1.0)
Requirement already satisfied: argon2-cffi-bindings==21.2.0 in /usr/local/lib/python
3.10/dist-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/as
signment2//colab_requirements.txt (line 4)) (21.2.0)
Collecting arrow==1.2.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignmen
t2/assignment2//colab_requirements.txt (line 5))
  Downloading arrow-1.2.3-py3-none-any.whl.metadata (6.9 kB)
Collecting asttokens==2.2.1 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 6))
  Downloading asttokens-2.2.1-py2.py3-none-any.whl.metadata (4.8 kB)
Collecting async-lru==2.0.4 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 7))
  Downloading async_lru-2.0.4-py3-none-any.whl.metadata (4.5 kB)
Collecting attrs==23.1.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 8))
  Downloading attrs-23.1.0-py3-none-any.whl.metadata (11 kB)
Collecting Babel==2.12.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 9))
  Downloading Babel-2.12.1-py3-none-any.whl.metadata (1.3 kB)
Requirement already satisfied: backcall==0.2.0 in /usr/local/lib/python3.10/dist-pack
ages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//col
ab_requirements.txt (line 10)) (0.2.0)
Collecting beautifulsoup4==4.12.2 (from -r /content/drive/My Drive/CS6353/Assignment
s/assignment2/assignment2//colab_requirements.txt (line 11))
  Downloading beautifulsoup4-4.12.2-py3-none-any.whl.metadata (3.6 kB)
Collecting bleach==6.0.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 12))
  Downloading bleach-6.0.0-py3-none-any.whl.metadata (29 kB)
```

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Collecting certifi==2023.7.22 (from -r /content/drive/My Drive/CS6353/Assignments/ass
ignment2/assignment2//colab_requirements.txt (line 13))
  Downloading certifi-2023.7.22-py3-none-any.whl.metadata (2.2 kB)
Collecting cffi==1.15.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignmen
t2/assignment2//colab_requirements.txt (line 14))
  Downloading cffi-1.15.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.
metadata (1.1 kB)
Collecting charset-normalizer==3.2.0 (from -r /content/drive/My Drive/CS6353/Assignme
nts/assignment2/assignment2//colab_requirements.txt (line 15))
  Downloading charset_normalizer-3.2.0-cp310-cp310-manylinux_2_17_x86_64.manylinux201
4_x86_64.whl.metadata (31 kB)
Collecting comm==0.1.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment
2/assignment2//colab_requirements.txt (line 16))
  Downloading comm-0.1.4-py3-none-any.whl.metadata (4.2 kB)
Collecting contourpy==1.1.0 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 17))
  Downloading contourpy-1.1.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.
whl.metadata (5.7 kB)
Collecting cycler==0.11.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 18))
  Downloading cycler-0.11.0-py3-none-any.whl.metadata (785 bytes)
Collecting debugpy==1.6.7.post1 (from -r /content/drive/My Drive/CS6353/Assignments/a
ssignment2/assignment2//colab_requirements.txt (line 19))
  Downloading debugpy-1.6.7.post1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86
_64.whl.metadata (1.1 kB)
Requirement already satisfied: decorator<=5.0 in /usr/local/lib/python3.10/dist-packa
ges (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//cola
b_requirements.txt (line 20)) (4.4.2)
Requirement already satisfied: defusedxml==0.7.1 in /usr/local/lib/python3.10/dist-pa
ckages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//c
olab_requirements.txt (line 21)) (0.7.1)
Collecting executing==1.2.0 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 22))
  Downloading executing-1.2.0-py2.py3-none-any.whl.metadata (8.9 kB)
Collecting fastjsonschema==2.18.0 (from -r /content/drive/My Drive/CS6353/Assignment
s/assignment2/assignment2//colab_requirements.txt (line 23))
  Downloading fastjsonschema-2.18.0-py3-none-any.whl.metadata (2.0 kB)
Collecting fonttools==4.42.1 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 24))
  Downloading fonttools-4.42.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl.metadata (150 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 151.0/151.0 kB 6.6 MB/s eta 0:00:00
Collecting fqdn==1.5.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignment
2/assignment2//colab_requirements.txt (line 25))
  Downloading fqdn-1.5.1-py3-none-any.whl.metadata (1.4 kB)
Collecting idna==3.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/
assignment2//colab_requirements.txt (line 26))
  Downloading idna-3.4-py3-none-any.whl.metadata (9.8 kB)
Collecting imageio==2.31.1 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 27))
  Downloading imageio-2.31.1-py3-none-any.whl.metadata (4.7 kB)
Requirement already satisfied: ipykernel<=5.5.6 in /usr/local/lib/python3.10/dist-pac
kages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//co
lab_requirements.txt (line 28)) (5.5.6)
Requirement already satisfied: ipython<=7.34.0 in /usr/local/lib/python3.10/dist-pack
ages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//col
ab_requirements.txt (line 29)) (7.34.0)
Collecting isoduration==20.11.0 (from -r /content/drive/My Drive/CS6353/Assignments/a
ssignment2/assignment2//colab_requirements.txt (line 30))
  Downloading isoduration-20.11.0-py3-none-any.whl.metadata (5.7 kB)
```

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Collecting jedi==0.19.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignmen
t2/assignment2//colab_requirements.txt (line 31))
  Downloading jedi-0.19.0-py2.py3-none-any.whl.metadata (22 kB)
Collecting Jinja2==3.1.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 32))
  Downloading Jinja2-3.1.2-py3-none-any.whl.metadata (3.5 kB)
Collecting json5==0.9.14 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 33))
  Downloading json5-0.9.14-py2.py3-none-any.whl.metadata (10 kB)
Collecting jsonpointer==2.4 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 34))
  Downloading jsonpointer-2.4-py2.py3-none-any.whl.metadata (2.5 kB)
Collecting jsonschema==4.19.0 (from -r /content/drive/My Drive/CS6353/Assignments/ass
ignment2/assignment2//colab_requirements.txt (line 35))
  Downloading jsonschema-4.19.0-py3-none-any.whl.metadata (8.2 kB)
Collecting jsonschema-specifications==2023.7.1 (from -r /content/drive/My Drive/CS635
3/Assignments/assignment2/assignment2//colab_requirements.txt (line 36))
  Downloading jsonschema_specifications-2023.7.1-py3-none-any.whl.metadata (2.8 kB)
Collecting jupyter-events==0.7.0 (from -r /content/drive/My Drive/CS6353/Assignments/
assignment2/assignment2//colab_requirements.txt (line 37))
  Downloading jupyter_events-0.7.0-py3-none-any.whl.metadata (5.5 kB)
Collecting jupyter-lsp==2.2.0 (from -r /content/drive/My Drive/CS6353/Assignments/ass
ignment2/assignment2//colab_requirements.txt (line 38))
  Downloading jupyter_lsp-2.2.0-py3-none-any.whl.metadata (1.8 kB)
Requirement already satisfied: jupyter_client<8.0 in /usr/local/lib/python3.10/dist-p
ackages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//
colab_requirements.txt (line 39)) (6.1.12)
Collecting jupyter_core==5.3.1 (from -r /content/drive/My Drive/CS6353/Assignments/as
signment2/assignment2//colab_requirements.txt (line 40))
  Downloading jupyter_core-5.3.1-py3-none-any.whl.metadata (3.4 kB)
Collecting jupyter_server==2.7.2 (from -r /content/drive/My Drive/CS6353/Assignments/
assignment2/assignment2//colab_requirements.txt (line 41))
  Downloading jupyter_server-2.7.2-py3-none-any.whl.metadata (8.6 kB)
Collecting jupyter_server_terminals==0.4.4 (from -r /content/drive/My Drive/CS6353/As
signments/assignment2/assignment2//colab_requirements.txt (line 42))
  Downloading jupyter_server_terminals-0.4.4-py3-none-any.whl.metadata (6.3 kB)
Collecting jupyterlab==4.0.5 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 43))
  Downloading jupyterlab-4.0.5-py3-none-any.whl.metadata (15 kB)
Collecting jupyterlab-pygments==0.2.2 (from -r /content/drive/My Drive/CS6353/Assignm
ents/assignment2/assignment2//colab_requirements.txt (line 44))
  Downloading jupyterlab_pygments-0.2.2-py2.py3-none-any.whl.metadata (1.9 kB)
Collecting jupyterlab_server==2.24.0 (from -r /content/drive/My Drive/CS6353/Assignme
nts/assignment2/assignment2//colab_requirements.txt (line 45))
  Downloading jupyterlab_server-2.24.0-py3-none-any.whl.metadata (5.8 kB)
Collecting kiwisolver==1.4.5 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 46))
  Downloading kiwisolver-1.4.5-cp310-cp310-manylinux_2_12_x86_64.manylinux2010_x86_6
4.whl.metadata (6.4 kB)
Collecting MarkupSafe==2.1.3 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 47))
  Downloading MarkupSafe-2.1.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl.metadata (3.0 kB)
Collecting matplotlib==3.7.2 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 48))
  Downloading matplotlib-3.7.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl.metadata (5.6 kB)
Collecting matplotlib-inline==0.1.6 (from -r /content/drive/My Drive/CS6353/Assignmen
ts/assignment2/assignment2//colab_requirements.txt (line 49))
  Downloading matplotlib_inline-0.1.6-py3-none-any.whl.metadata (2.8 kB)
```

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Collecting mistune==3.0.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 50))
  Downloading mistune-3.0.1-py3-none-any.whl.metadata (1.7 kB)
Collecting nbclient==0.8.0 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 51))
  Downloading nbclient-0.8.0-py3-none-any.whl.metadata (7.8 kB)
Collecting nbconvert==7.7.4 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 52))
  Downloading nbconvert-7.7.4-py3-none-any.whl.metadata (8.0 kB)
Collecting nbformat==5.9.2 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 53))
  Downloading nbformat-5.9.2-py3-none-any.whl.metadata (3.4 kB)
Collecting nest-asyncio==1.5.7 (from -r /content/drive/My Drive/CS6353/Assignments/as
signment2/assignment2//colab_requirements.txt (line 54))
  Downloading nest_asyncio-1.5.7-py3-none-any.whl.metadata (2.7 kB)
Collecting notebook_shim==0.2.3 (from -r /content/drive/My Drive/CS6353/Assignments/a
ssignment2/assignment2//colab_requirements.txt (line 55))
  Downloading notebook_shim-0.2.3-py3-none-any.whl.metadata (4.0 kB)
Collecting numpy<1.24,>=1.22 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 56))
  Downloading numpy-1.23.5-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (2.3 kB)
Collecting overrides==7.4.0 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 57))
  Downloading overrides-7.4.0-py3-none-any.whl.metadata (5.7 kB)
Collecting packaging==23.1 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 58))
  Downloading packaging-23.1-py3-none-any.whl.metadata (3.1 kB)
Collecting pandas<=1.5.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 59))
  Downloading pandas-1.5.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (11 kB)
Collecting pandocfilters==1.5.0 (from -r /content/drive/My Drive/CS6353/Assignments/a
ssignment2/assignment2//colab_requirements.txt (line 60))
  Downloading pandocfilters-1.5.0-py2.py3-none-any.whl.metadata (9.0 kB)
Collecting parso==0.8.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignmen
t2/assignment2//colab_requirements.txt (line 61))
  Downloading parso-0.8.3-py2.py3-none-any.whl.metadata (7.5 kB)
Collecting pexpect==4.8.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 62))
  Downloading pexpect-4.8.0-py2.py3-none-any.whl.metadata (2.2 kB)
Requirement already satisfied: pickleshare==0.7.5 in /usr/local/lib/python3.10/dist-p
ackages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//
colab_requirements.txt (line 63)) (0.7.5)
Collecting Pillow==10.0.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 64))
  Downloading Pillow-10.0.0-cp310-cp310-manylinux_2_28_x86_64.whl.metadata (9.5 kB)
Collecting platformdirs==3.10.0 (from -r /content/drive/My Drive/CS6353/Assignments/a
ssignment2/assignment2//colab_requirements.txt (line 65))
  Downloading platformdirs-3.10.0-py3-none-any.whl.metadata (11 kB)
Collecting prometheus-client==0.17.1 (from -r /content/drive/My Drive/CS6353/Assignme
nts/assignment2/assignment2//colab_requirements.txt (line 66))
  Downloading prometheus_client-0.17.1-py3-none-any.whl.metadata (24 kB)
Collecting prompt-toolkit==3.0.39 (from -r /content/drive/My Drive/CS6353/Assignment
s/assignment2/assignment2//colab_requirements.txt (line 67))
  Downloading prompt_toolkit-3.0.39-py3-none-any.whl.metadata (6.4 kB)
Requirement already satisfied: psutil==5.9.5 in /usr/local/lib/python3.10/dist-packag
es (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab
_requirements.txt (line 68)) (5.9.5)
Requirement already satisfied: ptyprocess==0.7.0 in /usr/local/lib/python3.10/dist-pa
```

```
ckages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//c
olab_requirements.txt (line 69)) (0.7.0)
Collecting pure-eval==0.2.2 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 70))
  Downloading pure_eval-0.2.2-py3-none-any.whl.metadata (6.2 kB)
Collecting pycparser==2.21 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 71))
  Downloading pycparser-2.21-py2.py3-none-any.whl.metadata (1.1 kB)
Collecting Pygments==2.16.1 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 72))
  Downloading Pygments-2.16.1-py3-none-any.whl.metadata (2.5 kB)
Collecting pyparsing==3.0.9 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 73))
  Downloading pyparsing-3.0.9-py3-none-any.whl.metadata (4.2 kB)
Requirement already satisfied: python-dateutil==2.8.2 in /usr/local/lib/python3.10/di
st-packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignmen
t2//colab_requirements.txt (line 74)) (2.8.2)
Collecting python-json-logger==2.0.7 (from -r /content/drive/My Drive/CS6353/Assignme
nts/assignment2/assignment2//colab_requirements.txt (line 75))
  Downloading python_json_logger-2.0.7-py3-none-any.whl.metadata (6.5 kB)
Collecting pytz==2023.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignmen
t2/assignment2//colab_requirements.txt (line 76))
  Downloading pytz-2023.3-py2.py3-none-any.whl.metadata (22 kB)
Collecting PyYAML==6.0.1 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 77))
  Downloading PyYAML-6.0.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (2.1 kB)
Requirement already satisfied: pyzmq<25 in /usr/local/lib/python3.10/dist-packages (f
rom -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_requ
irements.txt (line 78)) (24.0.1)
Collecting referencing==0.30.2 (from -r /content/drive/My Drive/CS6353/Assignments/as
signment2/assignment2//colab_requirements.txt (line 79))
  Downloading referencing-0.30.2-py3-none-any.whl.metadata (2.6 kB)
Collecting requests==2.31.0 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 80))
  Downloading requests-2.31.0-py3-none-any.whl.metadata (4.6 kB)
Collecting rfc3339-validator==0.1.4 (from -r /content/drive/My Drive/CS6353/Assignmen
ts/assignment2/assignment2//colab_requirements.txt (line 81))
  Downloading rfc3339_validator-0.1.4-py2.py3-none-any.whl.metadata (1.5 kB)
Collecting rfc3986-validator==0.1.1 (from -r /content/drive/My Drive/CS6353/Assignmen
ts/assignment2/assignment2//colab_requirements.txt (line 82))
  Downloading rfc3986_validator-0.1.1-py2.py3-none-any.whl.metadata (1.7 kB)
Collecting rpds-py==0.9.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 83))
  Downloading rpds_py-0.9.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (3.7 kB)
Collecting scipy==1.11.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignme
nt2/assignment2//colab_requirements.txt (line 84))
  Downloading scipy-1.11.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l.metadata (59 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 59.1/59.1 kB 2.9 MB/s eta 0:00:00
Collecting seaborn==0.12.2 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 85))
  Downloading seaborn-0.12.2-py3-none-any.whl.metadata (5.4 kB)
Collecting Send2Trash==1.8.2 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 86))
  Downloading Send2Trash-1.8.2-py3-none-any.whl.metadata (4.0 kB)
Requirement already satisfied: six==1.16.0 in /usr/local/lib/python3.10/dist-packages
(from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment2//colab_re
quirements.txt (line 87)) (1.16.0)
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Collecting sniffio==1.3.0 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 88))
  Downloading sniffio-1.3.0-py3-none-any.whl.metadata (3.6 kB)
Collecting soupsieve==2.4.1 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 89))
  Downloading soupsieve-2.4.1-py3-none-any.whl.metadata (4.7 kB)
Collecting stack-data==0.6.2 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 90))
  Downloading stack_data-0.6.2-py3-none-any.whl.metadata (18 kB)
Collecting terminado==0.17.1 (from -r /content/drive/My Drive/CS6353/Assignments/assi
gnment2/assignment2//colab_requirements.txt (line 91))
  Downloading terminado-0.17.1-py3-none-any.whl.metadata (5.9 kB)
Collecting tinycss2==1.2.1 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 92))
  Downloading tinycss2-1.2.1-py3-none-any.whl.metadata (3.0 kB)
Collecting tornado<=6.3.2 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 93))
  Downloading tornado-6.3.2-cp38-abi3-manylinux_2_5_x86_64.manylinux1_x86_64.manylinu
x_2_17_x86_64.manylinux2014_x86_64.whl.metadata (2.5 kB)
Collecting traitlets==5.9.0 (from -r /content/drive/My Drive/CS6353/Assignments/assig
nment2/assignment2//colab_requirements.txt (line 94))
  Downloading traitlets-5.9.0-py3-none-any.whl.metadata (10 kB)
Collecting tzdata==2023.3 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 95))
  Downloading tzdata-2023.3-py2.py3-none-any.whl.metadata (1.4 kB)
Collecting uri-template==1.3.0 (from -r /content/drive/My Drive/CS6353/Assignments/as
signment2/assignment2//colab_requirements.txt (line 96))
  Downloading uri_template-1.3.0-py3-none-any.whl.metadata (8.8 kB)
Collecting urllib3==2.0.4 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 97))
  Downloading urllib3-2.0.4-py3-none-any.whl.metadata (6.6 kB)
Collecting wcwidth==0.2.6 (from -r /content/drive/My Drive/CS6353/Assignments/assignm
ent2/assignment2//colab_requirements.txt (line 98))
  Downloading wcwidth-0.2.6-py2.py3-none-any.whl.metadata (11 kB)
Collecting webcolors==1.13 (from -r /content/drive/My Drive/CS6353/Assignments/assign
ment2/assignment2//colab_requirements.txt (line 99))
  Downloading webcolors-1.13-py3-none-any.whl.metadata (2.6 kB)
Requirement already satisfied: webencodings==0.5.1 in /usr/local/lib/python3.10/dist-
packages (from -r /content/drive/My Drive/CS6353/Assignments/assignment2/assignment
2//colab_requirements.txt (line 100)) (0.5.1)
Collecting websocket-client==1.6.2 (from -r /content/drive/My Drive/CS6353/Assignment
s/assignment2/assignment2//colab_requirements.txt (line 101))
  Downloading websocket_client-1.6.2-py3-none-any.whl.metadata (7.5 kB)
Requirement already satisfied: exceptiongroup in /usr/local/lib/python3.10/dist-packa
ges (from anyio==3.7.1->-r /content/drive/My Drive/CS6353/Assignments/assignment2/ass
ignment2//colab_requirements.txt (line 1)) (1.2.2)
Requirement already satisfied: typing-extensions>=4.0.0 in /usr/local/lib/python3.10/
dist-packages (from async-lru==2.0.4->-r /content/drive/My Drive/CS6353/Assignments/a
ssignment2/assignment2//colab_requirements.txt (line 7)) (4.12.2)
Collecting jupyter_client<8.0 (from -r /content/drive/My Drive/CS6353/Assignments/ass
ignment2/assignment2//colab_requirements.txt (line 39))
  Downloading jupyter_client-7.4.9-py3-none-any.whl.metadata (8.5 kB)
Requirement already satisfied: tomli in /usr/local/lib/python3.10/dist-packages (from
jupyterlab==4.0.5->-r /content/drive/My Drive/CS6353/Assignments/assignment2/assignme
nt2//colab_requirements.txt (line 43)) (2.0.1)
Requirement already satisfied: ipython-genutils in /usr/local/lib/python3.10/dist-pac
kages (from ipykernel<=5.5.6->-r /content/drive/My Drive/CS6353/Assignments/assignmen
t2/assignment2//colab_requirements.txt (line 28)) (0.2.0)
Requirement already satisfied: setuptools>=18.5 in /usr/local/lib/python3.10/dist-pac
kages (from ipython<=7.34.0->-r /content/drive/My Drive/CS6353/Assignments/assignment
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2/assignment2//colab_requirements.txt (line 29)) (71.0.4)
Requirement already satisfied: entrypoints in /usr/local/lib/python3.10/dist-packages
(from jupyter_client<8.0->-r /content/drive/My Drive/CS6353/Assignments/assignment2/a
ssignment2//colab_requirements.txt (line 39)) (0.4)
Downloading appnope-0.1.3-py2.py3-none-any.whl (4.4 kB)
Downloading arrow-1.2.3-py3-none-any.whl (66 kB)
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Downloading asttokens-2.2.1-py2.py3-none-any.whl (26 kB)
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Downloading Babel-2.12.1-py3-none-any.whl (10.1 MB)
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Downloading beautifulsoup4-4.12.2-py3-none-any.whl (142 kB)
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Downloading bleach-6.0.0-py3-none-any.whl (162 kB)
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Downloading certifi-2023.7.22-py3-none-any.whl (158 kB)
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Downloading cffi-1.15.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (4
41 kB)
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Downloading charset_normalizer-3.2.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_
x86_64.whl (201 kB)
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Downloading comm-0.1.4-py3-none-any.whl (6.6 kB)
Downloading contourpy-1.1.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.wh
l (300 kB)
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Downloading cycler-0.11.0-py3-none-any.whl (6.4 kB)
Downloading debugpy-1.6.7.post1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_6
4.whl (3.0 MB)
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Downloading executing-1.2.0-py2.py3-none-any.whl (24 kB)
Downloading fastjsonschema-2.18.0-py3-none-any.whl (23 kB)
Downloading fonttools-4.42.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.w
hl (4.5 MB)
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Downloading fqdn-1.5.1-py3-none-any.whl (9.1 kB)
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Downloading jedi-0.19.0-py2.py3-none-any.whl (1.6 MB)
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Downloading Jinja2-3.1.2-py3-none-any.whl (133 kB)
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Downloading json5-0.9.14-py2.py3-none-any.whl (19 kB)
Downloading jsonpointer-2.4-py2.py3-none-any.whl (7.8 kB)
Downloading jsonschema-4.19.0-py3-none-any.whl (83 kB)
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Downloading jsonschema_specifications-2023.7.1-py3-none-any.whl (17 kB)
Downloading jupyter_events-0.7.0-py3-none-any.whl (18 kB)
Downloading jupyter_lsp-2.2.0-py3-none-any.whl (65 kB)
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Downloading jupyter_core-5.3.1-py3-none-any.whl (93 kB)
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Downloading jupyter_server_terminals-0.4.4-py3-none-any.whl (13 kB)
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Downloading jupyterlab_pygments-0.2.2-py2.py3-none-any.whl (21 kB)
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hl (1.6 MB)
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Downloading MarkupSafe-2.1.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.w
hl (25 kB)
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hl (11.6 MB)
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Downloading matplotlib_inline-0.1.6-py3-none-any.whl (9.4 kB)
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Downloading nest_asyncio-1.5.7-py3-none-any.whl (5.3 kB)
Downloading notebook_shim-0.2.3-py3-none-any.whl (13 kB)
Downloading overrides-7.4.0-py3-none-any.whl (17 kB)
Downloading packaging-23.1-py3-none-any.whl (48 kB)
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Downloading pandocfilters-1.5.0-py2.py3-none-any.whl (8.7 kB)
Downloading parso-0.8.3-py2.py3-none-any.whl (100 kB)
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Downloading pexpect-4.8.0-py2.py3-none-any.whl (59 kB)
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Downloading prometheus_client-0.17.1-py3-none-any.whl (60 kB)
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Downloading pure_eval-0.2.2-py3-none-any.whl (11 kB)
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   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 118.7/118.7 kB 9.3 MB/s eta 0:00:00
Downloading Pygments-2.16.1-py3-none-any.whl (1.2 MB)
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Downloading pyparsing-3.0.9-py3-none-any.whl (98 kB)
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Downloading pytz-2023.3-py2.py3-none-any.whl (502 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 502.3/502.3 kB 29.5 MB/s eta 0:00:00
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(705 kB)
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Downloading referencing-0.30.2-py3-none-any.whl (25 kB)
Downloading requests-2.31.0-py3-none-any.whl (62 kB)
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Downloading rfc3339_validator-0.1.4-py2.py3-none-any.whl (3.5 kB)
Downloading rfc3986_validator-0.1.1-py2.py3-none-any.whl (4.2 kB)
Downloading rpds_py-0.9.2-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(1.2 MB)
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   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.2/1.2 MB 49.5 MB/s eta 0:00:00
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(36.3 MB)
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Downloading sniffio-1.3.0-py3-none-any.whl (10 kB)
Downloading soupsieve-2.4.1-py3-none-any.whl (36 kB)
Downloading stack_data-0.6.2-py3-none-any.whl (24 kB)
Downloading terminado-0.17.1-py3-none-any.whl (17 kB)
Downloading tinycss2-1.2.1-py3-none-any.whl (21 kB)
Downloading traitlets-5.9.0-py3-none-any.whl (117 kB)
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Downloading urllib3-2.0.4-py3-none-any.whl (123 kB)
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Downloading wcwidth-0.2.6-py2.py3-none-any.whl (29 kB)
Downloading webcolors-1.13-py3-none-any.whl (14 kB)
Downloading websocket_client-1.6.2-py3-none-any.whl (57 kB)
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Downloading numpy-1.23.5-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(17.1 MB)
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Downloading pandas-1.5.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(12.1 MB)
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Downloading tornado-6.3.2-cp38-abi3-manylinux_2_5_x86_64.manylinux1_x86_64.manylinux_
2_17_x86_64.manylinux2014_x86_64.whl (426 kB)
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Installing collected packages: wcwidth, pytz, pure-eval, json5, fastjsonschema, execu
ting, appnope, websocket-client, webcolors, urllib3, uri-template, tzdata, traitlets,
tornado, tinycss2, soupsieve, sniffio, Send2Trash, rpds-py, rfc3986-validator, rfc333
9-validator, PyYAML, python-json-logger, pyparsing, Pygments, pycparser, prompt-toolk
it, prometheus-client, platformdirs, Pillow, pexpect, parso, pandocfilters, packagin
g, overrides, numpy, nest-asyncio, mistune, MarkupSafe, kiwisolver, jupyterlab-pygmen
ts, jsonpointer, idna, fqdn, fonttools, debugpy, cycler, charset-normalizer, certifi,
bleach, Babel, attrs, async-lru, asttokens, terminado, stack-data, scipy, requests, r
eferencing, pandas, matplotlib-inline, jupyter_core, Jinja2, jedi, imageio, contourp
y, comm, cffi, beautifulsoup4, arrow, matplotlib, jupyter_server_terminals, jupyter_c
lient, jsonschema-specifications, isoduration, seaborn, jsonschema, nbformat, nbclien
t, jupyter-events, nbconvert, jupyter_server, notebook_shim, jupyterlab_server, jupyt
er-lsp, jupyterlab
  Attempting uninstall: wcwidth
    Found existing installation: wcwidth 0.2.13
    Uninstalling wcwidth-0.2.13:
      Successfully uninstalled wcwidth-0.2.13
  Attempting uninstall: pytz
    Found existing installation: pytz 2024.2
    Uninstalling pytz-2024.2:
      Successfully uninstalled pytz-2024.2
  Attempting uninstall: fastjsonschema
    Found existing installation: fastjsonschema 2.20.0
    Uninstalling fastjsonschema-2.20.0:
      Successfully uninstalled fastjsonschema-2.20.0
  Attempting uninstall: websocket-client
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```
  Found existing installation: websocket-client 1.8.0
  Uninstalling websocket-client-1.8.0:
    Successfully uninstalled websocket-client-1.8.0
Attempting uninstall: webcolors
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  Uninstalling webcolors-24.8.0:
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Attempting uninstall: urllib3
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Attempting uninstall: tzdata
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  Uninstalling tzdata-2024.1:
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Attempting uninstall: traitlets
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  Uninstalling traitlets-5.7.1:
    Successfully uninstalled traitlets-5.7.1
Attempting uninstall: tornado
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  Uninstalling tornado-6.3.3:
    Successfully uninstalled tornado-6.3.3
Attempting uninstall: tinycss2
  Found existing installation: tinycss2 1.3.0
  Uninstalling tinycss2-1.3.0:
    Successfully uninstalled tinycss2-1.3.0
Attempting uninstall: soupsieve
  Found existing installation: soupsieve 2.6
  Uninstalling soupsieve-2.6:
    Successfully uninstalled soupsieve-2.6
Attempting uninstall: sniffio
  Found existing installation: sniffio 1.3.1
  Uninstalling sniffio-1.3.1:
    Successfully uninstalled sniffio-1.3.1
Attempting uninstall: Send2Trash
  Found existing installation: Send2Trash 1.8.3
  Uninstalling Send2Trash-1.8.3:
    Successfully uninstalled Send2Trash-1.8.3
Attempting uninstall: rpds-py
  Found existing installation: rpds-py 0.20.0
  Uninstalling rpds-py-0.20.0:
    Successfully uninstalled rpds-py-0.20.0
Attempting uninstall: PyYAML
  Found existing installation: PyYAML 6.0.2
  Uninstalling PyYAML-6.0.2:
    Successfully uninstalled PyYAML-6.0.2
Attempting uninstall: pyparsing
  Found existing installation: pyparsing 3.1.4
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    Successfully uninstalled pyparsing-3.1.4
Attempting uninstall: Pygments
  Found existing installation: Pygments 2.18.0
  Uninstalling Pygments-2.18.0:
    Successfully uninstalled Pygments-2.18.0
Attempting uninstall: pycparser
  Found existing installation: pycparser 2.22
  Uninstalling pycparser-2.22:
    Successfully uninstalled pycparser-2.22
Attempting uninstall: prompt-toolkit
```

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    Found existing installation: prompt_toolkit 3.0.47
    Uninstalling prompt_toolkit-3.0.47:
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  Attempting uninstall: prometheus-client
    Found existing installation: prometheus_client 0.21.0
    Uninstalling prometheus_client-0.21.0:
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  Attempting uninstall: platformdirs
    Found existing installation: platformdirs 4.3.6
    Uninstalling platformdirs-4.3.6:
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  Attempting uninstall: Pillow
    Found existing installation: pillow 10.4.0
    Uninstalling pillow-10.4.0:
      Successfully uninstalled pillow-10.4.0
  Attempting uninstall: pexpect
    Found existing installation: pexpect 4.9.0
    Uninstalling pexpect-4.9.0:
      Successfully uninstalled pexpect-4.9.0
  Attempting uninstall: parso
    Found existing installation: parso 0.8.4
    Uninstalling parso-0.8.4:
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  Attempting uninstall: pandocfilters
    Found existing installation: pandocfilters 1.5.1
    Uninstalling pandocfilters-1.5.1:
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  Attempting uninstall: packaging
    Found existing installation: packaging 24.1
    Uninstalling packaging-24.1:
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  Attempting uninstall: numpy
    Found existing installation: numpy 1.26.4
    Uninstalling numpy-1.26.4:
      Successfully uninstalled numpy-1.26.4
  Attempting uninstall: nest-asyncio
    Found existing installation: nest-asyncio 1.6.0
    Uninstalling nest-asyncio-1.6.0:
      Successfully uninstalled nest-asyncio-1.6.0
  Attempting uninstall: mistune
    Found existing installation: mistune 0.8.4
    Uninstalling mistune-0.8.4:
      Successfully uninstalled mistune-0.8.4
  Attempting uninstall: MarkupSafe
    Found existing installation: MarkupSafe 2.1.5
    Uninstalling MarkupSafe-2.1.5:
      Successfully uninstalled MarkupSafe-2.1.5
  Attempting uninstall: kiwisolver
    Found existing installation: kiwisolver 1.4.7
    Uninstalling kiwisolver-1.4.7:
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  Attempting uninstall: jupyterlab-pygments
    Found existing installation: jupyterlab_pygments 0.3.0
    Uninstalling jupyterlab_pygments-0.3.0:
      Successfully uninstalled jupyterlab_pygments-0.3.0
  Attempting uninstall: idna
    Found existing installation: idna 3.10
    Uninstalling idna-3.10:
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  Attempting uninstall: fonttools
```

```
  Found existing installation: fonttools 4.53.1
  Uninstalling fonttools-4.53.1:
    Successfully uninstalled fonttools-4.53.1
Attempting uninstall: debugpy
  Found existing installation: debugpy 1.6.6
  Uninstalling debugpy-1.6.6:
    Successfully uninstalled debugpy-1.6.6
Attempting uninstall: cycler
  Found existing installation: cycler 0.12.1
  Uninstalling cycler-0.12.1:
    Successfully uninstalled cycler-0.12.1
Attempting uninstall: charset-normalizer
  Found existing installation: charset-normalizer 3.3.2
  Uninstalling charset-normalizer-3.3.2:
    Successfully uninstalled charset-normalizer-3.3.2
Attempting uninstall: certifi
  Found existing installation: certifi 2024.8.30
  Uninstalling certifi-2024.8.30:
    Successfully uninstalled certifi-2024.8.30
Attempting uninstall: bleach
  Found existing installation: bleach 6.1.0
  Uninstalling bleach-6.1.0:
    Successfully uninstalled bleach-6.1.0
Attempting uninstall: Babel
  Found existing installation: babel 2.16.0
  Uninstalling babel-2.16.0:
    Successfully uninstalled babel-2.16.0
Attempting uninstall: attrs
  Found existing installation: attrs 24.2.0
  Uninstalling attrs-24.2.0:
    Successfully uninstalled attrs-24.2.0
Attempting uninstall: terminado
  Found existing installation: terminado 0.18.1
  Uninstalling terminado-0.18.1:
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Attempting uninstall: scipy
  Found existing installation: scipy 1.13.1
  Uninstalling scipy-1.13.1:
    Successfully uninstalled scipy-1.13.1
Attempting uninstall: requests
  Found existing installation: requests 2.32.3
  Uninstalling requests-2.32.3:
    Successfully uninstalled requests-2.32.3
Attempting uninstall: referencing
  Found existing installation: referencing 0.35.1
  Uninstalling referencing-0.35.1:
    Successfully uninstalled referencing-0.35.1
Attempting uninstall: pandas
  Found existing installation: pandas 2.1.4
  Uninstalling pandas-2.1.4:
    Successfully uninstalled pandas-2.1.4
Attempting uninstall: matplotlib-inline
  Found existing installation: matplotlib-inline 0.1.7
  Uninstalling matplotlib-inline-0.1.7:
    Successfully uninstalled matplotlib-inline-0.1.7
Attempting uninstall: jupyter_core
  Found existing installation: jupyter_core 5.7.2
  Uninstalling jupyter_core-5.7.2:
    Successfully uninstalled jupyter_core-5.7.2
Attempting uninstall: Jinja2
```

```
    Found existing installation: Jinja2 3.1.4
    Uninstalling Jinja2-3.1.4:
      Successfully uninstalled Jinja2-3.1.4
  Attempting uninstall: imageio
    Found existing installation: imageio 2.35.1
    Uninstalling imageio-2.35.1:
      Successfully uninstalled imageio-2.35.1
  Attempting uninstall: contourpy
    Found existing installation: contourpy 1.3.0
    Uninstalling contourpy-1.3.0:
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  Attempting uninstall: cffi
    Found existing installation: cffi 1.17.1
    Uninstalling cffi-1.17.1:
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  Attempting uninstall: beautifulsoup4
    Found existing installation: beautifulsoup4 4.12.3
    Uninstalling beautifulsoup4-4.12.3:
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  Attempting uninstall: matplotlib
    Found existing installation: matplotlib 3.7.1
    Uninstalling matplotlib-3.7.1:
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  Attempting uninstall: jupyter_client
    Found existing installation: jupyter-client 6.1.12
    Uninstalling jupyter-client-6.1.12:
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  Attempting uninstall: jsonschema-specifications
    Found existing installation: jsonschema-specifications 2023.12.1
    Uninstalling jsonschema-specifications-2023.12.1:
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  Attempting uninstall: seaborn
    Found existing installation: seaborn 0.13.1
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  Attempting uninstall: jsonschema
    Found existing installation: jsonschema 4.23.0
    Uninstalling jsonschema-4.23.0:
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  Attempting uninstall: nbformat
    Found existing installation: nbformat 5.10.4
    Uninstalling nbformat-5.10.4:
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  Attempting uninstall: nbclient
    Found existing installation: nbclient 0.10.0
    Uninstalling nbclient-0.10.0:
      Successfully uninstalled nbclient-0.10.0
  Attempting uninstall: nbconvert
    Found existing installation: nbconvert 6.5.4
    Uninstalling nbconvert-6.5.4:
      Successfully uninstalled nbconvert-6.5.4
  Attempting uninstall: jupyter_server
    Found existing installation: jupyter-server 1.24.0
    Uninstalling jupyter-server-1.24.0:
      Successfully uninstalled jupyter-server-1.24.0
  Attempting uninstall: notebook_shim
    Found existing installation: notebook_shim 0.2.4
    Uninstalling notebook_shim-0.2.4:
      Successfully uninstalled notebook_shim-0.2.4
ERROR: pip's dependency resolver does not currently take into account all the package
```

```
s that are installed. This behaviour is the source of the following dependency confli
cts.
albucore 0.0.16 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatibl
e.
albumentations 1.4.15 requires numpy>=1.24.4, but you have numpy 1.23.5 which is inco
mpatible.
bigframes 1.18.0 requires numpy>=1.24.0, but you have numpy 1.23.5 which is incompati
ble.
bokeh 3.4.3 requires contourpy>=1.2, but you have contourpy 1.1.0 which is incompatib
le.
chex 0.1.86 requires numpy>=1.24.1, but you have numpy 1.23.5 which is incompatible.
cudf-cu12 24.4.1 requires pandas<2.2.2dev0,>=2.0, but you have pandas 1.5.3 which is
incompatible.
google-colab 1.0.0 requires pandas==2.1.4, but you have pandas 1.5.3 which is incompa
tible.
google-colab 1.0.0 requires requests==2.32.3, but you have requests 2.31.0 which is i
ncompatible.
google-colab 1.0.0 requires tornado==6.3.3, but you have tornado 6.3.2 which is incom
patible.
jax 0.4.33 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.
jaxlib 0.4.33 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatible.
mizani 0.11.4 requires pandas>=2.1.0, but you have pandas 1.5.3 which is incompatibl
e.
pandas-stubs 2.1.4.231227 requires numpy>=1.26.0; python_version < "3.13", but you ha
ve numpy 1.23.5 which is incompatible.
plotnine 0.13.6 requires pandas<3.0.0,>=2.1.0, but you have pandas 1.5.3 which is inc
ompatible.
scikit-image 0.24.0 requires imageio>=2.33, but you have imageio 2.31.1 which is inco
mpatible.
xarray 2024.9.0 requires numpy>=1.24, but you have numpy 1.23.5 which is incompatibl
e.
xarray 2024.9.0 requires pandas>=2.1, but you have pandas 1.5.3 which is incompatibl
e.
Successfully installed Babel-2.12.1 Jinja2-3.1.2 MarkupSafe-2.1.3 Pillow-10.0.0 PyYAM
L-6.0.1 Pygments-2.16.1 Send2Trash-1.8.2 appnope-0.1.3 arrow-1.2.3 asttokens-2.2.1 as
ync-lru-2.0.4 attrs-23.1.0 beautifulsoup4-4.12.2 bleach-6.0.0 certifi-2023.7.22 cffi-
1.15.1 charset-normalizer-3.2.0 comm-0.1.4 contourpy-1.1.0 cycler-0.11.0 debugpy-1.6.
7.post1 executing-1.2.0 fastjsonschema-2.18.0 fonttools-4.42.1 fqdn-1.5.1 idna-3.4 im
ageio-2.31.1 isoduration-20.11.0 jedi-0.19.0 json5-0.9.14 jsonpointer-2.4 jsonschema-
4.19.0 jsonschema-specifications-2023.7.1 jupyter-events-0.7.0 jupyter-lsp-2.2.0 jupy
ter_client-7.4.9 jupyter_core-5.3.1 jupyter_server-2.7.2 jupyter_server_terminals-0.
4.4 jupyterlab-4.0.5 jupyterlab-pygments-0.2.2 jupyterlab_server-2.24.0 kiwisolver-1.
4.5 matplotlib-3.7.2 matplotlib-inline-0.1.6 mistune-3.0.1 nbclient-0.8.0 nbconvert-
7.7.4 nbformat-5.9.2 nest-asyncio-1.5.7 notebook_shim-0.2.3 numpy-1.23.5 overrides-7.
4.0 packaging-23.1 pandas-1.5.3 pandocfilters-1.5.0 parso-0.8.3 pexpect-4.8.0 platfor
mdirs-3.10.0 prometheus-client-0.17.1 prompt-toolkit-3.0.39 pure-eval-0.2.2 pycparser
-2.21 pyparsing-3.0.9 python-json-logger-2.0.7 pytz-2023.3 referencing-0.30.2 request
s-2.31.0 rfc3339-validator-0.1.4 rfc3986-validator-0.1.1 rpds-py-0.9.2 scipy-1.11.2 s
eaborn-0.12.2 sniffio-1.3.0 soupsieve-2.4.1 stack-data-0.6.2 terminado-0.17.1 tinycss
2-1.2.1 tornado-6.3.2 traitlets-5.9.0 tzdata-2023.3 uri-template-1.3.0 urllib3-2.0.4
wcwidth-0.2.6 webcolors-1.13 websocket-client-1.6.2
```

Implementing a Neural Network

In this exercise we will develop a neural network with fully-connected layers to perform classification, and test it out on the CIFAR-10 dataset.

In [ ]:
```
# A bit of setup

from __future__ import print_function
import numpy as np
import matplotlib.pyplot as plt

from cs6353.classifiers.neural_net import TwoLayerNet


%matplotlib inline
plt.rcParams['figure.figsize'] = (10.0, 8.0) # set default size of plots
plt.rcParams['image.interpolation'] = 'nearest'
plt.rcParams['image.cmap'] = 'gray'

# for auto-reloading external modules
# see http://stackoverflow.com/questions/1907993/autoreload-of-modules-in-ipython
%load_ext autoreload
%autoreload 2

def rel_error(x, y):
    """ returns relative error """
    return np.max(np.abs(x - y) / (np.maximum(1e-8, np.abs(x) + np.abs(y))))
```

We will use the class `TwoLayerNet` in the file `cs6353/classifiers/neural_net.py` to represent instances of our network. The network parameters are stored in the instance variable `self.params` where keys are string parameter names and values are numpy arrays. Below, we initialize toy data and a toy model that we will use to develop your implementation.

In [ ]:
```
# Create a small net and some toy data to check your implementations.
# Note that we set the random seed for repeatable experiments.

input_size = 4
hidden_size = 10
num_classes = 3
num_inputs = 5

def init_toy_model():
    np.random.seed(0)
    return TwoLayerNet(input_size, hidden_size, num_classes, std=1e-1)

def init_toy_data():
    np.random.seed(1)
    X = 10 * np.random.randn(num_inputs, input_size)
    y = np.array([0, 1, 2, 2, 1])
    return X, y

net = init_toy_model()
X, y = init_toy_data()
```

Forward pass: compute scores

Open the file `cs6353/classifiers/neural_net.py` and look at the method `TwoLayerNet.loss`. This function is very similar to the loss functions you have written for the

SVM and Softmax exercises: It takes the data and weights and computes the class scores, the loss, and the gradients on the parameters.

Implement the first part of the forward pass which uses the weights and biases to compute the scores for all inputs.

In [ ]:
```
scores = net.loss(X)
print('Your scores:')
print(scores)
print()
print('correct scores:')
correct_scores = np.asarray([
  [-0.81233741, -1.27654624, -0.70335995],
  [-0.17129677, -1.18803311, -0.47310444],
  [-0.51590475, -1.01354314, -0.8504215 ],
  [-0.15419291, -0.48629638, -0.52901952],
  [-0.00618733, -0.12435261, -0.15226949]])
print(correct_scores)
print()

# The difference should be very small. We get < 1e-7
print('Difference between your scores and correct scores:')
print(np.sum(np.abs(scores - correct_scores)))
```

```
Your scores:
[[-0.81233741 -1.27654624 -0.70335995]
 [-0.17129677 -1.18803311 -0.47310444]
 [-0.51590475 -1.01354314 -0.8504215 ]
 [-0.15419291 -0.48629638 -0.52901952]
 [-0.00618733 -0.12435261 -0.15226949]]

correct scores:
[[-0.81233741 -1.27654624 -0.70335995]
 [-0.17129677 -1.18803311 -0.47310444]
 [-0.51590475 -1.01354314 -0.8504215 ]
 [-0.15419291 -0.48629638 -0.52901952]
 [-0.00618733 -0.12435261 -0.15226949]]

Difference between your scores and correct scores:
3.6802720745909845e-08
```

Forward pass: compute loss

In the same function, implement the second part that computes the data and regularization loss.

In [ ]:
```
loss, _ = net.loss(X, y, reg=0.05)
correct_loss = 1.30378789133

# should be very small, we get < 1e-12
print('Difference between your loss and correct loss:')
print(np.sum(np.abs(loss - correct_loss)))
```

```
Difference between your loss and correct loss:
1.7985612998927536e-13
```

Backward pass

Implement the rest of the function. This will compute the gradient of the loss with respect to the variables `W1`, `b1`, `W2`, and `b2`. Now that you (hopefully!) have a correctly implemented forward pass, you can debug your backward pass using a numeric gradient check:

In [ ]:
```
from cs6353.gradient_check import eval_numerical_gradient

# Use numeric gradient checking to check your implementation of the backward pass.
# If your implementation is correct, the difference between the numeric and
# analytic gradients should be less than 1e-8 for each of W1, W2, b1, and b2.

loss, grads = net.loss(X, y, reg=0.05)

# these should all be less than 1e-8 or so
for param_name in grads:
    f = lambda W: net.loss(X, y, reg=0.05)[0]
    param_grad_num = eval_numerical_gradient(f, net.params[param_name], verbose=False)
    print('%s max relative error: %e' % (param_name, rel_error(param_grad_num, grads[p
```

```
W2 max relative error: 3.440708e-09
b2 max relative error: 4.447625e-11
W1 max relative error: 3.561318e-09
b1 max relative error: 2.738421e-09
```

Train the network

To train the network we will use stochastic gradient descent (SGD), similar to the SVM and Softmax classifiers. Look at the function `TwoLayerNet.train` and fill in the missing sections to implement the training procedure. This should be very similar to the training procedure you used for the SVM and Softmax classifiers. You will also have to implement `TwoLayerNet.predict`, as the training process periodically performs prediction to keep track of accuracy over time while the network trains.

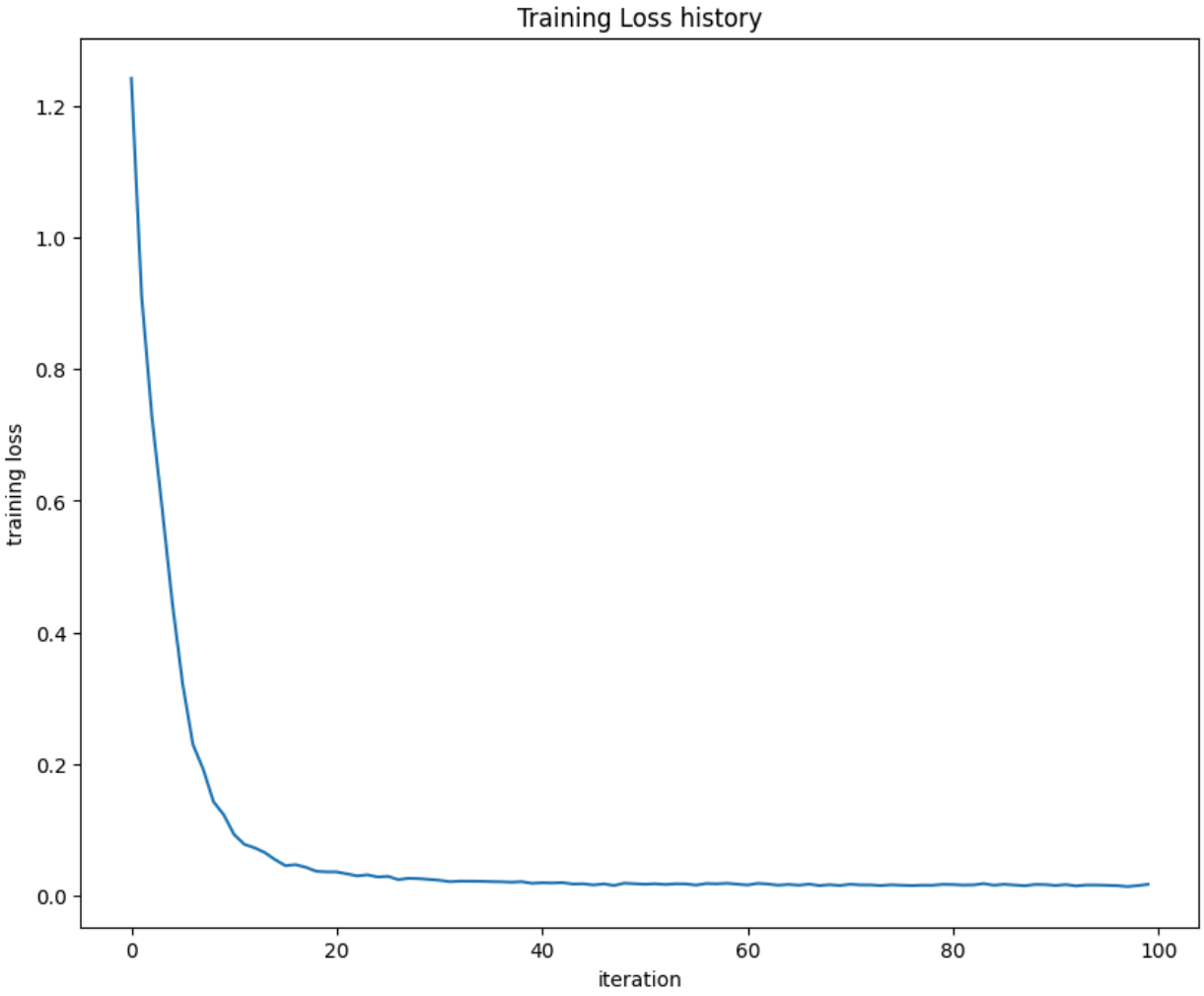
Once you have implemented the method, run the code below to train a two-layer network on toy data. You should achieve a training loss less than 0.2.

In [ ]:
```
net = init_toy_model()
stats = net.train(X, y, X, y,
            learning_rate=1e-1, reg=5e-6,
            num_iters=100, verbose=False)

print('Final training loss: ', stats['loss_history'][-1])

# plot the loss history
plt.plot(stats['loss_history'])
plt.xlabel('iteration')
plt.ylabel('training loss')
plt.title('Training Loss history')
plt.show()
```

```
Final training loss:  0.017149607938732093
```



Load the data

Now that you have implemented a two-layer network that passes gradient checks and works on toy data, it's time to load up our favorite CIFAR-10 data so we can use it to train a classifier on a real dataset.

In [ ]:

```
from cs6353.data_utils import load_CIFAR10

def get_CIFAR10_data(num_training=49000, num_validation=1000, num_test=1000):
    """
    Load the CIFAR-10 dataset from disk and perform preprocessing to prepare
    it for the two-layer neural net classifier. These are the same steps as
    we used for the SVM, but condensed to a single function.
    """
    # Load the raw CIFAR-10 data
    cifar10_dir = 'cs6353/datasets/cifar-10-batches-py'

    X_train, y_train, X_test, y_test = load_CIFAR10(cifar10_dir)

    # Subsample the data
    mask = list(range(num_training, num_training + num_validation))
    X_val = X_train[mask]
    y_val = y_train[mask]
```

```
    mask = list(range(num_training))
    X_train = X_train[mask]
    y_train = y_train[mask]
    mask = list(range(num_test))
    X_test = X_test[mask]
    y_test = y_test[mask]

    # Normalize the data: subtract the mean image
    mean_image = np.mean(X_train, axis=0)
    X_train -= mean_image
    X_val -= mean_image
    X_test -= mean_image

    # Reshape data to rows
    X_train = X_train.reshape(num_training, -1)
    X_val = X_val.reshape(num_validation, -1)
    X_test = X_test.reshape(num_test, -1)

    return X_train, y_train, X_val, y_val, X_test, y_test


# Cleaning up variables to prevent loading data multiple times (which may cause memory
try:
   del X_train, y_train
   del X_test, y_test
   print('Clear previously loaded data.')
except:
   pass

# Invoke the above function to get our data.
X_train, y_train, X_val, y_val, X_test, y_test = get_CIFAR10_data()
print('Train data shape: ', X_train.shape)
print('Train labels shape: ', y_train.shape)
print('Validation data shape: ', X_val.shape)
print('Validation labels shape: ', y_val.shape)
print('Test data shape: ', X_test.shape)
print('Test labels shape: ', y_test.shape)
```

```
Train data shape:  (49000, 3072)
Train labels shape:  (49000,)
Validation data shape:  (1000, 3072)
Validation labels shape:  (1000,)
Test data shape:  (1000, 3072)
Test labels shape:  (1000,)
```

Train a network

To train our network we will use SGD. In addition, we will adjust the learning rate with an exponential learning rate schedule as optimization proceeds; after each epoch, we will reduce the learning rate by multiplying it by a decay rate.

In [ ]:
```
input_size = 32 * 32 * 3
hidden_size = 50
num_classes = 10
net = TwoLayerNet(input_size, hidden_size, num_classes)

# Train the network
```

```
stats = net.train(X_train, y_train, X_val, y_val,
            num_iters=1000, batch_size=200,
            learning_rate=1e-4, learning_rate_decay=0.95,
            reg=0.25, verbose=True)

# Predict on the validation set
val_acc = (net.predict(X_val) == y_val).mean()
print('Validation accuracy: ', val_acc)
```

```
iteration 0 / 1000: loss 2.302954
iteration 100 / 1000: loss 2.302550
iteration 200 / 1000: loss 2.297648
iteration 300 / 1000: loss 2.259602
iteration 400 / 1000: loss 2.204170
iteration 500 / 1000: loss 2.118565
iteration 600 / 1000: loss 2.051535
iteration 700 / 1000: loss 1.988466
iteration 800 / 1000: loss 2.006591
iteration 900 / 1000: loss 1.951473
Validation accuracy:  0.287
```

Debug the training

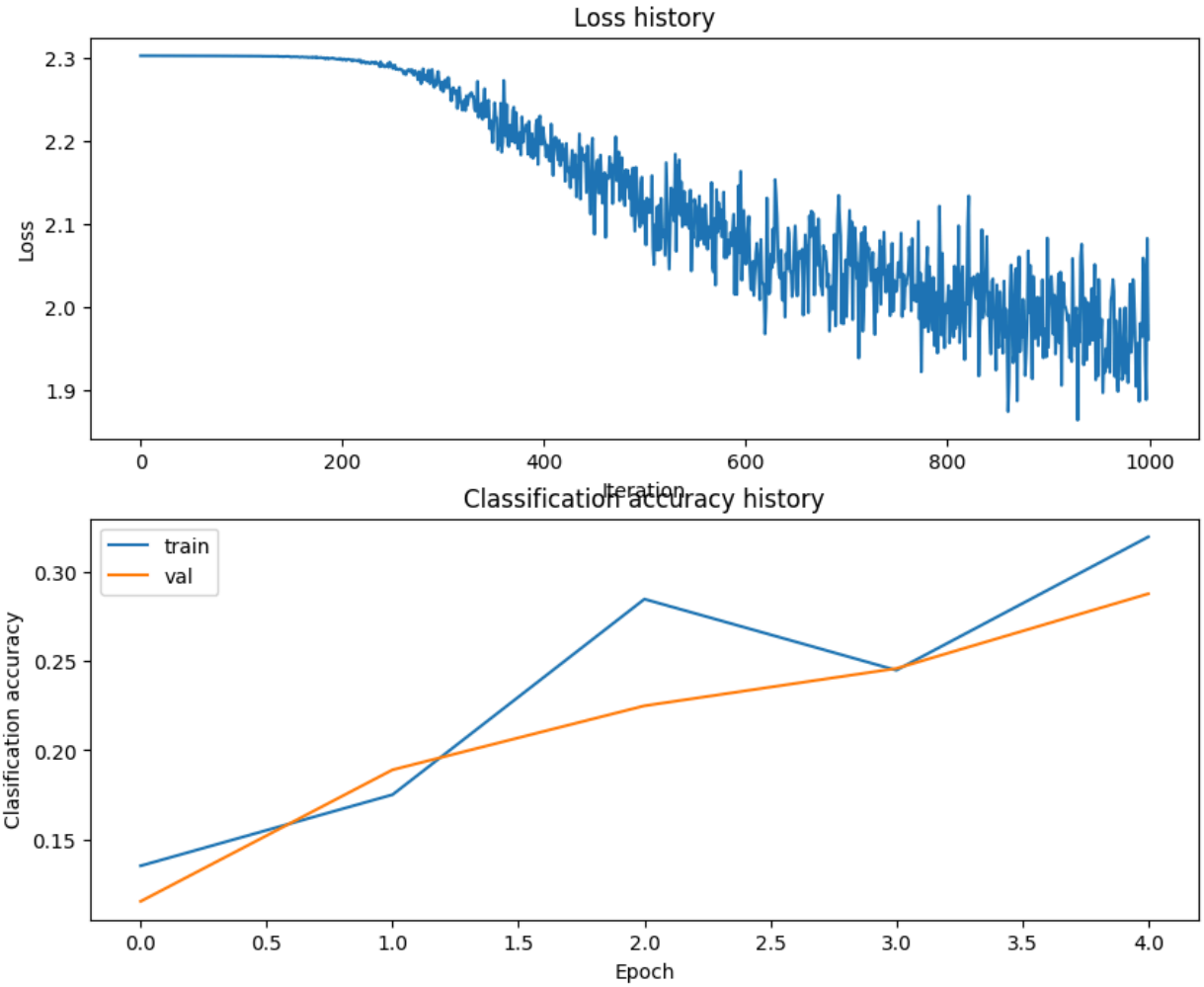
With the default parameters we provided above, you should get a validation accuracy of about 0.29 on the validation set. This isn't very good.

One strategy for getting insight into what's wrong is to plot the loss function and the accuracies on the training and validation sets during optimization.

Another strategy is to visualize the weights that were learned in the first layer of the network. In most neural networks trained on visual data, the first layer weights typically show some visible structure when visualized.

In [ ]:
```
# Plot the loss function and train / validation accuracies
plt.subplot(2, 1, 1)
plt.plot(stats['loss_history'])
plt.title('Loss history')
plt.xlabel('Iteration')
plt.ylabel('Loss')

plt.subplot(2, 1, 2)
plt.plot(stats['train_acc_history'], label='train')
plt.plot(stats['val_acc_history'], label='val')
plt.title('Classification accuracy history')
plt.xlabel('Epoch')
plt.ylabel('Clasification accuracy')
plt.legend()
plt.show()
```

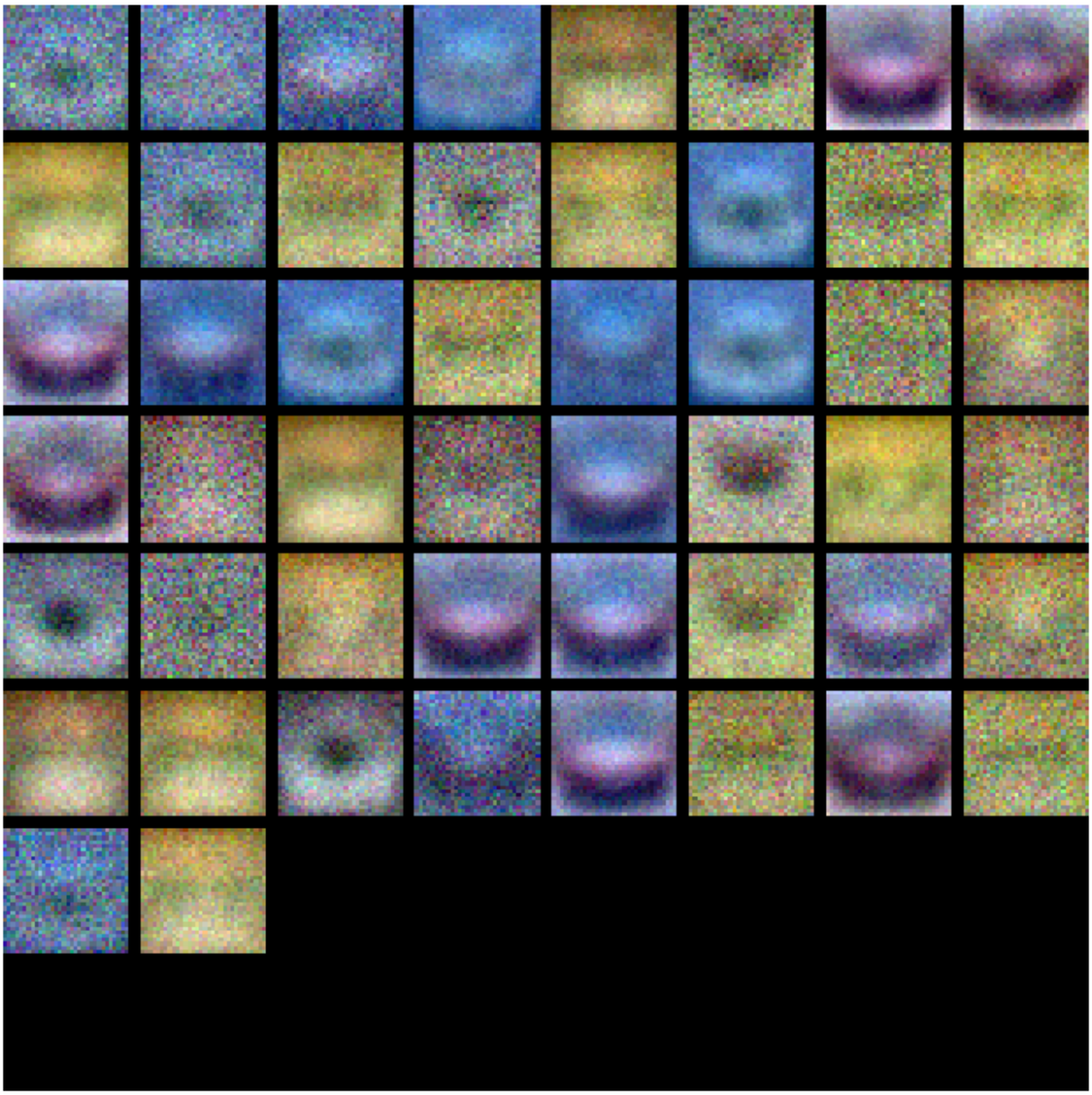


In [ ]:
```
from cs6353.vis_utils import visualize_grid

# Visualize the weights of the network

def show_net_weights(net):
    W1 = net.params['W1']
    W1 = W1.reshape(32, 32, 3, -1).transpose(3, 0, 1, 2)
    plt.imshow(visualize_grid(W1, padding=3).astype('uint8'))
    plt.gca().axis('off')
    plt.show()

show_net_weights(net)
```



Tune your hyperparameters

What's wrong?. Looking at the visualizations above, we see that the loss is decreasing more or less linearly, which seems to suggest that the learning rate may be too low. Moreover, there is no gap between the training and validation accuracy, suggesting that the model we used has low capacity, and that we should increase its size. On the other hand, with a very large model we would expect to see more overfitting, which would manifest itself as a very large gap between the training and validation accuracy.

Tuning. Tuning the hyperparameters and developing intuition for how they affect the final performance is a large part of using Neural Networks, so we want you to get a lot of practice. Below, you should experiment with different values of the various hyperparameters, including hidden layer size, learning rate, number of training epochs, and regularization strength. You

might also consider tuning the learning rate decay, but you should be able to get good performance using the default value.

Approximate results. You should be aim to achieve a classification accuracy of greater than 48% on the validation set. Our best network gets over 52% on the validation set.

Experiment: You goal in this exercise is to get as good of a result on CIFAR-10 as you can, with a fully-connected Neural Network. Feel free implement your own techniques (e.g. PCA to reduce dimensionality, or adding dropout, or adding features to the solver, etc.).

In [ ]:
```
best_net = None # store the best model into this

################################################################################
# TODO: Tune hyperparameters using the validation set. Store your best trained  #
# model in best_net.                                                            #
#                                                                               #
# To help debug your network, it may help to use visualizations similar to the  #
# ones we used above; these visualizations will have significant qualitative    #
# differences from the ones we saw above for the poorly tuned network.          #
#                                                                               #
# Tweaking hyperparameters by hand can be fun, but you might find it useful to  #
# write code to sweep through possible combinations of hyperparameters          #
# automatically like we did on the previous exercises.                          #
################################################################################
learning_rates = [1e-3, 2e-3]
regularization_strengths = [0.01, 0.05, 0.1, 0.2]
hidden_layer_sizes = [10, 50, 75, 100, 175]
num_of_epochs = [1500]
results = {}
best_val = -1
X_train, y_train, X_val, y_val, X_test, y_test = get_CIFAR10_data()


for lr in learning_rates:
    for reg in regularization_strengths:
      for hls in hidden_layer_sizes:
        for epochs in num_of_epochs:

          input_size = 32 * 32 * 3
          num_classes = 10
          net = TwoLayerNet(input_size, hls, num_classes)

          stats = net.train(X_train, y_train, X_val, y_val,
              num_iters=epochs, batch_size=200,
              learning_rate=lr, learning_rate_decay=0.95,
              reg=reg, verbose=True)

          y_train_pred = net.predict(X_train)
          y_val_pred = net.predict(X_val)

          train_acc = np.mean(y_train_pred == y_train)
          val_acc = np.mean(y_val_pred == y_val)


          results[(lr, reg, hls, epochs)] = (train_acc, val_acc)
          print(lr, reg, hls, epochs, train_acc, val_acc)
```

```
            if val_acc > best_val:
                best_val = val_acc
                best_net = net

for lr, reg, hls, epochs in sorted(results):
    train_accuracy, val_accuracy = results[(lr, reg, hls, epochs)]
    print('lr %e reg %e hidden_size %e num_training_epochs %e train accuracy: %f val a
           lr, reg, hls, epochs, train_accuracy, val_accuracy))

print('best validation accuracy achieved during cross-validation: %f' % best_val)
################################################################################
#                              END OF YOUR CODE                                #
################################################################################
```

```
iteration 0 / 1500: loss 2.302581
iteration 100 / 1500: loss 1.974147
iteration 200 / 1500: loss 1.825872
iteration 300 / 1500: loss 1.809073
iteration 400 / 1500: loss 1.829164
iteration 500 / 1500: loss 1.608163
iteration 600 / 1500: loss 1.788503
iteration 700 / 1500: loss 1.677658
iteration 800 / 1500: loss 1.636122
iteration 900 / 1500: loss 1.646538
iteration 1000 / 1500: loss 1.730433
iteration 1100 / 1500: loss 1.552284
iteration 1200 / 1500: loss 1.610167
iteration 1300 / 1500: loss 1.747374
iteration 1400 / 1500: loss 1.615684
0.001 0.01 10 1500 0.41981632653061224 0.405
iteration 0 / 1500: loss 2.302573
iteration 100 / 1500: loss 1.939704
iteration 200 / 1500: loss 1.653989
iteration 300 / 1500: loss 1.675380
iteration 400 / 1500: loss 1.629272
iteration 500 / 1500: loss 1.652488
iteration 600 / 1500: loss 1.521493
iteration 700 / 1500: loss 1.569525
iteration 800 / 1500: loss 1.408117
iteration 900 / 1500: loss 1.503961
iteration 1000 / 1500: loss 1.545182
iteration 1100 / 1500: loss 1.522084
iteration 1200 / 1500: loss 1.342073
iteration 1300 / 1500: loss 1.392764
iteration 1400 / 1500: loss 1.411536
0.001 0.01 50 1500 0.5157551020408163 0.478
iteration 0 / 1500: loss 2.302603
iteration 100 / 1500: loss 1.847776
iteration 200 / 1500: loss 1.834582
iteration 300 / 1500: loss 1.694456
iteration 400 / 1500: loss 1.613538
iteration 500 / 1500: loss 1.573353
iteration 600 / 1500: loss 1.646094
iteration 700 / 1500: loss 1.393890
iteration 800 / 1500: loss 1.561888
iteration 900 / 1500: loss 1.411730
iteration 1000 / 1500: loss 1.368661
iteration 1100 / 1500: loss 1.373301
iteration 1200 / 1500: loss 1.417317
iteration 1300 / 1500: loss 1.434986
iteration 1400 / 1500: loss 1.358610
0.001 0.01 75 1500 0.5349387755102041 0.494
iteration 0 / 1500: loss 2.302631
iteration 100 / 1500: loss 1.891271
iteration 200 / 1500: loss 1.841134
iteration 300 / 1500: loss 1.608803
iteration 400 / 1500: loss 1.745047
iteration 500 / 1500: loss 1.546296
iteration 600 / 1500: loss 1.540214
iteration 700 / 1500: loss 1.415954
iteration 800 / 1500: loss 1.533922
iteration 900 / 1500: loss 1.434874
iteration 1000 / 1500: loss 1.495634
iteration 1100 / 1500: loss 1.457333
```

```
iteration 1200 / 1500: loss 1.403894
iteration 1300 / 1500: loss 1.417297
iteration 1400 / 1500: loss 1.295456
0.001 0.01 100 1500 0.5325918367346939 0.488
iteration 0 / 1500: loss 2.302667
iteration 100 / 1500: loss 1.848674
iteration 200 / 1500: loss 1.697099
iteration 300 / 1500: loss 1.725101
iteration 400 / 1500: loss 1.560017
iteration 500 / 1500: loss 1.597732
iteration 600 / 1500: loss 1.532332
iteration 700 / 1500: loss 1.437468
iteration 800 / 1500: loss 1.467007
iteration 900 / 1500: loss 1.432513
iteration 1000 / 1500: loss 1.424042
iteration 1100 / 1500: loss 1.475901
iteration 1200 / 1500: loss 1.449034
iteration 1300 / 1500: loss 1.376109
iteration 1400 / 1500: loss 1.368243
0.001 0.01 175 1500 0.5448571428571428 0.479
iteration 0 / 1500: loss 2.302615
iteration 100 / 1500: loss 1.984518
iteration 200 / 1500: loss 1.871146
iteration 300 / 1500: loss 1.806074
iteration 400 / 1500: loss 1.644300
iteration 500 / 1500: loss 1.753788
iteration 600 / 1500: loss 1.669483
iteration 700 / 1500: loss 1.774881
iteration 800 / 1500: loss 1.796813
iteration 900 / 1500: loss 1.669230
iteration 1000 / 1500: loss 1.582772
iteration 1100 / 1500: loss 1.666023
iteration 1200 / 1500: loss 1.579431
iteration 1300 / 1500: loss 1.636563
iteration 1400 / 1500: loss 1.531957
0.001 0.05 10 1500 0.4174897959183673 0.393
iteration 0 / 1500: loss 2.302648
iteration 100 / 1500: loss 1.899407
iteration 200 / 1500: loss 1.826842
iteration 300 / 1500: loss 1.830116
iteration 400 / 1500: loss 1.626270
iteration 500 / 1500: loss 1.571816
iteration 600 / 1500: loss 1.623560
iteration 700 / 1500: loss 1.495094
iteration 800 / 1500: loss 1.465571
iteration 900 / 1500: loss 1.386988
iteration 1000 / 1500: loss 1.577928
iteration 1100 / 1500: loss 1.391478
iteration 1200 / 1500: loss 1.578307
iteration 1300 / 1500: loss 1.392800
iteration 1400 / 1500: loss 1.370366
0.001 0.05 50 1500 0.5179795918367347 0.495
iteration 0 / 1500: loss 2.302732
iteration 100 / 1500: loss 1.965302
iteration 200 / 1500: loss 1.866580
iteration 300 / 1500: loss 1.760200
iteration 400 / 1500: loss 1.597303
iteration 500 / 1500: loss 1.611230
iteration 600 / 1500: loss 1.594060
iteration 700 / 1500: loss 1.482644
```

```
iteration 800 / 1500: loss 1.459311
iteration 900 / 1500: loss 1.393259
iteration 1000 / 1500: loss 1.425219
iteration 1100 / 1500: loss 1.538297
iteration 1200 / 1500: loss 1.411221
iteration 1300 / 1500: loss 1.457041
iteration 1400 / 1500: loss 1.308681
0.001 0.05 75 1500 0.5263265306122449 0.478
iteration 0 / 1500: loss 2.302727
iteration 100 / 1500: loss 1.896443
iteration 200 / 1500: loss 1.786748
iteration 300 / 1500: loss 1.646337
iteration 400 / 1500: loss 1.582530
iteration 500 / 1500: loss 1.654073
iteration 600 / 1500: loss 1.554874
iteration 700 / 1500: loss 1.582179
iteration 800 / 1500: loss 1.504040
iteration 900 / 1500: loss 1.530995
iteration 1000 / 1500: loss 1.380532
iteration 1100 / 1500: loss 1.427156
iteration 1200 / 1500: loss 1.367041
iteration 1300 / 1500: loss 1.386233
iteration 1400 / 1500: loss 1.414279
0.001 0.05 100 1500 0.5405510204081633 0.497
iteration 0 / 1500: loss 2.302847
iteration 100 / 1500: loss 1.966210
iteration 200 / 1500: loss 1.674648
iteration 300 / 1500: loss 1.729593
iteration 400 / 1500: loss 1.574419
iteration 500 / 1500: loss 1.481668
iteration 600 / 1500: loss 1.368150
iteration 700 / 1500: loss 1.493285
iteration 800 / 1500: loss 1.412429
iteration 900 / 1500: loss 1.333159
iteration 1000 / 1500: loss 1.441580
iteration 1100 / 1500: loss 1.249393
iteration 1200 / 1500: loss 1.349668
iteration 1300 / 1500: loss 1.327294
iteration 1400 / 1500: loss 1.356886
0.001 0.05 175 1500 0.5495102040816326 0.497
iteration 0 / 1500: loss 2.302617
iteration 100 / 1500: loss 1.917738
iteration 200 / 1500: loss 1.851924
iteration 300 / 1500: loss 1.875052
iteration 400 / 1500: loss 1.806317
iteration 500 / 1500: loss 1.736647
iteration 600 / 1500: loss 1.591002
iteration 700 / 1500: loss 1.720169
iteration 800 / 1500: loss 1.754130
iteration 900 / 1500: loss 1.633410
iteration 1000 / 1500: loss 1.710909
iteration 1100 / 1500: loss 1.708574
iteration 1200 / 1500: loss 1.554480
iteration 1300 / 1500: loss 1.648432
iteration 1400 / 1500: loss 1.567624
0.001 0.1 10 1500 0.4213265306122449 0.417
iteration 0 / 1500: loss 2.302718
iteration 100 / 1500: loss 1.841435
iteration 200 / 1500: loss 1.860598
iteration 300 / 1500: loss 1.603514
```

```
iteration 400 / 1500: loss 1.618434
iteration 500 / 1500: loss 1.584280
iteration 600 / 1500: loss 1.585440
iteration 700 / 1500: loss 1.693593
iteration 800 / 1500: loss 1.336018
iteration 900 / 1500: loss 1.612018
iteration 1000 / 1500: loss 1.462693
iteration 1100 / 1500: loss 1.392181
iteration 1200 / 1500: loss 1.390081
iteration 1300 / 1500: loss 1.335786
iteration 1400 / 1500: loss 1.398952
0.001 0.1 50 1500 0.5190204081632653 0.481
iteration 0 / 1500: loss 2.302791
iteration 100 / 1500: loss 1.917598
iteration 200 / 1500: loss 1.704846
iteration 300 / 1500: loss 1.706951
iteration 400 / 1500: loss 1.648095
iteration 500 / 1500: loss 1.481745
iteration 600 / 1500: loss 1.570443
iteration 700 / 1500: loss 1.376391
iteration 800 / 1500: loss 1.520935
iteration 900 / 1500: loss 1.539532
iteration 1000 / 1500: loss 1.446267
iteration 1100 / 1500: loss 1.448221
iteration 1200 / 1500: loss 1.573629
iteration 1300 / 1500: loss 1.329988
iteration 1400 / 1500: loss 1.447993
0.001 0.1 75 1500 0.5269183673469388 0.498
iteration 0 / 1500: loss 2.302895
iteration 100 / 1500: loss 1.907553
iteration 200 / 1500: loss 1.702193
iteration 300 / 1500: loss 1.703395
iteration 400 / 1500: loss 1.717506
iteration 500 / 1500: loss 1.478786
iteration 600 / 1500: loss 1.542609
iteration 700 / 1500: loss 1.496846
iteration 800 / 1500: loss 1.526187
iteration 900 / 1500: loss 1.516049
iteration 1000 / 1500: loss 1.536404
iteration 1100 / 1500: loss 1.527520
iteration 1200 / 1500: loss 1.461063
iteration 1300 / 1500: loss 1.367854
iteration 1400 / 1500: loss 1.506590
0.001 0.1 100 1500 0.5365102040816326 0.507
iteration 0 / 1500: loss 2.303150
iteration 100 / 1500: loss 1.885639
iteration 200 / 1500: loss 1.813416
iteration 300 / 1500: loss 1.666411
iteration 400 / 1500: loss 1.612956
iteration 500 / 1500: loss 1.676996
iteration 600 / 1500: loss 1.599660
iteration 700 / 1500: loss 1.481737
iteration 800 / 1500: loss 1.528940
iteration 900 / 1500: loss 1.540344
iteration 1000 / 1500: loss 1.607985
iteration 1100 / 1500: loss 1.354850
iteration 1200 / 1500: loss 1.434934
iteration 1300 / 1500: loss 1.355213
iteration 1400 / 1500: loss 1.407208
0.001 0.1 175 1500 0.5428775510204081 0.489
```

```
iteration 0 / 1500: loss 2.302650
iteration 100 / 1500: loss 2.018231
iteration 200 / 1500: loss 1.856572
iteration 300 / 1500: loss 1.741457
iteration 400 / 1500: loss 1.780761
iteration 500 / 1500: loss 1.731473
iteration 600 / 1500: loss 1.710156
iteration 700 / 1500: loss 1.703554
iteration 800 / 1500: loss 1.688609
iteration 900 / 1500: loss 1.661758
iteration 1000 / 1500: loss 1.770494
iteration 1100 / 1500: loss 1.707810
iteration 1200 / 1500: loss 1.653869
iteration 1300 / 1500: loss 1.697022
iteration 1400 / 1500: loss 1.798931
0.001 0.2 10 1500 0.4159591836734694 0.425
iteration 0 / 1500: loss 2.302897
iteration 100 / 1500: loss 1.995605
iteration 200 / 1500: loss 1.868293
iteration 300 / 1500: loss 1.733241
iteration 400 / 1500: loss 1.559577
iteration 500 / 1500: loss 1.638549
iteration 600 / 1500: loss 1.636789
iteration 700 / 1500: loss 1.582128
iteration 800 / 1500: loss 1.404489
iteration 900 / 1500: loss 1.597191
iteration 1000 / 1500: loss 1.374982
iteration 1100 / 1500: loss 1.451304
iteration 1200 / 1500: loss 1.534912
iteration 1300 / 1500: loss 1.494886
iteration 1400 / 1500: loss 1.464489
0.001 0.2 50 1500 0.5098571428571429 0.488
iteration 0 / 1500: loss 2.303066
iteration 100 / 1500: loss 1.877479
iteration 200 / 1500: loss 1.714940
iteration 300 / 1500: loss 1.709760
iteration 400 / 1500: loss 1.646792
iteration 500 / 1500: loss 1.508114
iteration 600 / 1500: loss 1.543537
iteration 700 / 1500: loss 1.528517
iteration 800 / 1500: loss 1.441495
iteration 900 / 1500: loss 1.487699
iteration 1000 / 1500: loss 1.485014
iteration 1100 / 1500: loss 1.560177
iteration 1200 / 1500: loss 1.313585
iteration 1300 / 1500: loss 1.475316
iteration 1400 / 1500: loss 1.410356
0.001 0.2 75 1500 0.5180204081632653 0.513
iteration 0 / 1500: loss 2.303239
iteration 100 / 1500: loss 1.976057
iteration 200 / 1500: loss 1.809361
iteration 300 / 1500: loss 1.703631
iteration 400 / 1500: loss 1.640818
iteration 500 / 1500: loss 1.573741
iteration 600 / 1500: loss 1.509390
iteration 700 / 1500: loss 1.654938
iteration 800 / 1500: loss 1.464060
iteration 900 / 1500: loss 1.473062
iteration 1000 / 1500: loss 1.635358
iteration 1100 / 1500: loss 1.414466
```

```
iteration 1200 / 1500: loss 1.515283
iteration 1300 / 1500: loss 1.471828
iteration 1400 / 1500: loss 1.539441
0.001 0.2 100 1500 0.5273061224489796 0.491
iteration 0 / 1500: loss 2.303660
iteration 100 / 1500: loss 1.951181
iteration 200 / 1500: loss 1.703394
iteration 300 / 1500: loss 1.710064
iteration 400 / 1500: loss 1.624007
iteration 500 / 1500: loss 1.541224
iteration 600 / 1500: loss 1.593130
iteration 700 / 1500: loss 1.616081
iteration 800 / 1500: loss 1.523449
iteration 900 / 1500: loss 1.544994
iteration 1000 / 1500: loss 1.505442
iteration 1100 / 1500: loss 1.393242
iteration 1200 / 1500: loss 1.613921
iteration 1300 / 1500: loss 1.345963
iteration 1400 / 1500: loss 1.427957
0.001 0.2 175 1500 0.542530612244898 0.503
iteration 0 / 1500: loss 2.302586
iteration 100 / 1500: loss 1.936013
iteration 200 / 1500: loss 1.755611
iteration 300 / 1500: loss 1.622788
iteration 400 / 1500: loss 1.752205
iteration 500 / 1500: loss 1.800847
iteration 600 / 1500: loss 1.715860
iteration 700 / 1500: loss 1.652939
iteration 800 / 1500: loss 1.733479
iteration 900 / 1500: loss 1.613664
iteration 1000 / 1500: loss 1.691526
iteration 1100 / 1500: loss 1.625219
iteration 1200 / 1500: loss 1.715489
iteration 1300 / 1500: loss 1.786024
iteration 1400 / 1500: loss 1.800226
0.002 0.01 10 1500 0.4246122448979592 0.422
iteration 0 / 1500: loss 2.302588
iteration 100 / 1500: loss 1.679137
iteration 200 / 1500: loss 1.630740
iteration 300 / 1500: loss 1.661055
iteration 400 / 1500: loss 1.610664
iteration 500 / 1500: loss 1.483693
iteration 600 / 1500: loss 1.500198
iteration 700 / 1500: loss 1.481397
iteration 800 / 1500: loss 1.338846
iteration 900 / 1500: loss 1.473960
iteration 1000 / 1500: loss 1.355679
iteration 1100 / 1500: loss 1.369272
iteration 1200 / 1500: loss 1.408348
iteration 1300 / 1500: loss 1.371862
iteration 1400 / 1500: loss 1.186500
0.002 0.01 50 1500 0.517265306122449 0.469
iteration 0 / 1500: loss 2.302636
iteration 100 / 1500: loss 1.842706
iteration 200 / 1500: loss 1.633716
iteration 300 / 1500: loss 1.693347
iteration 400 / 1500: loss 1.457477
iteration 500 / 1500: loss 1.627703
iteration 600 / 1500: loss 1.453924
iteration 700 / 1500: loss 1.417954
```

```
iteration 800 / 1500: loss 1.548755
iteration 900 / 1500: loss 1.461433
iteration 1000 / 1500: loss 1.583802
iteration 1100 / 1500: loss 1.376772
iteration 1200 / 1500: loss 1.404984
iteration 1300 / 1500: loss 1.330388
iteration 1400 / 1500: loss 1.407420
0.002 0.01 75 1500 0.517673469387755 0.477
iteration 0 / 1500: loss 2.302608
iteration 100 / 1500: loss 1.868025
iteration 200 / 1500: loss 1.804395
iteration 300 / 1500: loss 1.536416
iteration 400 / 1500: loss 1.633291
iteration 500 / 1500: loss 1.572034
iteration 600 / 1500: loss 1.486844
iteration 700 / 1500: loss 1.302225
iteration 800 / 1500: loss 1.537931
iteration 900 / 1500: loss 1.487552
iteration 1000 / 1500: loss 1.450825
iteration 1100 / 1500: loss 1.414719
iteration 1200 / 1500: loss 1.431065
iteration 1300 / 1500: loss 1.364014
iteration 1400 / 1500: loss 1.233104
0.002 0.01 100 1500 0.5637142857142857 0.506
iteration 0 / 1500: loss 2.302644
iteration 100 / 1500: loss 1.742485
iteration 200 / 1500: loss 1.827878
iteration 300 / 1500: loss 1.612123
iteration 400 / 1500: loss 1.633973
iteration 500 / 1500: loss 1.438447
iteration 600 / 1500: loss 1.668466
iteration 700 / 1500: loss 1.469488
iteration 800 / 1500: loss 1.363785
iteration 900 / 1500: loss 1.484550
iteration 1000 / 1500: loss 1.366088
iteration 1100 / 1500: loss 1.573756
iteration 1200 / 1500: loss 1.280131
iteration 1300 / 1500: loss 1.324836
iteration 1400 / 1500: loss 1.276357
0.002 0.01 175 1500 0.5568775510204081 0.481
iteration 0 / 1500: loss 2.302609
iteration 100 / 1500: loss 1.810241
iteration 200 / 1500: loss 1.797240
iteration 300 / 1500: loss 1.670123
iteration 400 / 1500: loss 1.743107
iteration 500 / 1500: loss 1.653194
iteration 600 / 1500: loss 1.561071
iteration 700 / 1500: loss 1.683172
iteration 800 / 1500: loss 1.683133
iteration 900 / 1500: loss 1.698611
iteration 1000 / 1500: loss 1.599151
iteration 1100 / 1500: loss 1.647735
iteration 1200 / 1500: loss 1.655624
iteration 1300 / 1500: loss 1.562890
iteration 1400 / 1500: loss 1.720932
0.002 0.05 10 1500 0.4134081632653061 0.406
iteration 0 / 1500: loss 2.302684
iteration 100 / 1500: loss 1.811452
iteration 200 / 1500: loss 1.659404
iteration 300 / 1500: loss 1.747122
```

```
iteration 400 / 1500: loss 1.544560
iteration 500 / 1500: loss 1.559885
iteration 600 / 1500: loss 1.626393
iteration 700 / 1500: loss 1.676859
iteration 800 / 1500: loss 1.510586
iteration 900 / 1500: loss 1.324762
iteration 1000 / 1500: loss 1.380596
iteration 1100 / 1500: loss 1.536937
iteration 1200 / 1500: loss 1.522462
iteration 1300 / 1500: loss 1.410302
iteration 1400 / 1500: loss 1.358331
0.002 0.05 50 1500 0.5162244897959184 0.479
iteration 0 / 1500: loss 2.302696
iteration 100 / 1500: loss 1.867827
iteration 200 / 1500: loss 1.669973
iteration 300 / 1500: loss 1.542844
iteration 400 / 1500: loss 1.583350
iteration 500 / 1500: loss 1.588674
iteration 600 / 1500: loss 1.535836
iteration 700 / 1500: loss 1.568247
iteration 800 / 1500: loss 1.555164
iteration 900 / 1500: loss 1.457909
iteration 1000 / 1500: loss 1.454219
iteration 1100 / 1500: loss 1.371683
iteration 1200 / 1500: loss 1.487892
iteration 1300 / 1500: loss 1.415991
iteration 1400 / 1500: loss 1.340583
0.002 0.05 75 1500 0.5375510204081633 0.489
iteration 0 / 1500: loss 2.302787
iteration 100 / 1500: loss 1.892947
iteration 200 / 1500: loss 1.635978
iteration 300 / 1500: loss 1.646842
iteration 400 / 1500: loss 1.534368
iteration 500 / 1500: loss 1.545403
iteration 600 / 1500: loss 1.375824
iteration 700 / 1500: loss 1.549551
iteration 800 / 1500: loss 1.477621
iteration 900 / 1500: loss 1.435314
iteration 1000 / 1500: loss 1.391520
iteration 1100 / 1500: loss 1.473445
iteration 1200 / 1500: loss 1.516047
iteration 1300 / 1500: loss 1.259968
iteration 1400 / 1500: loss 1.312495
0.002 0.05 100 1500 0.5521020408163265 0.485
iteration 0 / 1500: loss 2.302870
iteration 100 / 1500: loss 1.873280
iteration 200 / 1500: loss 1.767165
iteration 300 / 1500: loss 1.650776
iteration 400 / 1500: loss 1.430998
iteration 500 / 1500: loss 1.497013
iteration 600 / 1500: loss 1.558588
iteration 700 / 1500: loss 1.475155
iteration 800 / 1500: loss 1.466894
iteration 900 / 1500: loss 1.460159
iteration 1000 / 1500: loss 1.316684
iteration 1100 / 1500: loss 1.356986
iteration 1200 / 1500: loss 1.472925
iteration 1300 / 1500: loss 1.425580
iteration 1400 / 1500: loss 1.333032
0.002 0.05 175 1500 0.5592857142857143 0.503
```

```
iteration 0 / 1500: loss 2.302612
iteration 100 / 1500: loss 1.962913
iteration 200 / 1500: loss 1.808733
iteration 300 / 1500: loss 1.878951
iteration 400 / 1500: loss 1.672078
iteration 500 / 1500: loss 1.762464
iteration 600 / 1500: loss 1.743507
iteration 700 / 1500: loss 1.651068
iteration 800 / 1500: loss 1.681621
iteration 900 / 1500: loss 1.563291
iteration 1000 / 1500: loss 1.687142
iteration 1100 / 1500: loss 1.567468
iteration 1200 / 1500: loss 1.637531
iteration 1300 / 1500: loss 1.742697
iteration 1400 / 1500: loss 1.639406
0.002 0.1 10 1500 0.42718367346938774 0.406
iteration 0 / 1500: loss 2.302753
iteration 100 / 1500: loss 1.827849
iteration 200 / 1500: loss 1.547716
iteration 300 / 1500: loss 1.523356
iteration 400 / 1500: loss 1.568197
iteration 500 / 1500: loss 1.607688
iteration 600 / 1500: loss 1.462818
iteration 700 / 1500: loss 1.763992
iteration 800 / 1500: loss 1.476784
iteration 900 / 1500: loss 1.549522
iteration 1000 / 1500: loss 1.468769
iteration 1100 / 1500: loss 1.385158
iteration 1200 / 1500: loss 1.494301
iteration 1300 / 1500: loss 1.491146
iteration 1400 / 1500: loss 1.336829
0.002 0.1 50 1500 0.5305102040816326 0.504
iteration 0 / 1500: loss 2.302799
iteration 100 / 1500: loss 1.769530
iteration 200 / 1500: loss 1.618694
iteration 300 / 1500: loss 1.578498
iteration 400 / 1500: loss 1.744103
iteration 500 / 1500: loss 1.518144
iteration 600 / 1500: loss 1.475301
iteration 700 / 1500: loss 1.607258
iteration 800 / 1500: loss 1.402574
iteration 900 / 1500: loss 1.651034
iteration 1000 / 1500: loss 1.413401
iteration 1100 / 1500: loss 1.466483
iteration 1200 / 1500: loss 1.483266
iteration 1300 / 1500: loss 1.339728
iteration 1400 / 1500: loss 1.412421
0.002 0.1 75 1500 0.5206938775510204 0.483
iteration 0 / 1500: loss 2.302903
iteration 100 / 1500: loss 1.705539
iteration 200 / 1500: loss 1.632057
iteration 300 / 1500: loss 1.637294
iteration 400 / 1500: loss 1.659235
iteration 500 / 1500: loss 1.461950
iteration 600 / 1500: loss 1.506024
iteration 700 / 1500: loss 1.522659
iteration 800 / 1500: loss 1.507466
iteration 900 / 1500: loss 1.639763
iteration 1000 / 1500: loss 1.619040
iteration 1100 / 1500: loss 1.600849
```

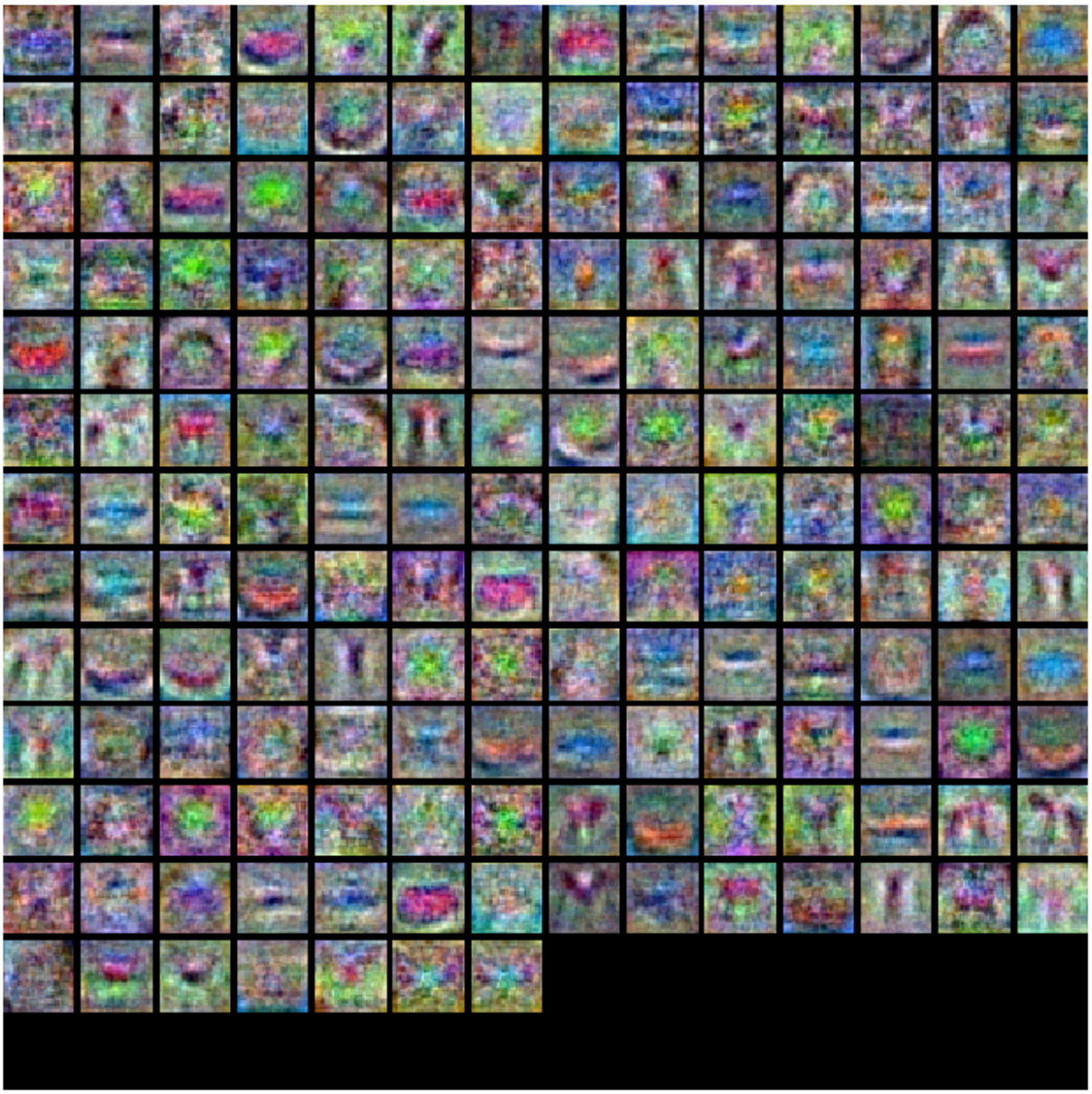
```
iteration 1200 / 1500: loss 1.304731
iteration 1300 / 1500: loss 1.346517
iteration 1400 / 1500: loss 1.325150
0.002 0.1 100 1500 0.5467142857142857 0.496
iteration 0 / 1500: loss 2.303174
iteration 100 / 1500: loss 1.755206
iteration 200 / 1500: loss 1.765400
iteration 300 / 1500: loss 1.551595
iteration 400 / 1500: loss 1.547892
iteration 500 / 1500: loss 1.487882
iteration 600 / 1500: loss 1.540200
iteration 700 / 1500: loss 1.536664
iteration 800 / 1500: loss 1.499859
iteration 900 / 1500: loss 1.480225
iteration 1000 / 1500: loss 1.545118
iteration 1100 / 1500: loss 1.448452
iteration 1200 / 1500: loss 1.412277
iteration 1300 / 1500: loss 1.500328
iteration 1400 / 1500: loss 1.453195
0.002 0.1 175 1500 0.5447755102040817 0.493
iteration 0 / 1500: loss 2.302655
iteration 100 / 1500: loss 1.833127
iteration 200 / 1500: loss 1.876331
iteration 300 / 1500: loss 1.813361
iteration 400 / 1500: loss 1.816237
iteration 500 / 1500: loss 1.697454
iteration 600 / 1500: loss 1.706733
iteration 700 / 1500: loss 1.608339
iteration 800 / 1500: loss 1.676824
iteration 900 / 1500: loss 1.750544
iteration 1000 / 1500: loss 1.647144
iteration 1100 / 1500: loss 1.625029
iteration 1200 / 1500: loss 1.714080
iteration 1300 / 1500: loss 1.729352
iteration 1400 / 1500: loss 1.754859
0.002 0.2 10 1500 0.42220408163265305 0.403
iteration 0 / 1500: loss 2.302890
iteration 100 / 1500: loss 1.745245
iteration 200 / 1500: loss 1.629616
iteration 300 / 1500: loss 1.639269
iteration 400 / 1500: loss 1.671483
iteration 500 / 1500: loss 1.554921
iteration 600 / 1500: loss 1.676845
iteration 700 / 1500: loss 1.627795
iteration 800 / 1500: loss 1.528215
iteration 900 / 1500: loss 1.557568
iteration 1000 / 1500: loss 1.552441
iteration 1100 / 1500: loss 1.495685
iteration 1200 / 1500: loss 1.427848
iteration 1300 / 1500: loss 1.704368
iteration 1400 / 1500: loss 1.481764
0.002 0.2 50 1500 0.5090204081632653 0.495
iteration 0 / 1500: loss 2.303092
iteration 100 / 1500: loss 1.787655
iteration 200 / 1500: loss 1.645438
iteration 300 / 1500: loss 1.621044
iteration 400 / 1500: loss 1.728610
iteration 500 / 1500: loss 1.548264
iteration 600 / 1500: loss 1.506396
iteration 700 / 1500: loss 1.517344
```

```
iteration 800 / 1500: loss 1.668029
iteration 900 / 1500: loss 1.520800
iteration 1000 / 1500: loss 1.510949
iteration 1100 / 1500: loss 1.594933
iteration 1200 / 1500: loss 1.344070
iteration 1300 / 1500: loss 1.471513
iteration 1400 / 1500: loss 1.557916
0.002 0.2 75 1500 0.5399183673469388 0.513
iteration 0 / 1500: loss 2.303173
iteration 100 / 1500: loss 1.698156
iteration 200 / 1500: loss 1.695287
iteration 300 / 1500: loss 1.515822
iteration 400 / 1500: loss 1.564219
iteration 500 / 1500: loss 1.485791
iteration 600 / 1500: loss 1.504949
iteration 700 / 1500: loss 1.473937
iteration 800 / 1500: loss 1.526825
iteration 900 / 1500: loss 1.483404
iteration 1000 / 1500: loss 1.530143
iteration 1100 / 1500: loss 1.457893
iteration 1200 / 1500: loss 1.588844
iteration 1300 / 1500: loss 1.538501
iteration 1400 / 1500: loss 1.450776
0.002 0.2 100 1500 0.5317142857142857 0.487
iteration 0 / 1500: loss 2.303691
iteration 100 / 1500: loss 1.759024
iteration 200 / 1500: loss 1.608597
iteration 300 / 1500: loss 1.734630
iteration 400 / 1500: loss 1.635697
iteration 500 / 1500: loss 1.599272
iteration 600 / 1500: loss 1.439598
iteration 700 / 1500: loss 1.572509
iteration 800 / 1500: loss 1.545757
iteration 900 / 1500: loss 1.560142
iteration 1000 / 1500: loss 1.447020
iteration 1100 / 1500: loss 1.504310
iteration 1200 / 1500: loss 1.674203
iteration 1300 / 1500: loss 1.345916
iteration 1400 / 1500: loss 1.273366
0.002 0.2 175 1500 0.547469387755102 0.526
lr 1.000000e-03 reg 1.000000e-02 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.419816 val accuracy: 0.405000
lr 1.000000e-03 reg 1.000000e-02 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.515755 val accuracy: 0.478000
lr 1.000000e-03 reg 1.000000e-02 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.534939 val accuracy: 0.494000
lr 1.000000e-03 reg 1.000000e-02 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.532592 val accuracy: 0.488000
lr 1.000000e-03 reg 1.000000e-02 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.544857 val accuracy: 0.479000
lr 1.000000e-03 reg 5.000000e-02 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.417490 val accuracy: 0.393000
lr 1.000000e-03 reg 5.000000e-02 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.517980 val accuracy: 0.495000
lr 1.000000e-03 reg 5.000000e-02 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.526327 val accuracy: 0.478000
lr 1.000000e-03 reg 5.000000e-02 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.540551 val accuracy: 0.497000
lr 1.000000e-03 reg 5.000000e-02 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.549510 val accuracy: 0.497000
```

```
lr 1.000000e-03 reg 1.000000e-01 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.421327 val accuracy: 0.417000
lr 1.000000e-03 reg 1.000000e-01 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.519020 val accuracy: 0.481000
lr 1.000000e-03 reg 1.000000e-01 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.526918 val accuracy: 0.498000
lr 1.000000e-03 reg 1.000000e-01 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.536510 val accuracy: 0.507000
lr 1.000000e-03 reg 1.000000e-01 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.542878 val accuracy: 0.489000
lr 1.000000e-03 reg 2.000000e-01 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.415959 val accuracy: 0.425000
lr 1.000000e-03 reg 2.000000e-01 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.509857 val accuracy: 0.488000
lr 1.000000e-03 reg 2.000000e-01 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.518020 val accuracy: 0.513000
lr 1.000000e-03 reg 2.000000e-01 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.527306 val accuracy: 0.491000
lr 1.000000e-03 reg 2.000000e-01 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.542531 val accuracy: 0.503000
lr 2.000000e-03 reg 1.000000e-02 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.424612 val accuracy: 0.422000
lr 2.000000e-03 reg 1.000000e-02 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.517265 val accuracy: 0.469000
lr 2.000000e-03 reg 1.000000e-02 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.517673 val accuracy: 0.477000
lr 2.000000e-03 reg 1.000000e-02 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.563714 val accuracy: 0.506000
lr 2.000000e-03 reg 1.000000e-02 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.556878 val accuracy: 0.481000
lr 2.000000e-03 reg 5.000000e-02 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.413408 val accuracy: 0.406000
lr 2.000000e-03 reg 5.000000e-02 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.516224 val accuracy: 0.479000
lr 2.000000e-03 reg 5.000000e-02 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.537551 val accuracy: 0.489000
lr 2.000000e-03 reg 5.000000e-02 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.552102 val accuracy: 0.485000
lr 2.000000e-03 reg 5.000000e-02 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.559286 val accuracy: 0.503000
lr 2.000000e-03 reg 1.000000e-01 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.427184 val accuracy: 0.406000
lr 2.000000e-03 reg 1.000000e-01 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.530510 val accuracy: 0.504000
lr 2.000000e-03 reg 1.000000e-01 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.520694 val accuracy: 0.483000
lr 2.000000e-03 reg 1.000000e-01 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.546714 val accuracy: 0.496000
lr 2.000000e-03 reg 1.000000e-01 hidden_size 1.750000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.544776 val accuracy: 0.493000
lr 2.000000e-03 reg 2.000000e-01 hidden_size 1.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.422204 val accuracy: 0.403000
lr 2.000000e-03 reg 2.000000e-01 hidden_size 5.000000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.509020 val accuracy: 0.495000
lr 2.000000e-03 reg 2.000000e-01 hidden_size 7.500000e+01 num_training_epochs 1.50000
0e+03 train accuracy: 0.539918 val accuracy: 0.513000
lr 2.000000e-03 reg 2.000000e-01 hidden_size 1.000000e+02 num_training_epochs 1.50000
0e+03 train accuracy: 0.531714 val accuracy: 0.487000
lr 2.000000e-03 reg 2.000000e-01 hidden_size 1.750000e+02 num_training_epochs 1.50000
```

```
0e+03 train accuracy: 0.547469 val accuracy: 0.526000
best validation accuracy achieved during cross-validation: 0.526000
```

In [ ]:
```
# visualize the weights of the best network
show_net_weights(best_net)
```



Run on the test set

When you are done experimenting, you should evaluate your final trained network on the test set; you should get above 48%.

In [ ]:
```
test_acc = (best_net.predict(X_test) == y_test).mean()
print('Test accuracy: ', test_acc)
```

```
Test accuracy:  0.514
```

Inline Question

Now that you have trained a Neural Network classifier, you may find that your testing accuracy is much lower than the training accuracy. In what ways can we decrease this gap? Select all that apply.

1. Train on a larger dataset.
2. Add more hidden units.
3. Increase the regularization strength.
4. None of the above.

Your answer: 1 and 3.

Your explanation:

1. Train on a larger dataset: Training on a larger dataset allows the model to generalize better, this is because it allows the model to see more diverse examples and prevents it form memorizing the training data or in other words it prevents the model from overfitting. This can reduce the gap between training and testing accuracy.

2. Add more hidden units: Increasing the number of hidden units increases the models complexity, this can allow the model to learn the noise in the dataset and in turn increase overfitting. Hence, this can increase the gap between the training and testing accuracy.

3. Increase the regularization strength: By increasing regularization, we reduce the models tendency to overfit by encouraging it to find simpler patterns in the dataset and therefore increase the models generalization capabilities. This can help decrease the gap between the training and testing accuracy.