iris

November 27, 2024

1 Bayesian Neural Network Classification on IRIS dataset

```
[ ]: import numpy as np
     from sklearn import datasets
     import torch
     import torch.nn as nn
     import torch.optim as optim
     import torchbnn as bnn
```

```
[1]: import matplotlib.pyplot as plt
     %matplotlib inline
```

1.1 1. Load Iris Data

```
[4]: iris = datasets.load_iris()
```

```
[5]: X = iris.data
     Y = iris.target
```

```
[31]: X
```

```
[31]: array([[5.1, 3.5, 1.4, 0.2],
             [4.9, 3. , 1.4, 0.2],
             [4.7, 3.2, 1.3, 0.2],
             [4.6, 3.1, 1.5, 0.2],
             [5. , 3.6, 1.4, 0.2],
             [5.4, 3.9, 1.7, 0.4],
             [4.6, 3.4, 1.4, 0.3],
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             [4.8, 3.4, 1.6, 0.2],
             [4.8, 3. , 1.4, 0.1],
             [4.3, 3. , 1.1, 0.1],
             [5.8, 4. , 1.2, 0.2],
             [5.7, 4.4, 1.5, 0.4],
             [5.4, 3.9, 1.3, 0.4],
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       [5.7, 3.8, 1.7, 0.3],
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       [5.1, 3.7, 1.5, 0.4],
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       [4.8, 3.4, 1.9, 0.2],
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       [5.2, 3.4, 1.4, 0.2],
       [4.7, 3.2, 1.6, 0.2],
       [4.8, 3.1, 1.6, 0.2],
       [5.4, 3.4, 1.5, 0.4],
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       [4.8, 3. , 1.4, 0.3],
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       [4.6, 3.2, 1.4, 0.2],
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       [5. , 3.3, 1.4, 0.2],
       [7. , 3.2, 4.7, 1.4],
       [6.4, 3.2, 4.5, 1.5],
       [6.9, 3.1, 4.9, 1.5],
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       [6.7, 3.1, 4.4, 1.4],
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       [6.4, 2.9, 4.3, 1.3],
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       [6.8, 2.8, 4.8, 1.4],
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       [6. , 2.9, 4.5, 1.5],
       [5.7, 2.6, 3.5, 1. ],
       [5.5, 2.4, 3.8, 1.1],
       [5.5, 2.4, 3.7, 1. ],
       [5.8, 2.7, 3.9, 1.2],
       [6. , 2.7, 5.1, 1.6],
       [5.4, 3. , 4.5, 1.5],
       [6. , 3.4, 4.5, 1.6],
       [6.7, 3.1, 4.7, 1.5],
       [6.3, 2.3, 4.4, 1.3],
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       [5.5, 2.5, 4. , 1.3],
       [5.5, 2.6, 4.4, 1.2],
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       [5.8, 2.6, 4. , 1.2],
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       [6.2, 2.9, 4.3, 1.3],
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       [7.6, 3. , 6.6, 2.1],
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       [6.7, 2.5, 5.8, 1.8],
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       [6.8, 3. , 5.5, 2.1],
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       [6.5, 3. , 5.5, 1.8],
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       [7.7, 2.6, 6.9, 2.3],
       [6. , 2.2, 5. , 1.5],
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       [6.3, 2.5, 5. , 1.9],
       [6.5, 3. , 5.2, 2. ],
       [6.2, 3.4, 5.4, 2.3],
       [5.9, 3. , 5.1, 1.8]])
```

[6]:
```
x, y = torch.from_numpy(X).float(), torch.from_numpy(Y).long()
x.shape, y.shape
```

[6]:
```
(torch.Size([150, 4]), torch.Size([150]))
```

[30]:
```
x
```

```
[30]: tensor([[5.1000, 3.5000, 1.4000, 0.2000],
              [4.9000, 3.0000, 1.4000, 0.2000],
              [4.7000, 3.2000, 1.3000, 0.2000],
              [4.6000, 3.1000, 1.5000, 0.2000],
              [5.0000, 3.6000, 1.4000, 0.2000],
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[6.7000, 3.1000, 5.6000, 2.4000],
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        [6.8000, 3.2000, 5.9000, 2.3000],
        [6.7000, 3.3000, 5.7000, 2.5000],
        [6.7000, 3.0000, 5.2000, 2.3000],
        [6.3000, 2.5000, 5.0000, 1.9000],
        [6.5000, 3.0000, 5.2000, 2.0000],
        [6.2000, 3.4000, 5.4000, 2.3000],
        [5.9000, 3.0000, 5.1000, 1.8000]])
```

```
[33]: #Train test split
      from sklearn.model_selection import train_test_split
      X = x
      X_train, X_test, y_train, y_test = train_test_split(X,y, test_size = 0.2,␣
       ↪random_state=41)
```

```
[38]: y_train
```

```
[38]: tensor([1, 1, 2, 1, 2, 0, 2, 1, 2, 1, 1, 1, 0, 2, 2, 0, 2, 1, 0, 1, 2, 1, 2, 0,
              0, 2, 2, 0, 1, 0, 0, 1, 0, 1, 2, 0, 1, 1, 2, 0, 1, 1, 0, 2, 1, 0, 2, 2,
              0, 1, 0, 0, 2, 2, 2, 0, 0, 0, 0, 0, 2, 2, 0, 2, 1, 0, 0, 2, 2, 2, 1, 1,
              2, 0, 1, 2, 1, 1, 0, 1, 0, 1, 0, 1, 2, 2, 2, 0, 0, 0, 0, 2, 0, 0, 1, 2,
              0, 2, 0, 1, 2, 1, 0, 2, 0, 1, 0, 2, 1, 1, 2, 1, 1, 2, 2, 0, 1, 1, 1, 2])
```

```
[34]: X_train.shape
```

```
[34]: torch.Size([120, 4])
```

```
[35]: X_test.shape
```

```
[35]: torch.Size([30, 4])
```

```
[41]: # Remove class 1 (out of classes 0, 1 and 2) from the train data
      X_train_filtered = X_train[y_train!=1]
      X_train_filtered.shape
```

```
[41]: torch.Size([81, 4])
```

```
[42]: y_train_filtered = y_train[y_train!=1]
      y_train_filtered.shape
```

```
[42]: torch.Size([81])
```

1.2 2. Define Model

[118]:

```
# model = nn.Sequential(
#     bnn.BayesLinear(prior_mu=0, prior_sigma=0.5, in_features=4,␣
 ↪out_features=8),
#     nn.ReLU(),
#     bnn.BayesLinear(prior_mu=0, prior_sigma=0.5, in_features=8,␣
 ↪out_features=9),
#     nn.ReLU(),
#     bnn.BayesLinear(prior_mu=0, prior_sigma=1, in_features=9, out_features=3)
# )

model = nn.Sequential(
    nn.Linear(in_features=4, out_features=8),
    nn.ReLU(),
    nn.Linear(in_features=8, out_features=9),
    nn.ReLU(),
    nn.Linear(in_features=9, out_features=3)
)
```

[119]:

```
ce_loss = nn.CrossEntropyLoss()
kl_loss = bnn.BKLLoss(reduction='mean', last_layer_only=False)

optimizer = optim.Adam(model.parameters(), lr=0.01)
```

1.3 3. Train Model

[ ]:

```
kl_weight = 0.0
filter_train = False
```

[122]:

```
#Train the model only on classes 0 and 2
for step in range(3000):
    pre = model(X_train)
    ce = ce_loss(pre, y_train)
    kl = kl_loss(model)
    cost = ce + kl_weight*kl

    optimizer.zero_grad()
    cost.backward()
    optimizer.step()

_, predicted = torch.max(pre.data, 1)
total = y_train.size(0)
correct = (predicted == y_train).sum()
print('- Accuracy: %f %%' % (100 * float(correct) / total))
print('- CE : %2.2f, KL : %2.2f' % (ce.item(), kl.item()))
```

```
- Accuracy: 100.000000 %
- CE : 0.00, KL : 0.00
```

```
[123]: for name, parameter in model.state_dict().items():
           print(name, parameter)
```

```
0.weight tensor([[-0.2525, -0.1950,  0.2696,  0.0260],
        [-0.0689, -0.1576, -0.7080, -0.6731],
        [-0.2594,  0.4185, -0.4825, -0.0513],
        [ 0.3598, -0.2508,  1.0308,  1.2364],
        [ 0.0680, -0.0781, -0.5002, -0.0210],
        [ 0.0039, -0.0609, -0.0455,  0.1205],
        [ 0.5498,  1.1914, -0.9266, -2.2827],
        [-0.3269, -0.7339,  0.7844,  1.7191]])
0.bias tensor([ 0.4471,  0.4178, -0.4209, -0.8103, -0.1197, -0.6919,  2.5408,
-2.4197])
2.weight tensor([[ 1.4378e-01,  5.9457e-01, -9.8407e-02, -4.4131e-01,
-2.2473e-01,
         -2.3250e-01,  3.4466e+00, -3.8154e+00],
        [-4.8422e-02,  3.4354e-01, -1.3934e-01, -8.8973e-01,  2.1324e-01,
         -1.7783e-01,  2.0284e+00, -7.2638e-01],
        [ 5.7522e-02, -1.4519e-01, -2.5984e-01, -3.0796e-02,  2.7233e-01,
          1.0703e-01, -3.0436e-01, -3.1306e-01],
        [-3.4683e-01, -3.8528e-01, -1.2821e-01, -1.3772e-01,  3.5216e-01,
         -2.0266e-01, -2.1372e-01, -5.9965e-02],
        [ 9.9056e-02,  4.8852e-02,  2.4655e-01, -7.5453e-02, -2.1781e-03,
         -8.3678e-02, -1.7942e-01,  1.9881e-01],
        [-1.5629e-01, -1.8789e-01,  2.3728e-01, -3.4595e-01,  2.0030e-01,
         -3.2549e-02, -1.7867e-01,  7.9373e-02],
        [ 5.3090e-03,  2.9234e-02, -2.8253e-01,  9.2919e-01,  7.8525e-03,
         -1.0951e-01, -1.3395e+00,  4.5823e-01],
        [-2.6670e-01, -5.5411e-02, -2.6654e-01, -6.9880e-01,  3.1762e-01,
         -7.7417e-02,  5.8403e-01, -1.9140e-01],
        [ 2.8441e-01,  4.9302e-01, -5.3000e-03, -6.3422e-01, -1.6039e-01,
         -1.1796e-01,  7.3667e-01, -7.8176e-01]])
2.bias tensor([ 2.2293,  1.1138, -0.3146,  0.1532, -0.4446,  0.1141,  0.5633,
0.4633,
        -0.0384])
4.weight tensor([[ 0.3736,  1.7545, -0.1023,  0.0898,  0.1476,  0.1561, -1.2670,
0.7360,
          0.4719],
        [ 2.1344, -2.1367,  0.2682,  0.1086, -0.0076, -0.1659, -0.4400, -0.2956,
         -0.2156],
        [-5.1444, -1.1858,  0.3262,  0.0439, -0.0967, -0.1496,  0.8538, -1.2980,
         -1.3593]])
4.bias tensor([-1.7292,  0.1276,  0.6161])
```

1.4 4. Test Model

[89]:
```
# Sample 10k models and store the results
n_models = 10000
models_result = [model(X_test) for k in range(n_models)]
```

[90]:
```
models_result[0][0].argmax().item()
```

[90]:
```
2
```

[91]:
```
results = np.zeros((n_models, 30))      # num. of models, number of test␣
  ↪datapoints
for i in range(n_models):
    for j in range(30):
        results[i][j] = models_result[i][j].argmax().item()
```

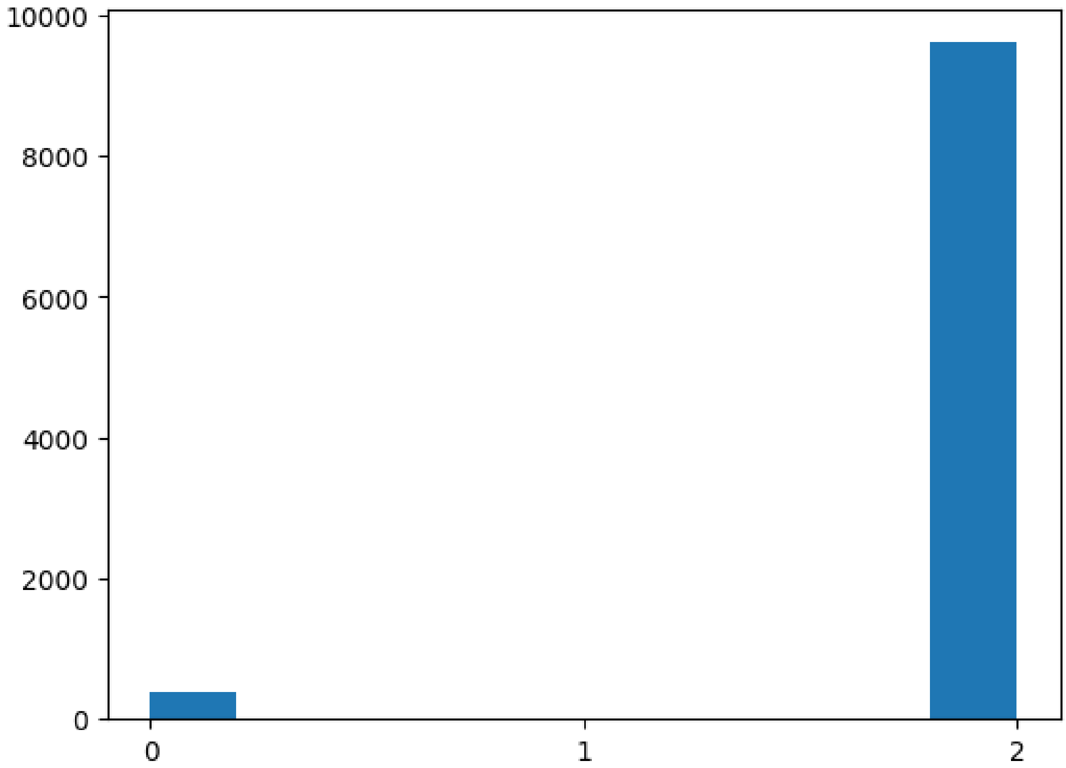
[99]:
```
np.argwhere(y_test==1)
```

[99]:
```
tensor([[ 3,  5,  7, 13, 17, 20, 24, 25, 26, 27, 29]])
```

[97]:
```
results[:,0]
```

[97]:
```
array([2., 2., 2., …, 2., 2., 2.])
```

[109]:
```
# Plotting histogram
plt.hist(results[:,13])
plt.xticks([0,1,2])
plt.show()
```

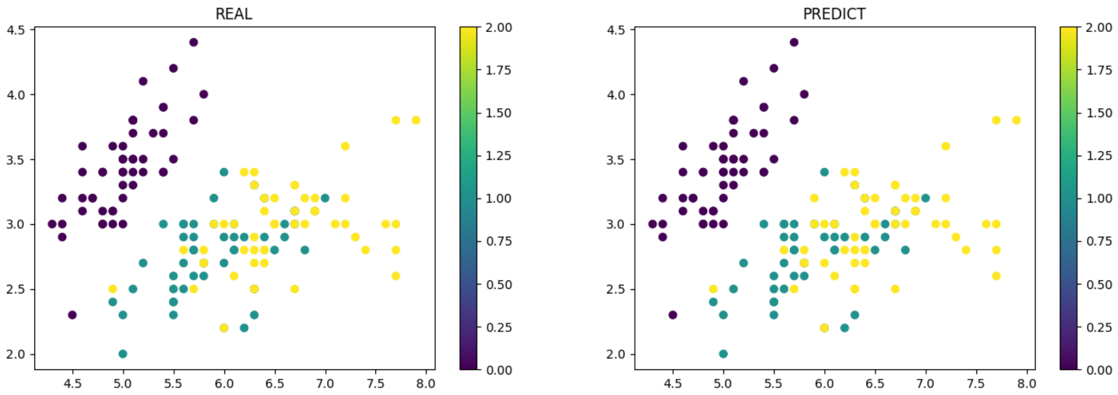


[11]:

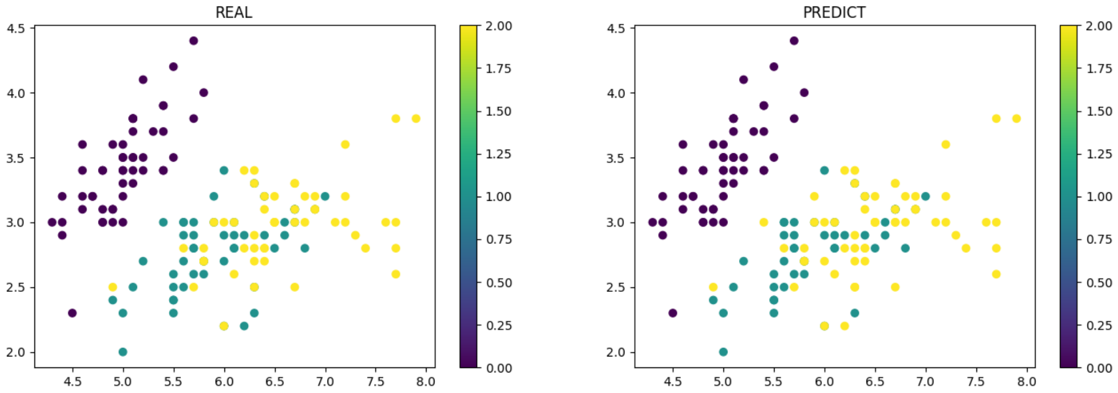
```python
def draw_plot(predicted) :
    fig = plt.figure(figsize = (16, 5))

    ax1 = fig.add_subplot(1, 2, 1)
    ax2 = fig.add_subplot(1, 2, 2)

    z1_plot = ax1.scatter(X[:, 0], X[:, 1], c = Y)
    z2_plot = ax2.scatter(X[:, 0], X[:, 1], c = predicted)

    plt.colorbar(z1_plot,ax=ax1)
    plt.colorbar(z2_plot,ax=ax2)

    ax1.set_title("REAL")
    ax2.set_title("PREDICT")

    plt.show()
```

[12]:

```python
pre = model(x)
_, predicted = torch.max(pre.data, 1)
draw_plot(predicted)
```



[27]:
```
# Bayesian Neural Network will return different outputs even if inputs are same.
# In other words, different plots will be shown every time forward method is␣
  ↪called.
pre = model(x)
_, predicted = torch.max(pre.data, 1)
draw_plot(predicted)
```



[ ]:
```
bnn.
```