NN_MarkusWiktorin_271117

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1 Assignment 8

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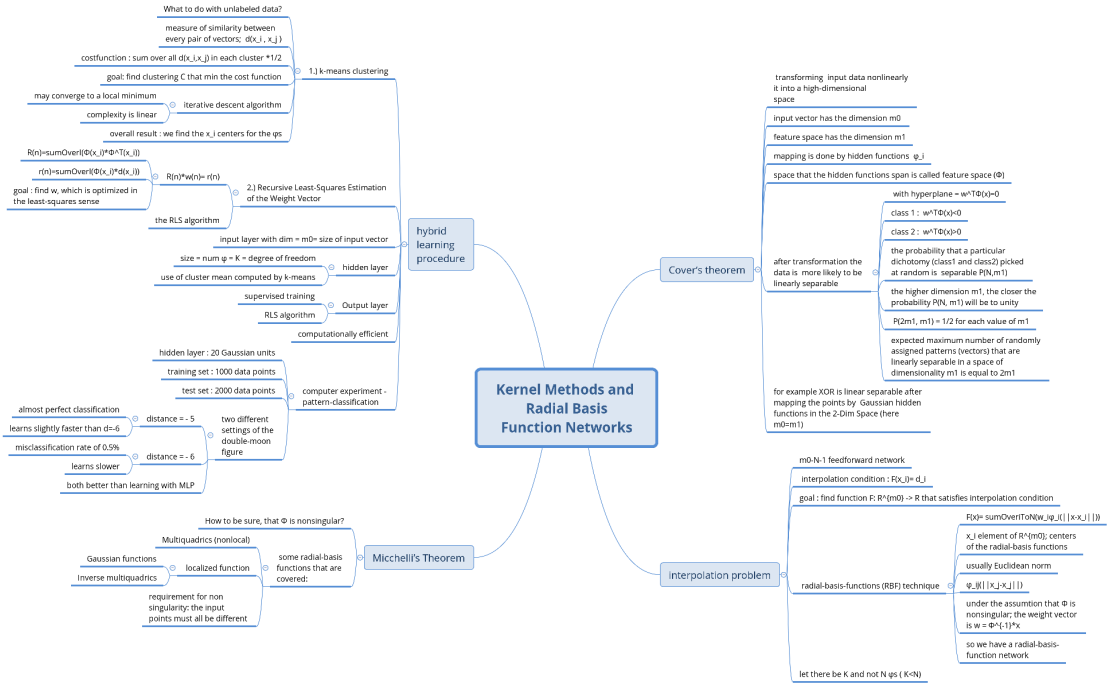
1.1 1

```
In [109]: from IPython.display import Image
          Image("Radial_Basis_Function_Networks.png")
```

Out[109]:



1.2 2

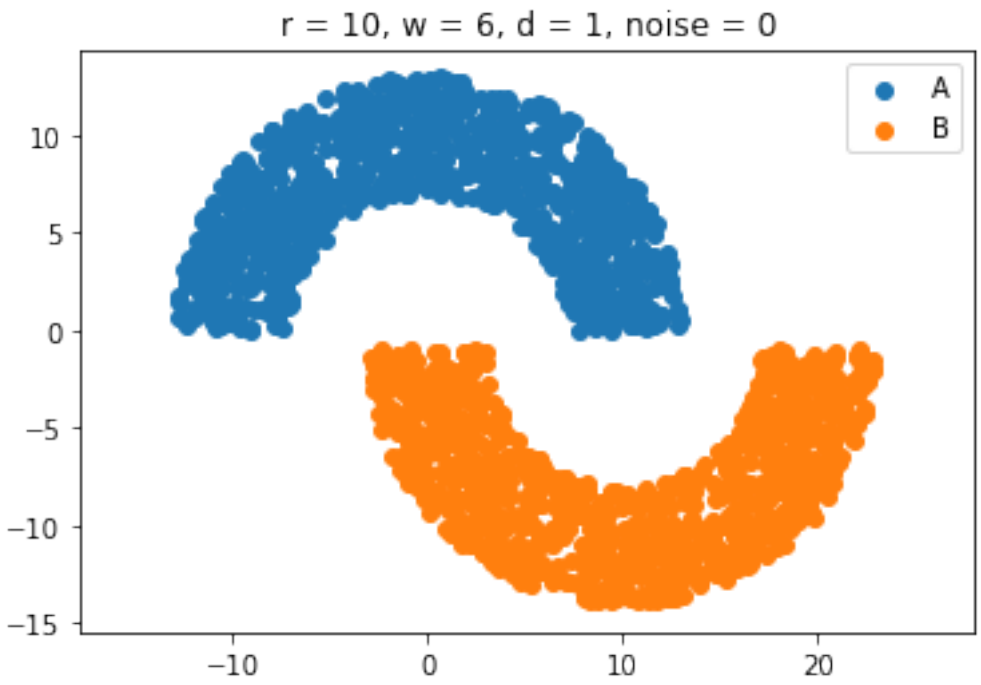
```
In [110]: import neurolab as nl
          import numpy as np
```

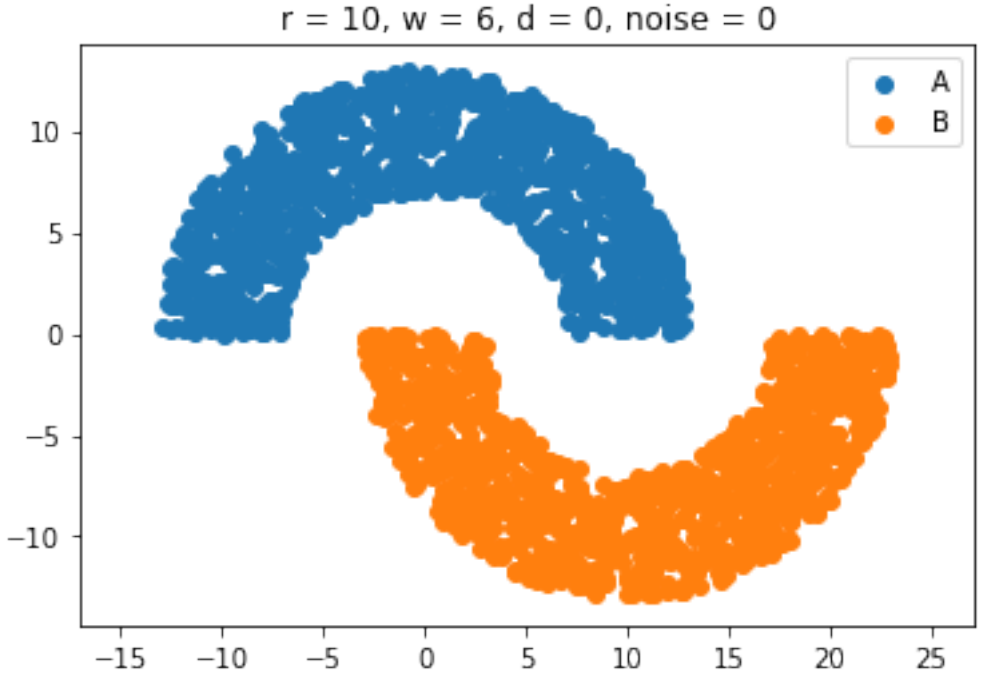
```
import sklearn.svm as svm
import matplotlib.pyplot as plt
%matplotlib inline
```

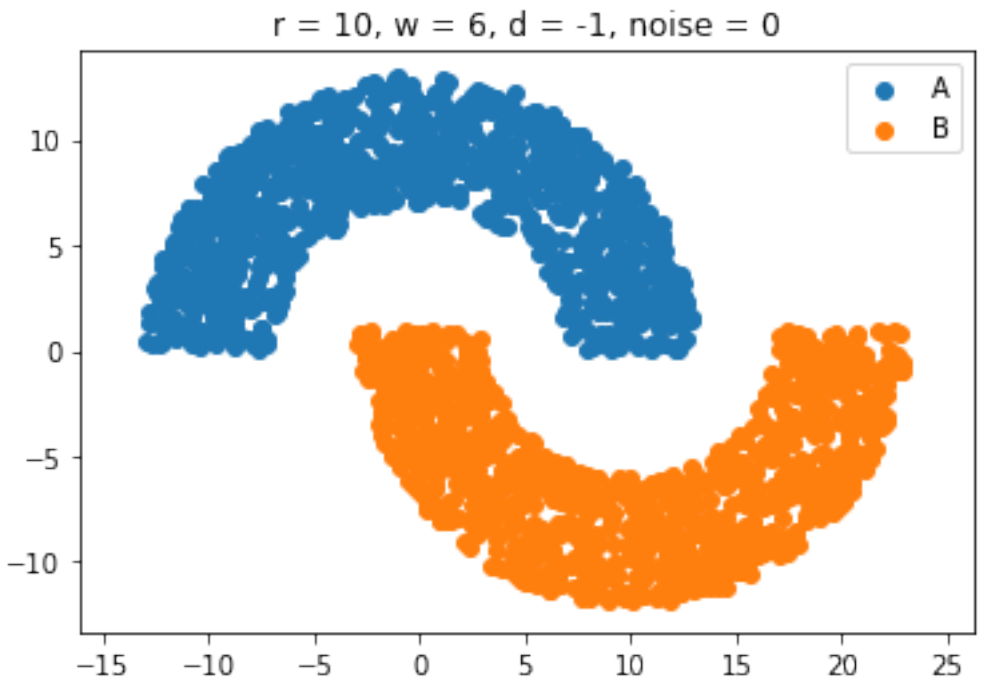
In [111]:
```
class MoonPair:
    def __init__(self, r, w, d, noise_probability=0):
        self.r = r
        self.w = w
        self.d = d
        self.noise_probability = noise_probability

    def get_region_a_point(self, sure=False):
        if not sure and np.random.rand() < self.noise_probability:
            return self.get_region_b_point(True)
        while True:
            point = np.array([np.random.rand() * (self.r + self.w/2) * 2 - (self.r +
                              np.random.rand() * (self.r + self.w/2)])
            norm = np.linalg.norm(point)
            if norm < self.r + self.w/2 and norm > self.r - self.w/2:
                return point

    def get_region_b_point(self, sure=False):
        if not sure and np.random.rand() < self.noise_probability:
            return self.get_region_a_point(True)
        while True:
            point = np.array([np.random.rand() * (self.r + self.w/2) * 2 - self.w/2,
                              -np.random.rand() * (self.r + self.w/2) - self.d])
            norm = np.linalg.norm(point - np.array([self.r, -self.d]))
            if norm < self.r + self.w/2 and norm > self.r - self.w/2:
                return point

    def print_pair(self):
        points_a = []
        points_b = []
        for i in range(1000):
            points_a.append(self.get_region_a_point())
            points_b.append(self.get_region_b_point())

        points_a = np.array(points_a)
        points_b = np.array(points_b)
        plt.figure()
        plt.axis('equal')
        plt.title("r = " + str(self.r) + ", w = " + str(self.w) + \
                  ", d = " + str(self.d) + ", noise = " + str(self.noise_probability)
        plt.scatter(points_a[:,0], points_a[:,1])
        plt.scatter(points_b[:,0], points_b[:,1])
        plt.legend(["A", "B"])
        plt.show()
```

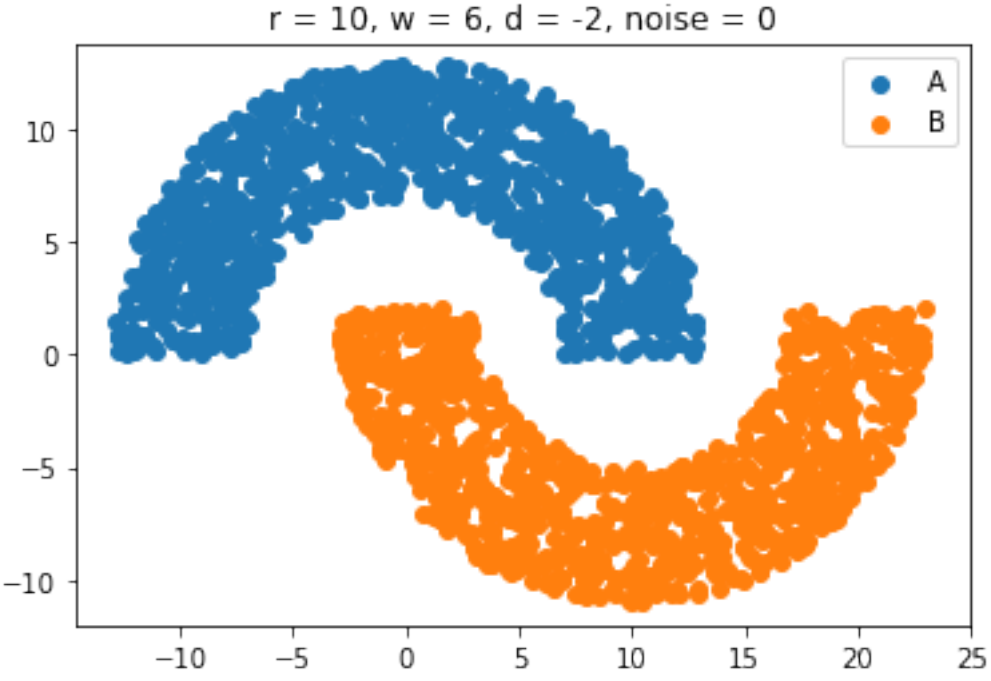
```
        def generate_sample_set(self, size, sure=False):
            sample = []
            for i in range(round(size / 2)):
                sample.append(np.hstack((self.get_region_a_point(sure))))
                sample.append(np.hstack((self.get_region_b_point(sure))))
            return np.array(sample)
```

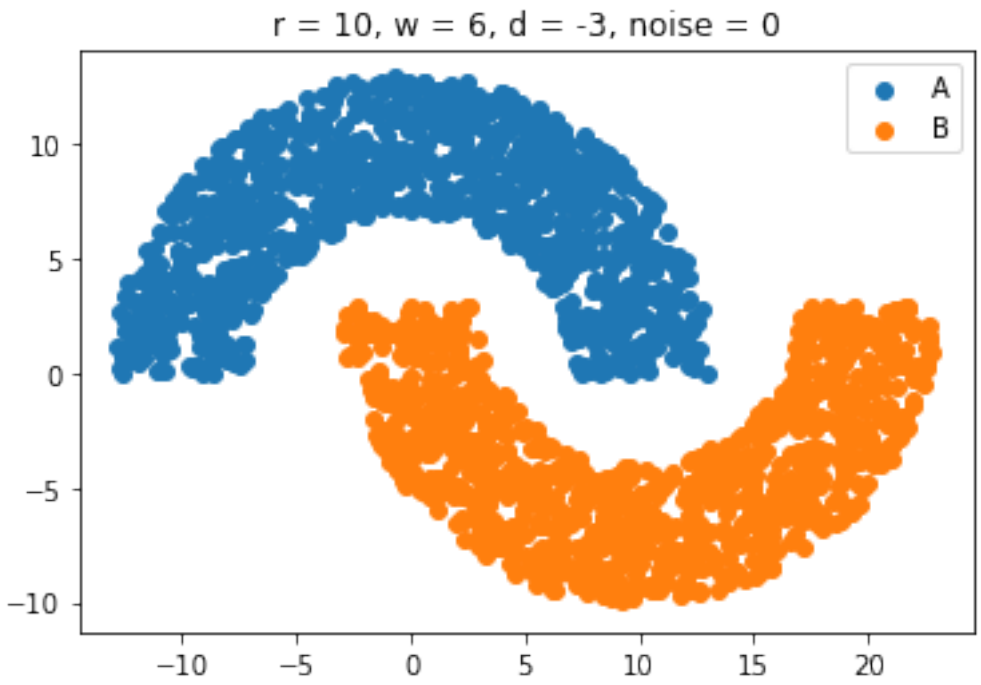
In [112]:
```
train_size = 1000
test_size = 2000

cases = []
cases.append(MoonPair(10, 6, 1))
cases.append(MoonPair(10, 6, 0))
cases.append(MoonPair(10, 6, -1))
cases.append(MoonPair(10, 6, -2))
cases.append(MoonPair(10, 6, -3))
cases.append(MoonPair(10, 6, -4))
cases.append(MoonPair(10, 6, -5))
cases.append(MoonPair(10, 6, -6))

cases[0].print_pair()
cases[1].print_pair()
cases[2].print_pair()
cases[3].print_pair()
cases[4].print_pair()
cases[5].print_pair()
cases[6].print_pair()
cases[7].print_pair()
```

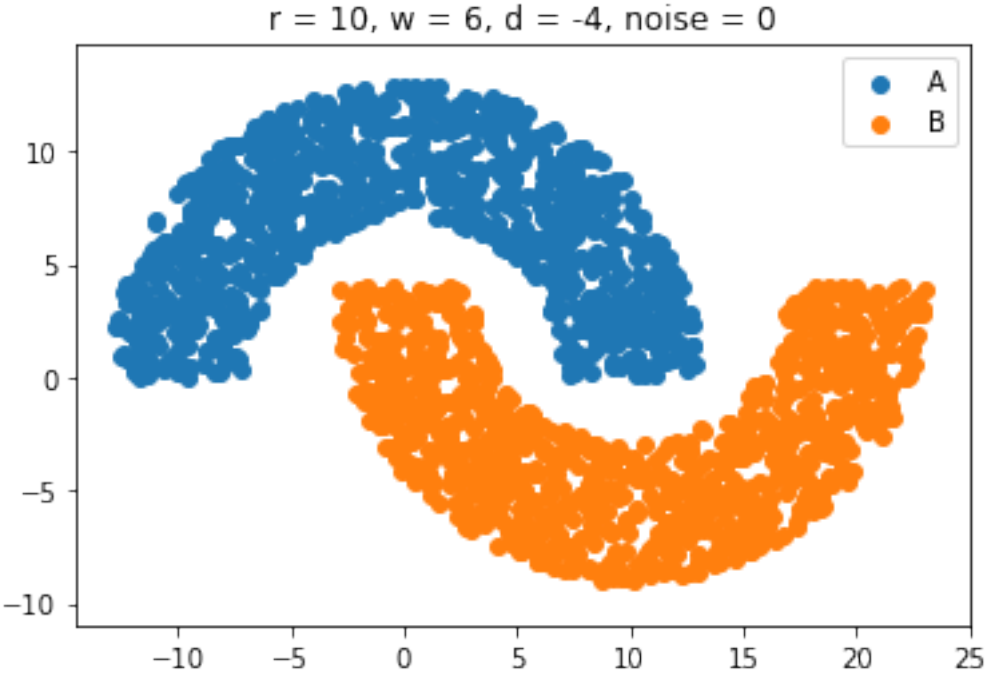

r = 10, w = 6, d = 1, noise = 0
A
B
10
5
0
−5
−10
−15
−10
0
10
20

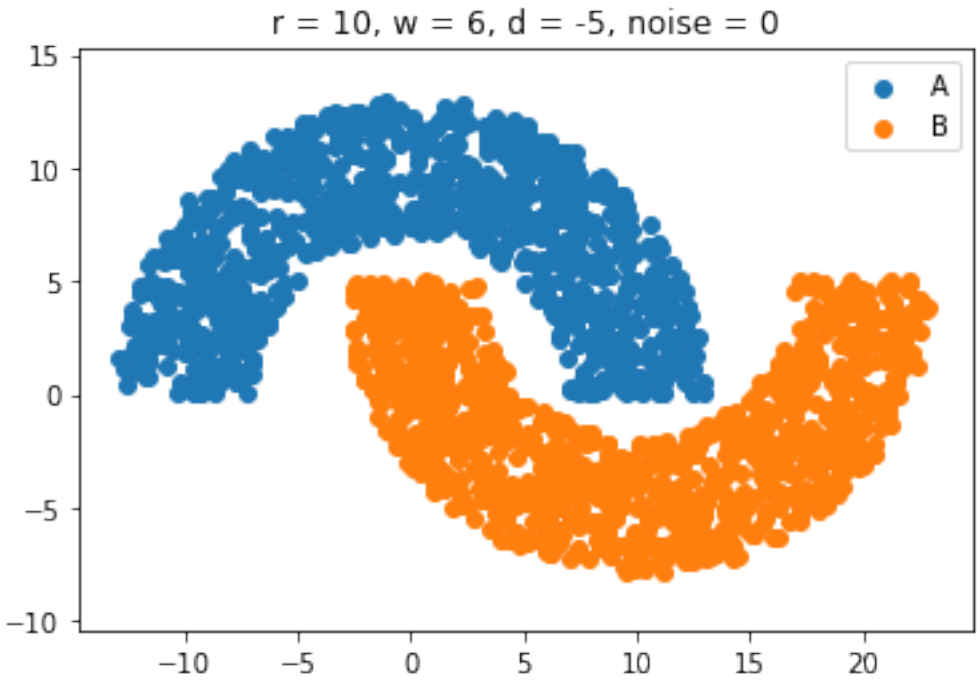

r = 10, w = 6, d = 0, noise = 0
A
B
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
25

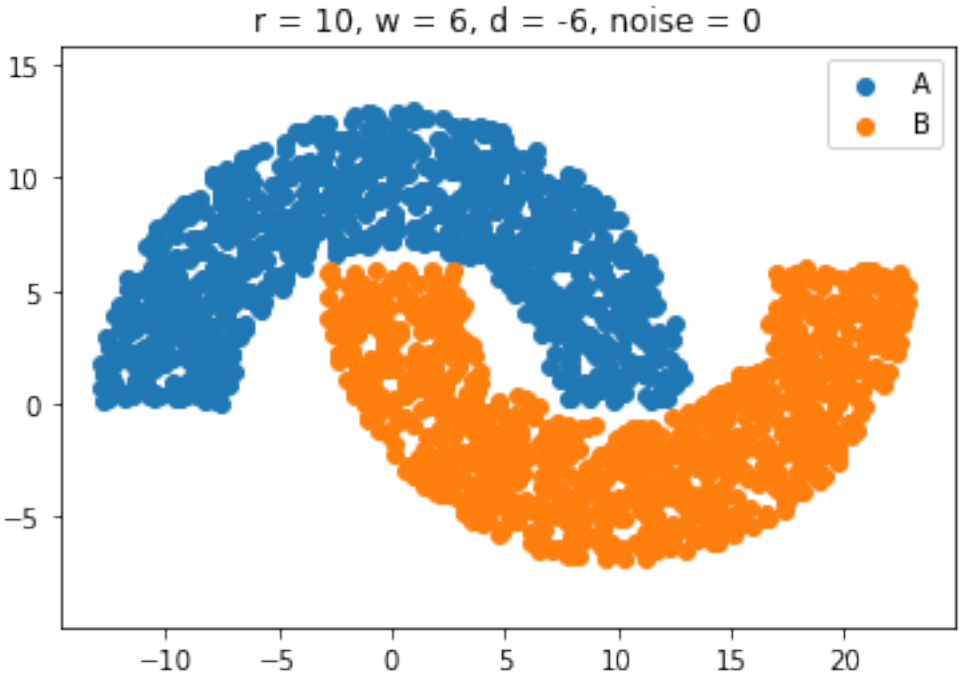

r = 10, w = 6, d = -1, noise = 0
A
B
10
5
0
−5
−10
−15
−10
−5
0
5
10
15
20
25


r = 10, w = 6, d = -2, noise = 0
A
B
10
5
0
−5
−10
−10
−5
0
5
10
15
20
25


r = 10, w = 6, d = -3, noise = 0
A
B
10
5
0
−5
−10
−10
−5
0
5
10
15
20


r = 10, w = 6, d = -4, noise = 0
A
B
10
5
0
−5
−10
−10
−5
0
5
10
15
20
25

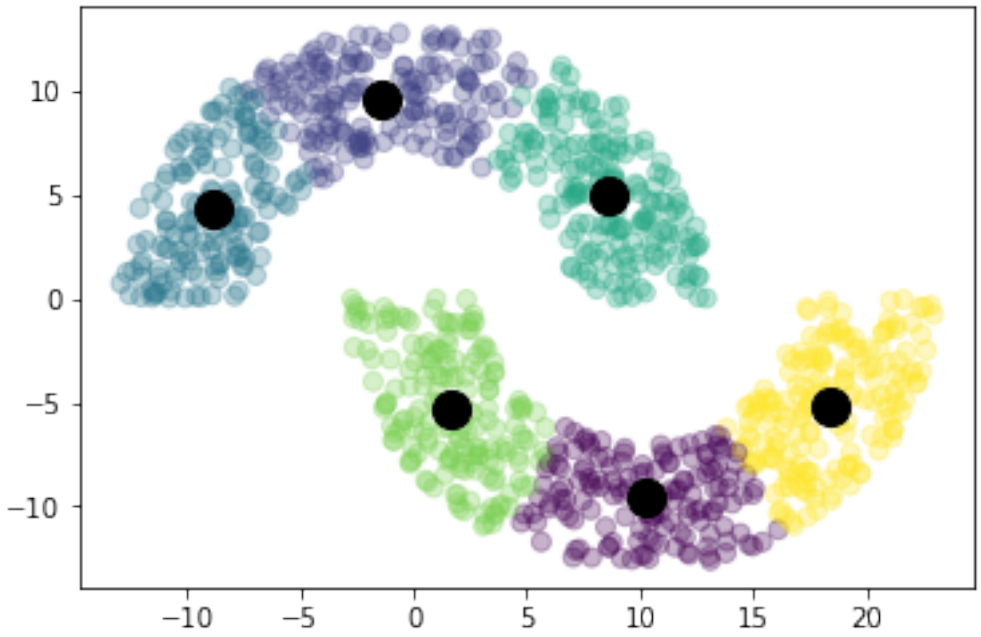


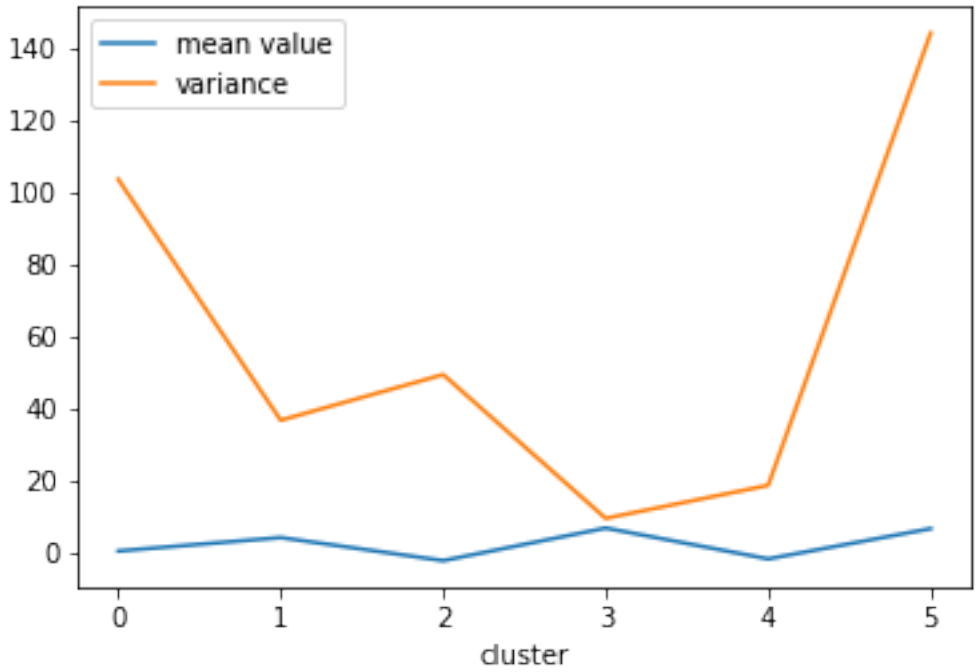


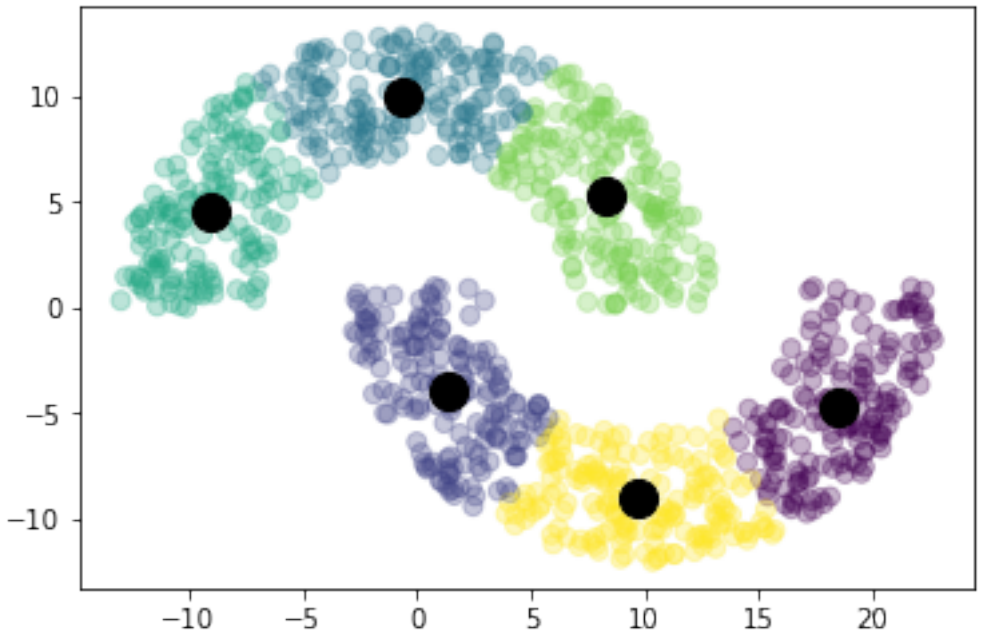

```
In [113]: from sklearn.cluster import KMeans
```

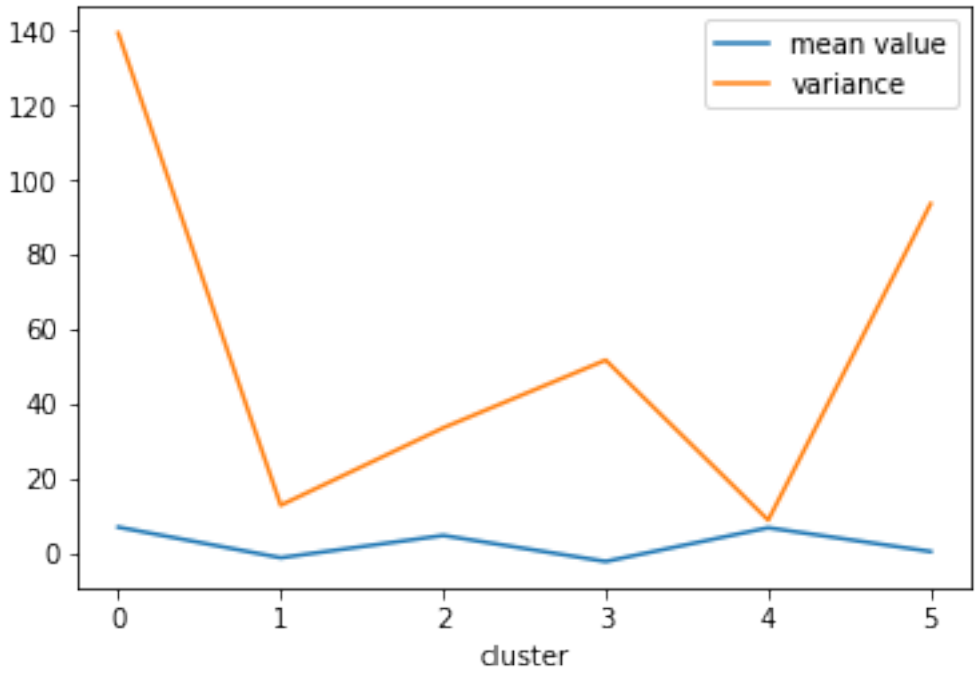
```
for i in range(1,8):
    Y = cases[i].generate_sample_set(1000)
    kmeans = KMeans(n_clusters=6)
    kmeans.fit(Y)
    y_kmeans = kmeans.predict(Y)

    plt.scatter(Y[:, 0], Y[:, 1], c=y_kmeans, s=50, cmap='viridis', alpha = 0.3)

    centers = kmeans.cluster_centers_
    plt.scatter(centers[:, 0], centers[:, 1], c='black', s=200, alpha=1);
    plt.show()

    Y1 = []
    Y2 = []
    Y3 = []
    Y4 = []
    Y5 = []
    Y6 = []

    for i in range(0,999):
        if y_kmeans[i] == 0:
            Y1.append(Y[i])
        if y_kmeans[i] == 1:
            Y2.append(Y[i])
        if y_kmeans[i] == 2:
            Y3.append(Y[i])
        if y_kmeans[i] == 3:
            Y4.append(Y[i])
        if y_kmeans[i] == 4:
            Y5.append(Y[i])
        if y_kmeans[i] == 5:
            Y6.append(Y[i])

    variances = []
    variances .append(np.var(Y1))
    variances .append(np.var(Y2))
    variances .append(np.var(Y3))
    variances .append(np.var(Y4))
    variances .append(np.var(Y5))
    variances .append(np.var(Y6))

    means = []
    means.append(np.mean(Y1))
    means.append(np.mean(Y2))
    means.append(np.mean(Y3))
    means.append(np.mean(Y4))
    means.append(np.mean(Y5))
    means.append(np.mean(Y6))
```

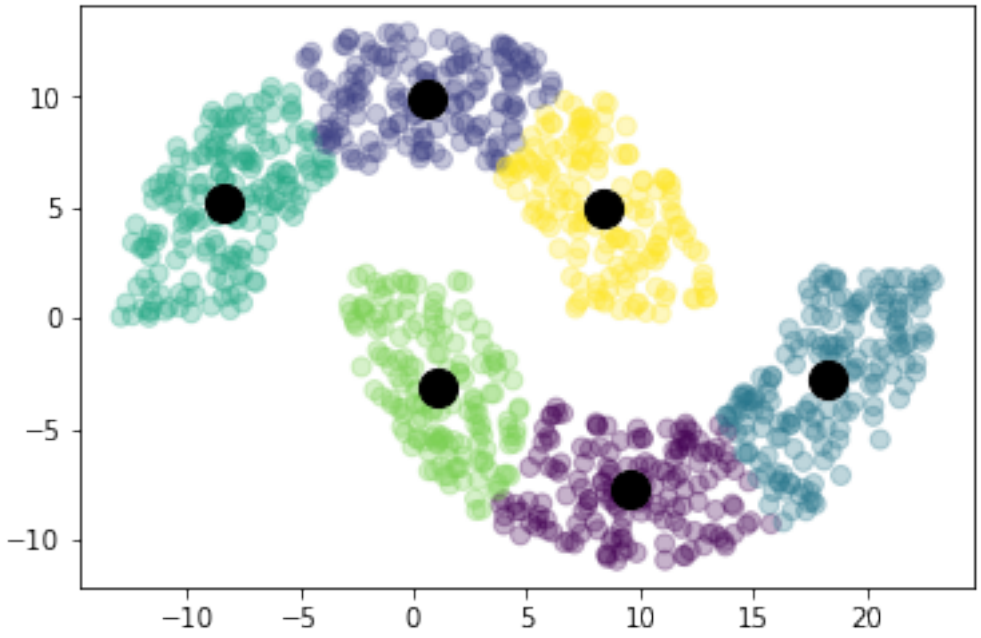
```
plt.plot(means)
plt.plot(variances)
plt.xlabel("cluster")
plt.ylabel(" ")
plt.legend(["mean value", "variance"])
plt.show()
```

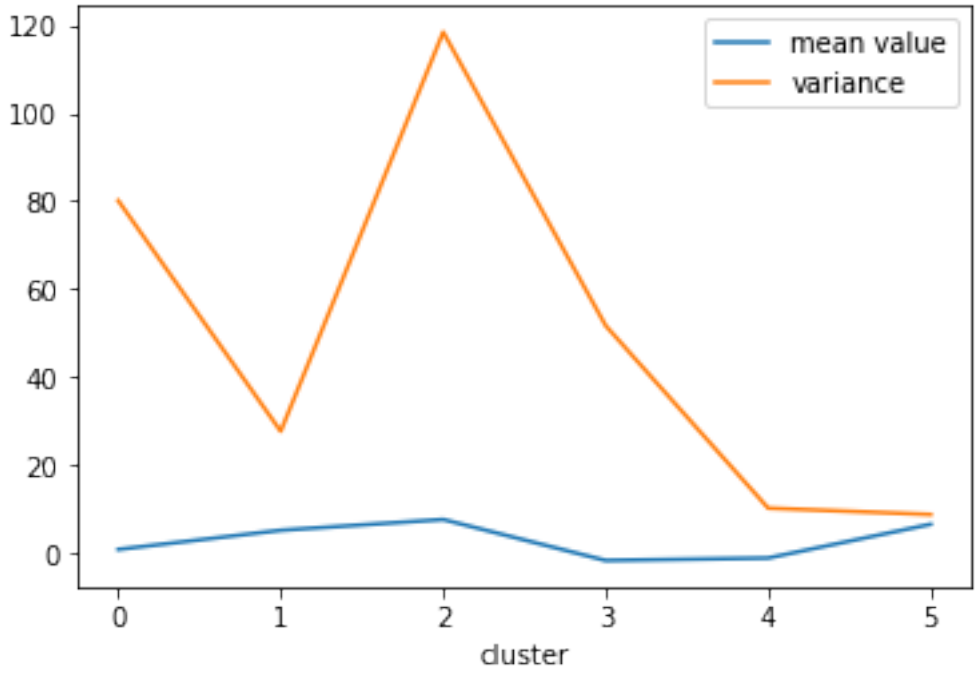


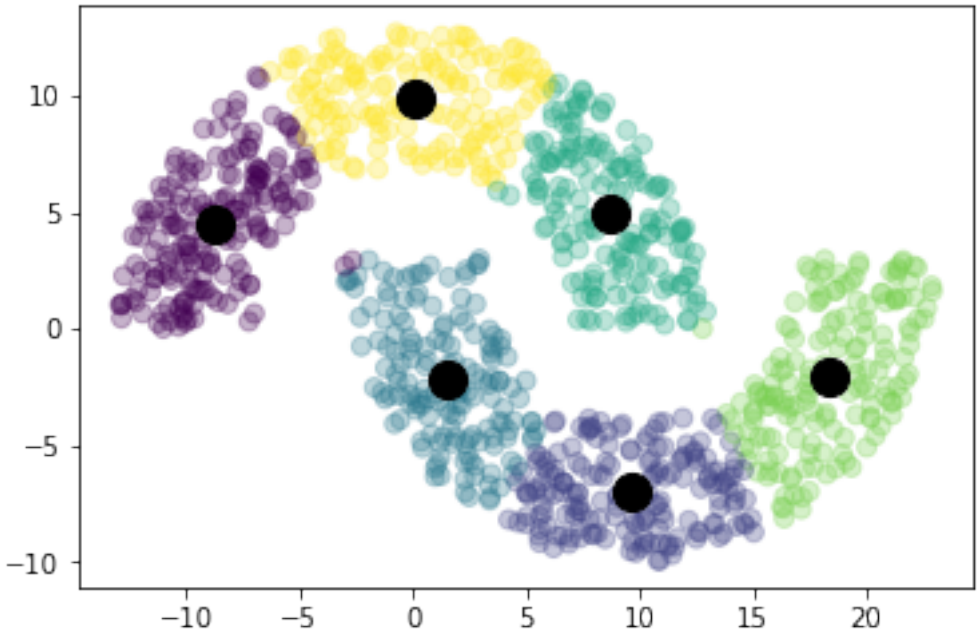


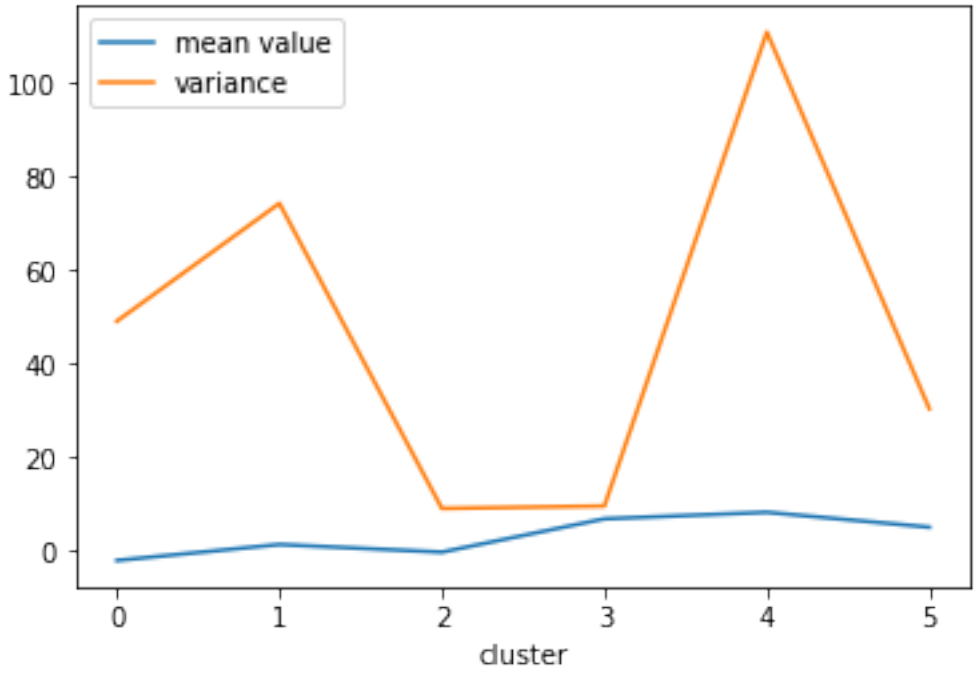

10
5
0
−5
−10
−10
−5
0
5
10
15
20

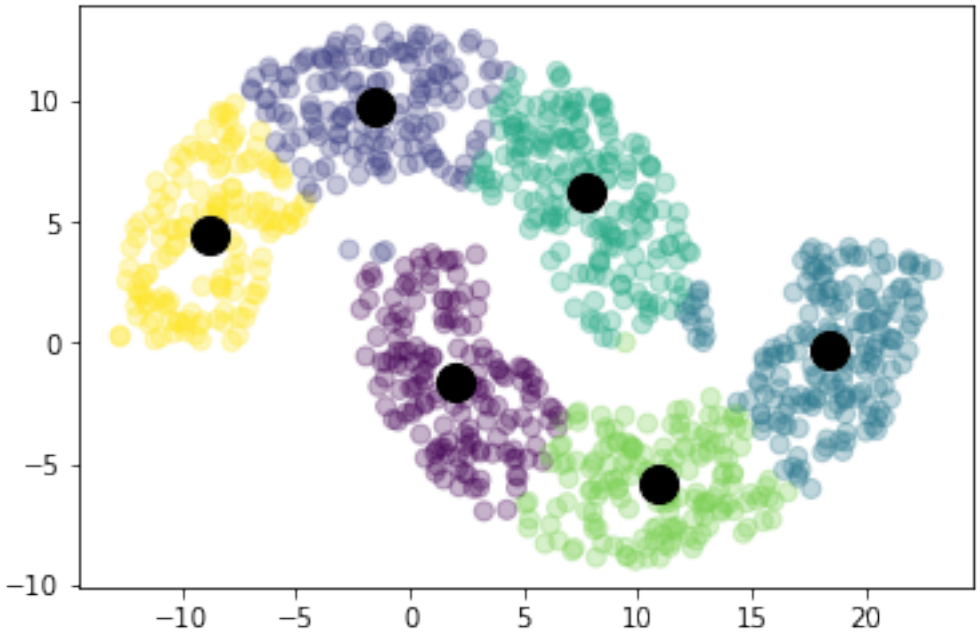

140
120
100
80
60
40
20
0
0
1
2
3
4
5
cluster
mean value
variance

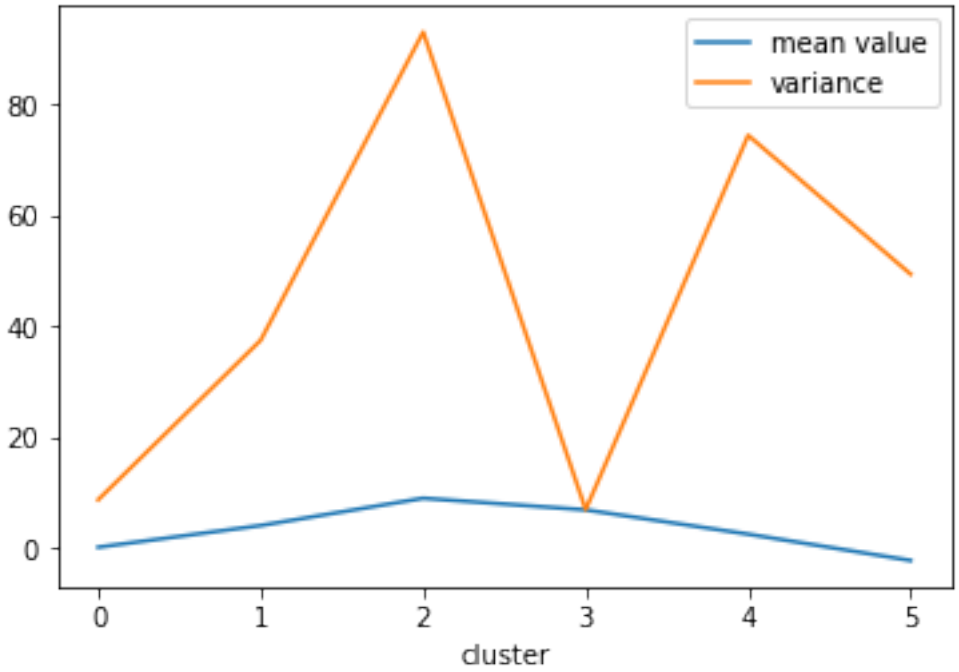

10
5
0
−5
−10
−10
−5
0
5
10
15
20

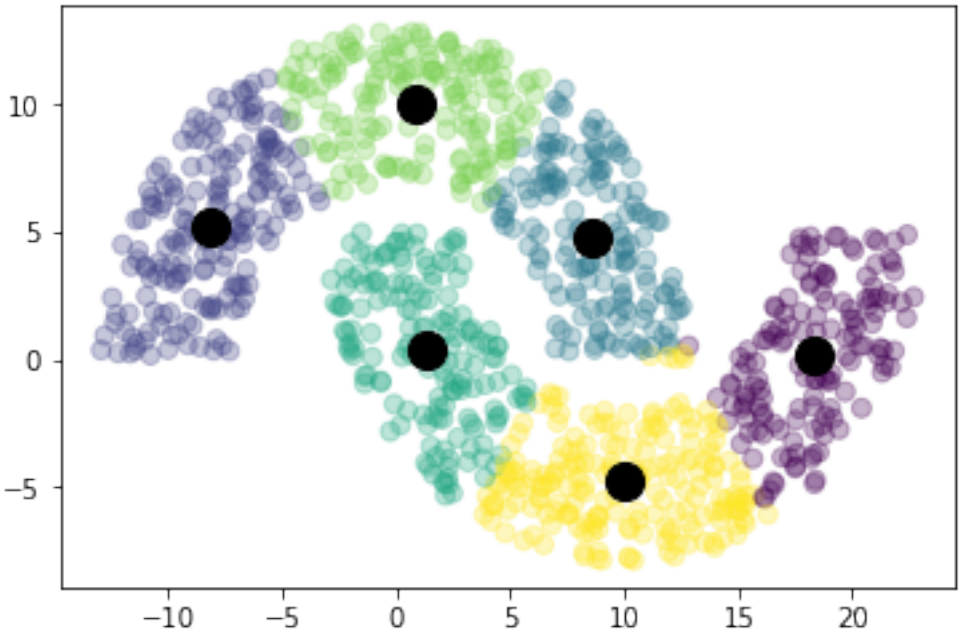

120
100
80
60
40
20
0
0
1
2
3
4
5
cluster
mean value
variance

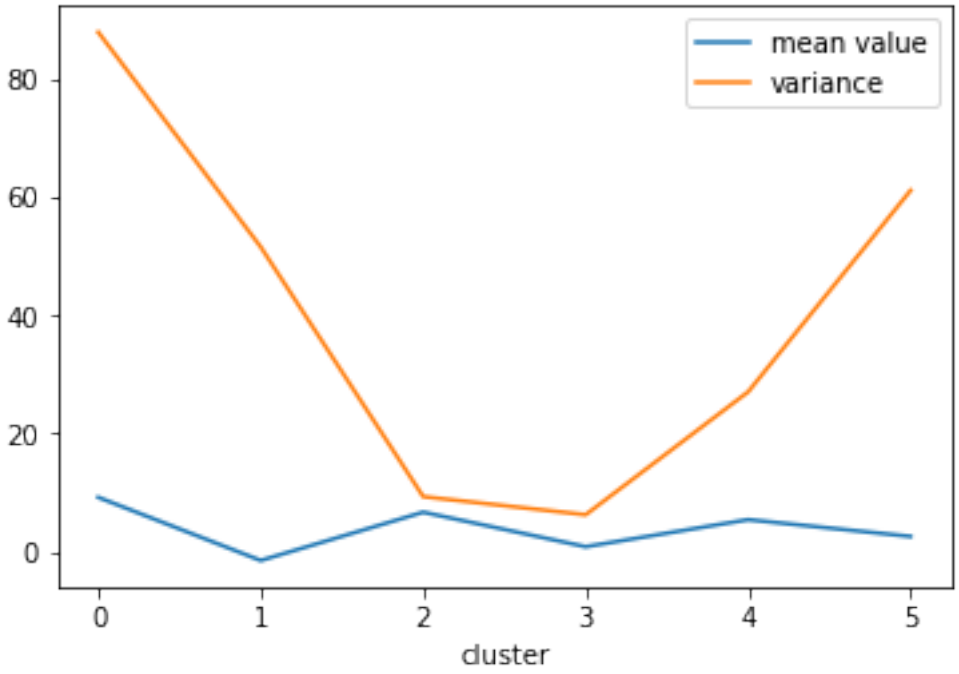

10
5
0
−5
−10
−10
−5
0
5
10
15
20

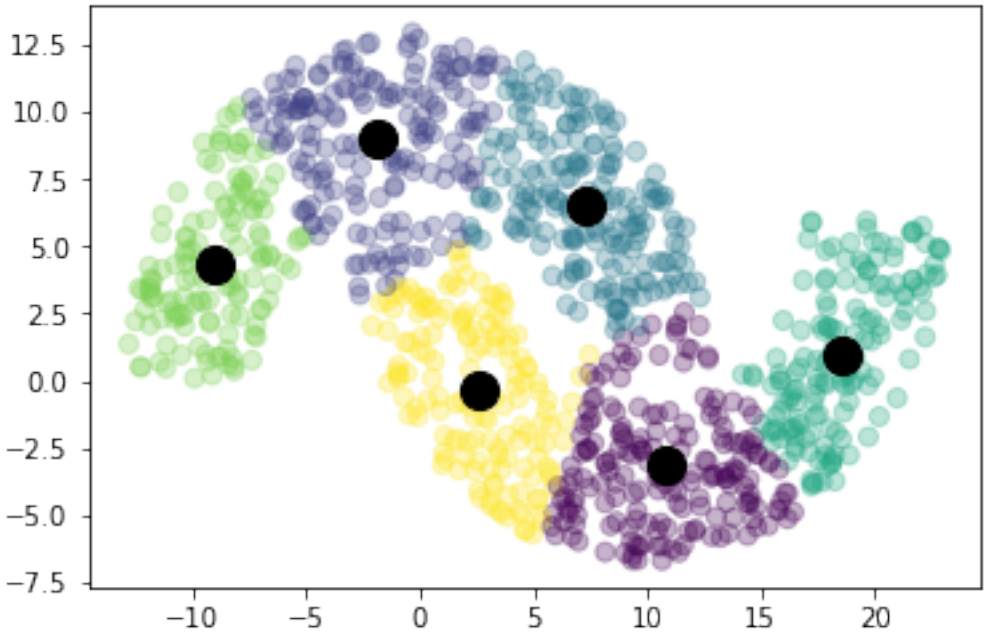

mean value
variance
100
80
60
40
20
0
0
1
2
3
4
5
cluster

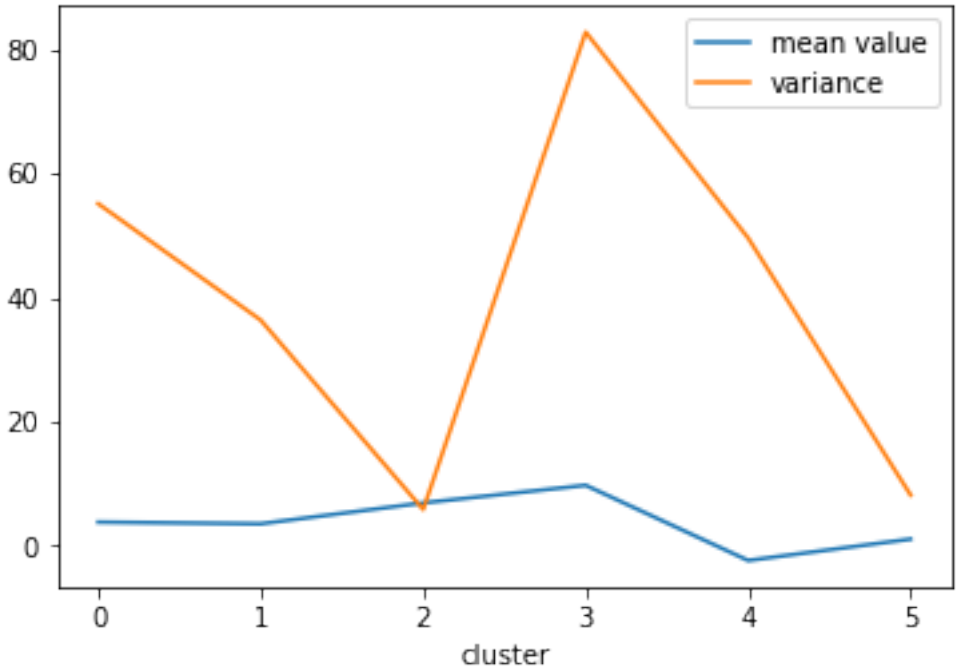

10
5
0
−5
−10
−10
−5
0
5
10
15
20


mean value
variance
80
60
40
20
0
0
1
2
3
4
5
cluster


10
5
0
−5
−10
−5
0
5
10
15
20


mean value
variance
80
60
40
20
0
0
1
2
3
4
5
cluster


12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10
−5
0
5
10
15
20


mean value
variance
80
60
40
20
0
0
1
2
3
4
5
cluster

1.3 3

K-means algorithm finds perfekt data centers for the two half moon circles with larger d. When the moons get closer together the regions begin to overlap. As d gets smaller the variance decreases.

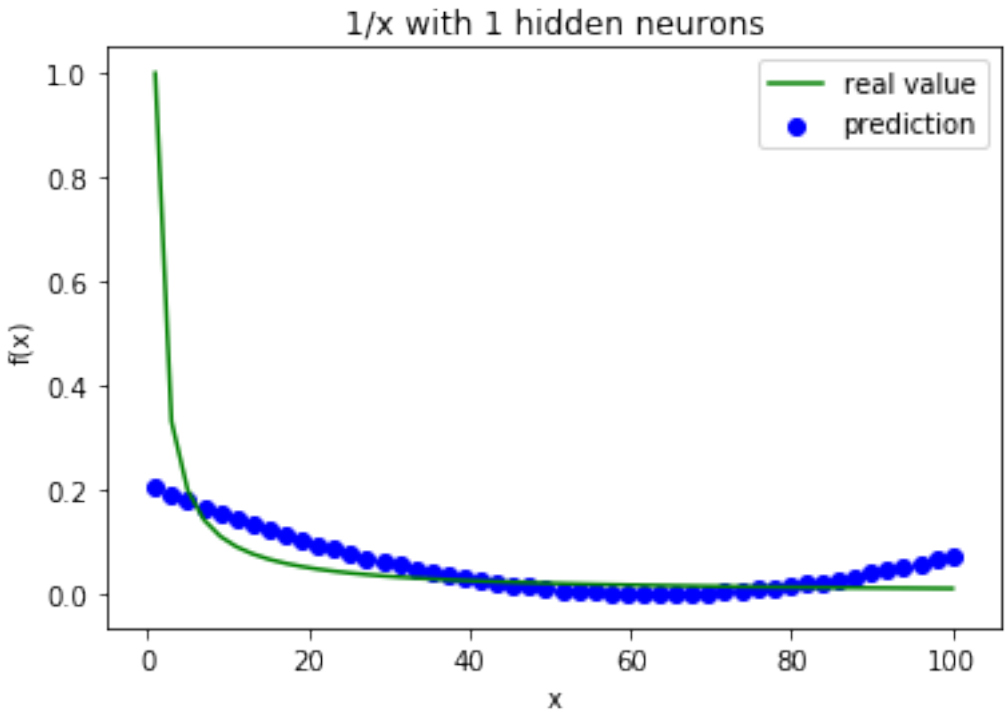
```
In [114]: import neurolab as nl
          import numpy as np
          import matplotlib.pyplot as plt
          %matplotlib inline

In [115]: def func1(x):
              return 1/x

          def func2(x):
              return np.log10(x)

          def func3(x):
              return np.exp(-x)

          def func4(x):
              return np.sin(x)

In [116]: class mapping:
              def __init__(self, function, range_, str_):
                  self.function = function
                  self.range_ = range_
                  self.str = str_

              def generate_set(self, size):
                  result = []
                  for i in range(size):
                      x = np.random.random() * (self.range_[1] - self.range_[0]) + self.range_
                      result.append(np.array([x, self.function(x)]))
                  return np.array((result))

In [117]: def get_error(net, test_set):
              error = 0
              for test in test_set:
                  error = error + abs(test[1] - net.sim(np.array([[test[0]]])))[0][0]
              return error / np.size(test_set, 0)

In [118]: class RadBasis:
              # output range
              out_minmax = [-1, 1]
              # input active range
              inp_active = [-2, 2]

              def __init__(self, center):
                  self.center = center
```

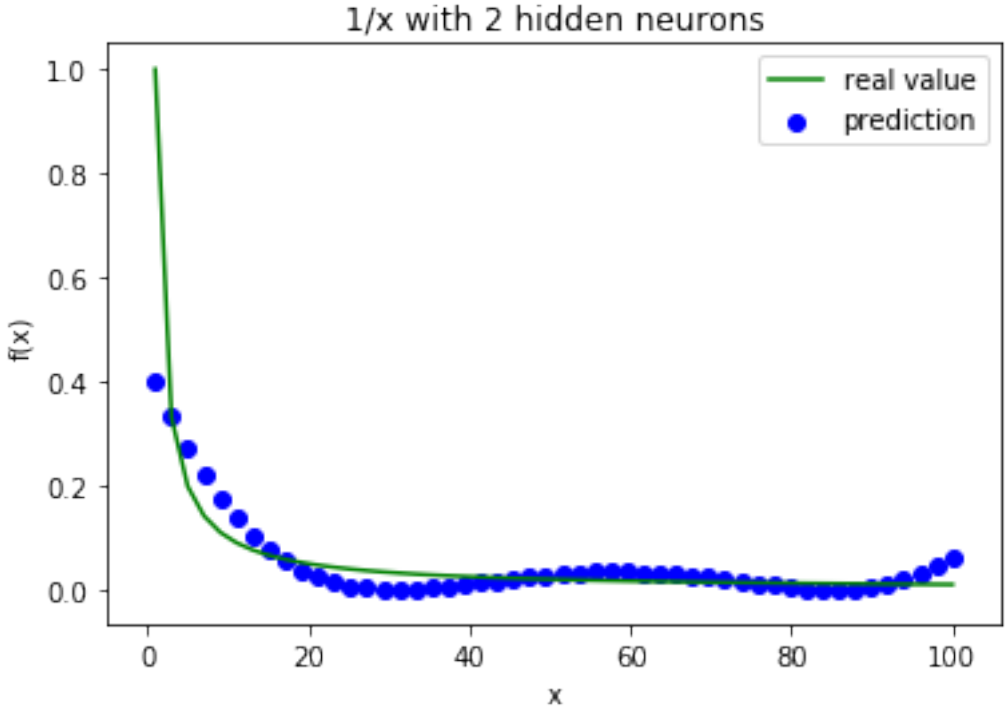
```
            def __call__(self, x):
                return (x - self.center)**2

            def deriv(self, x, y):
                return 2 * x - 2 * self.center
```

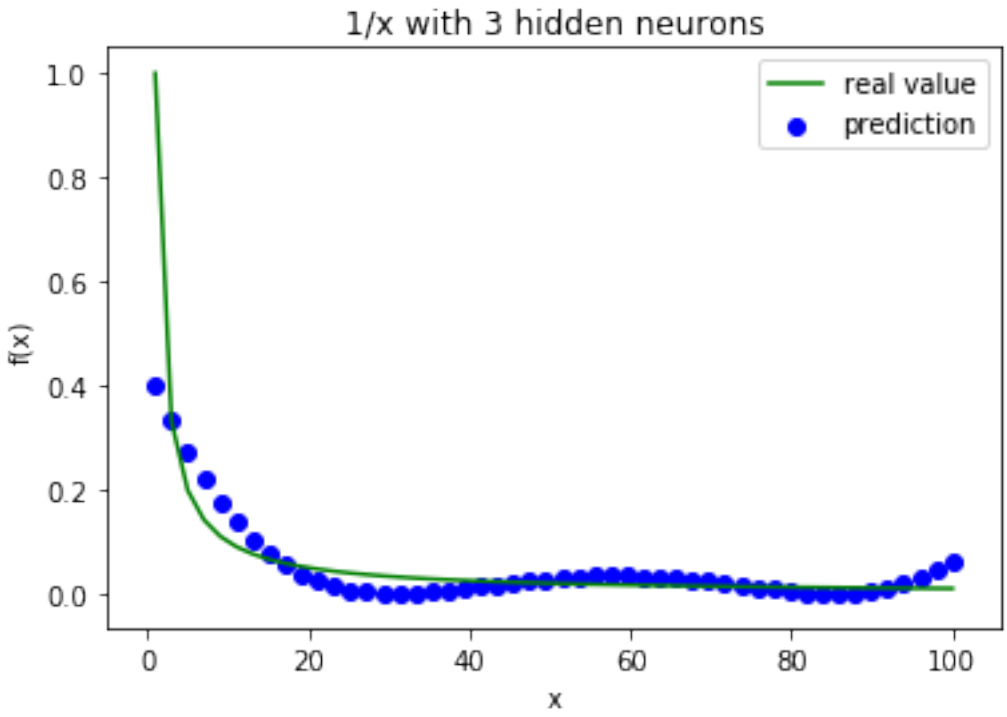
```
In [119]: %%javascript
          IPython.OutputArea.prototype._should_scroll = function(lines) {
              return false;
          }
```

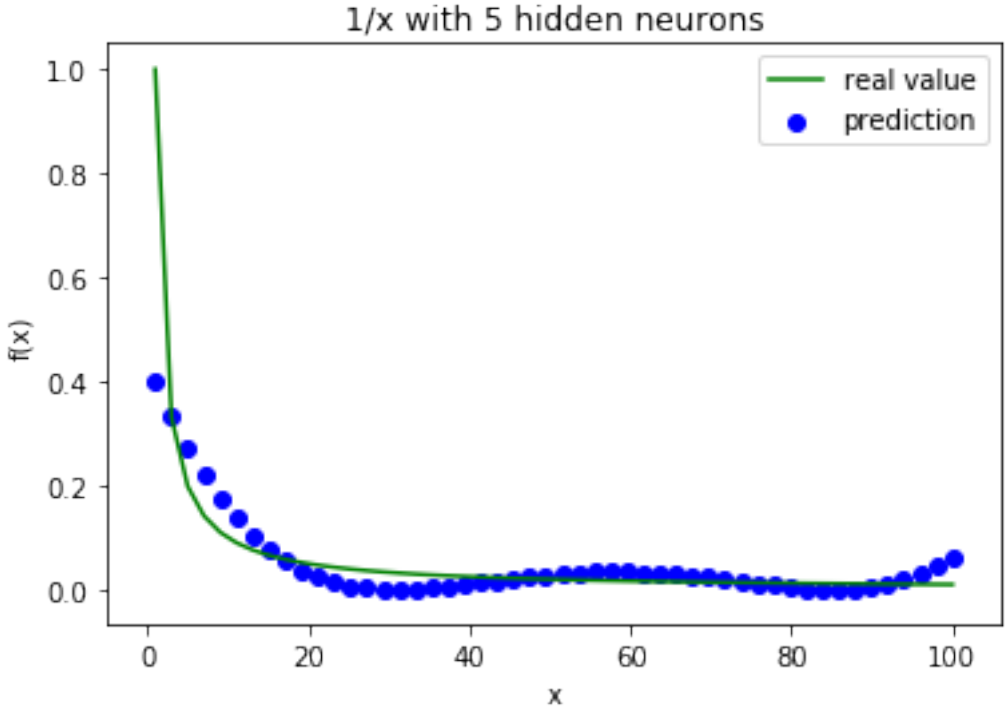
```
<IPython.core.display.Javascript object>
```

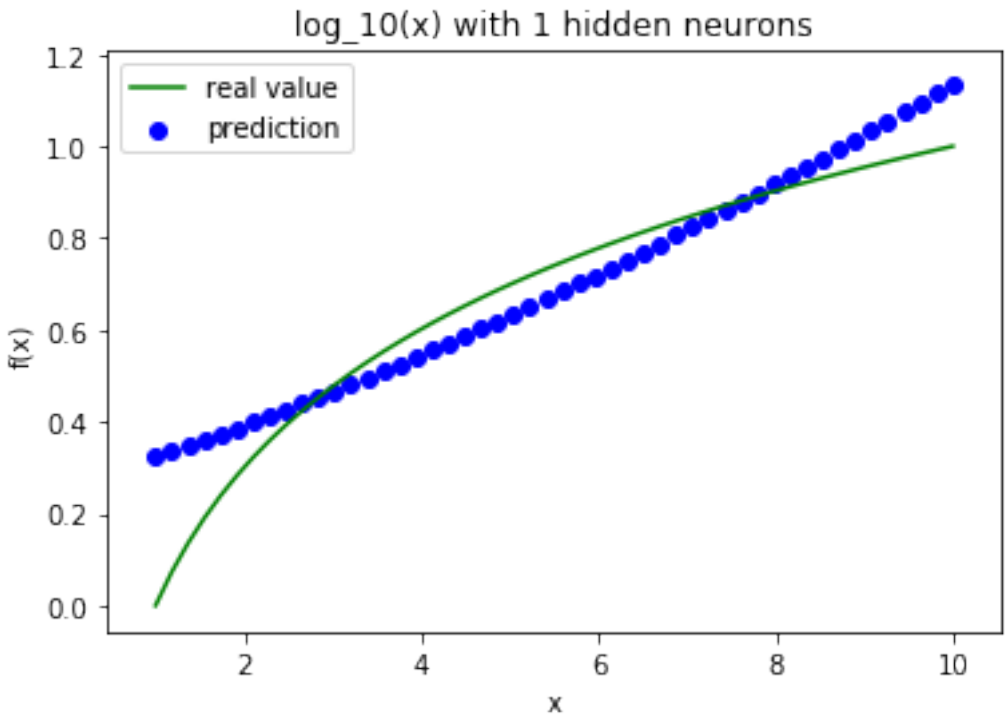
```
In [120]: training_size = 100
          test_size = 50
          hidden_neurons = [1, 2, 3, 5]

          mappings = []
          mappings.append(mapping(func1, [1,100], "1/x"))
          mappings.append(mapping(func2, [1,10], "log_10(x)"))
          mappings.append(mapping(func3, [1,10], "exp(-x)"))
          mappings.append(mapping(func4, [0, np.pi / 2], "sin(x)"))

          for m in mappings:
              training_set = m.generate_set(training_size)
              input = training_set[:,0].reshape(training_size, 1)
              target = training_set[:,1].reshape(training_size, 1)

              errors = np.zeros((len(hidden_neurons), 1))

              for num_hidden_neurons in hidden_neurons:
                  net = nl.net.newff([m.range_], [num_hidden_neurons,1], transf=[RadBasis(np.m
                  net.train(input, target, epochs=training_size, show=0)
                  predictions = []
                  space = np.linspace(m.range_[0], m.range_[1], test_size)
                  for x in space:
                      predictions.append(net.sim(np.array([[x]])))

                  plt.figure()
                  plt.plot(space, m.function(space), c="g")
                  plt.scatter(space, np.array(predictions), c="b")
                  plt.title(m.str + " with " + str(num_hidden_neurons) + " hidden neurons")
                  plt.xlabel("x")
                  plt.ylabel("f(x)")
                  plt.legend(["real value", "prediction"])
```

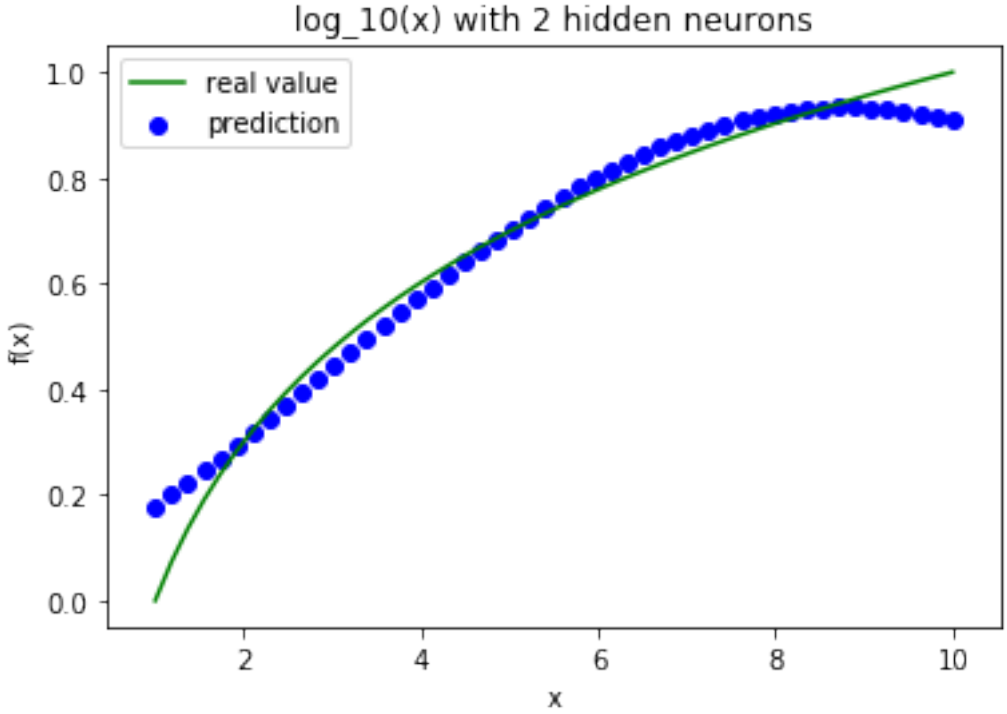

1/x with 1 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

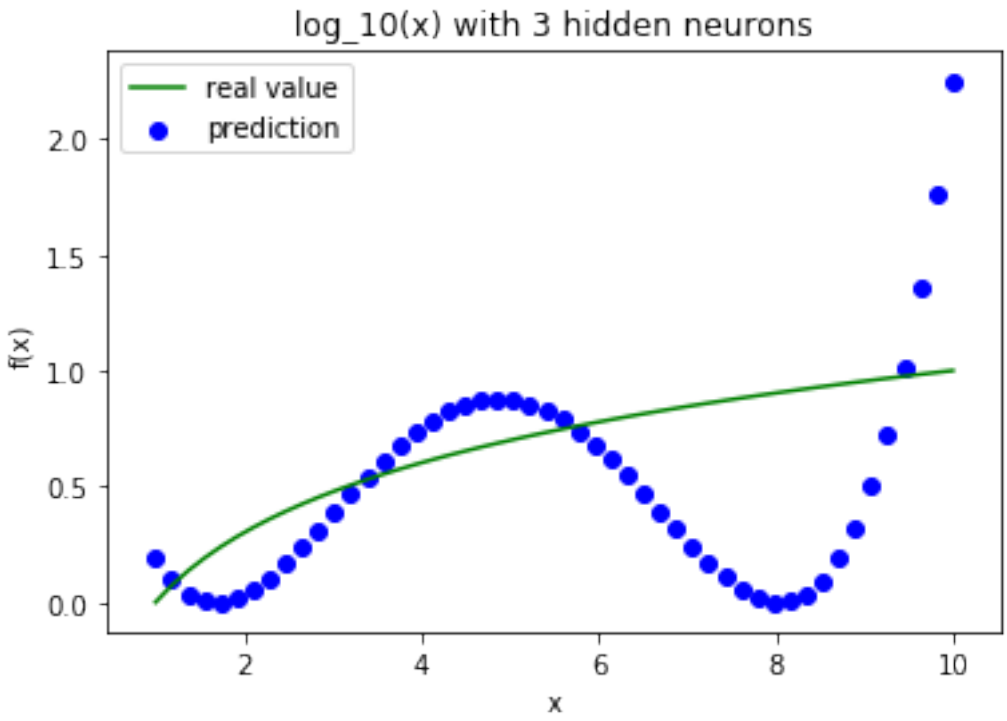

1/x with 2 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

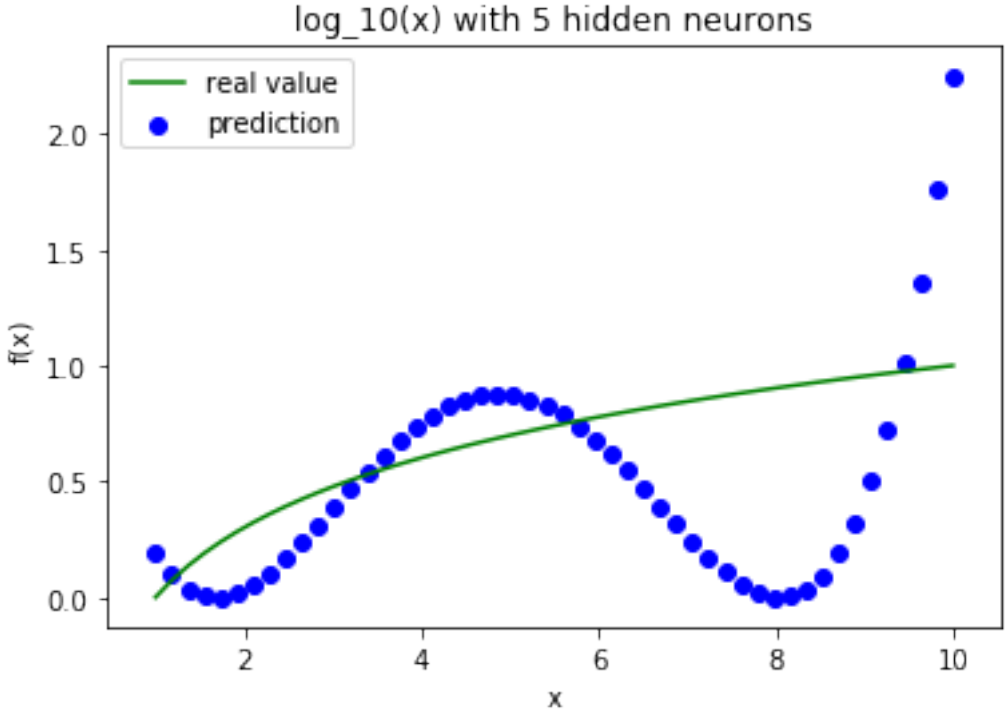

1/x with 3 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

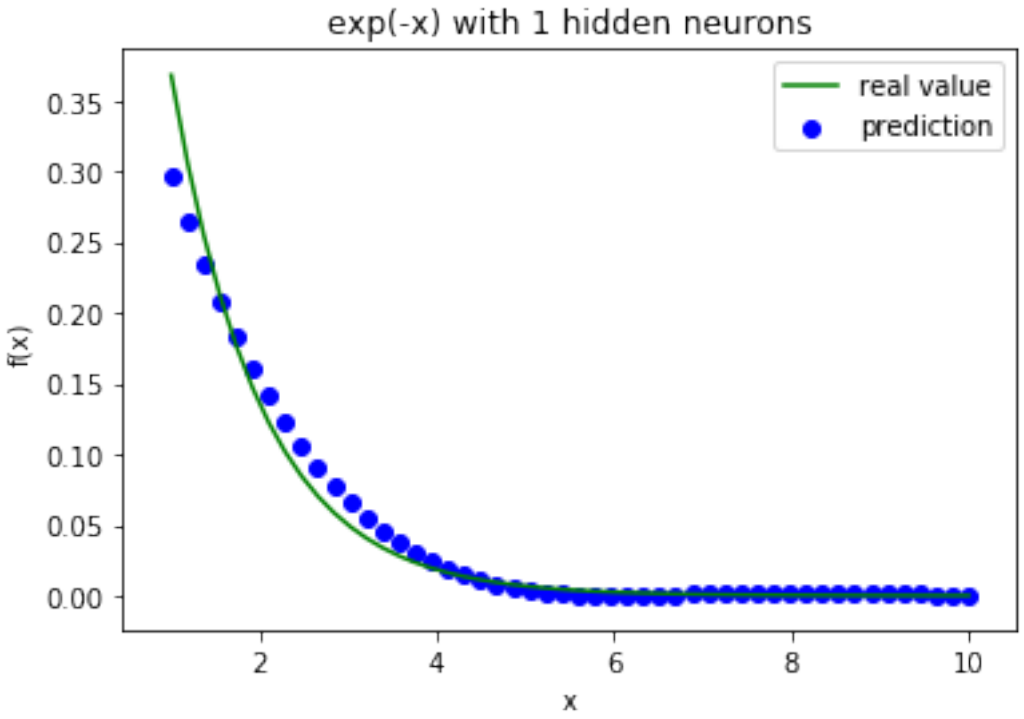

1/x with 5 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

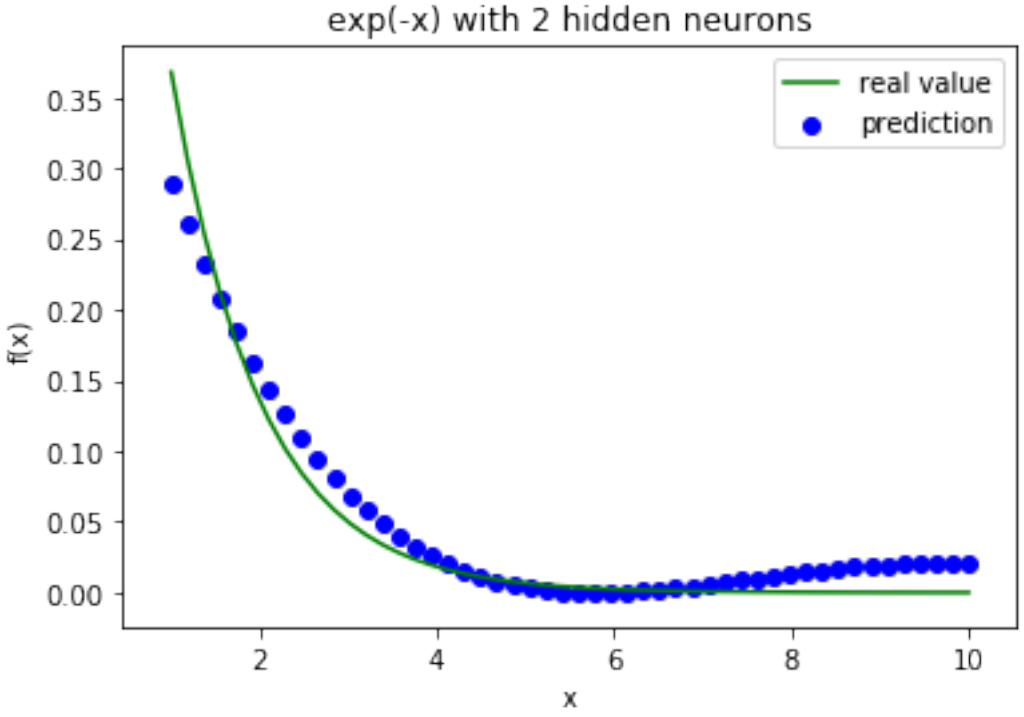

log_10(x) with 1 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
1.2
2
4
6
8
10

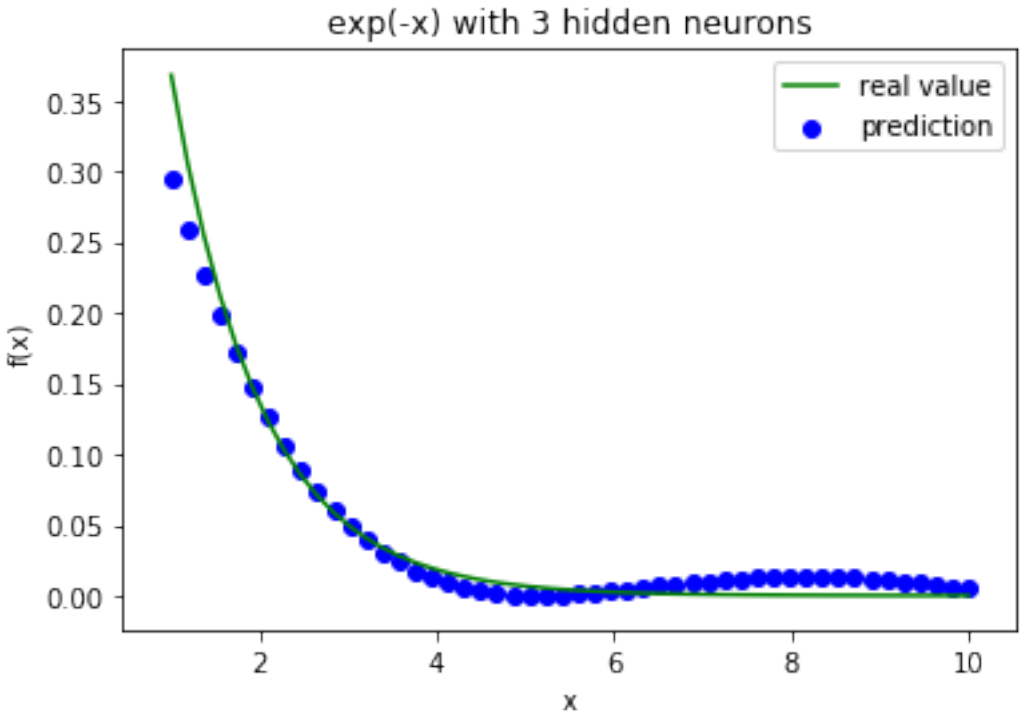

log_10(x) with 2 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10

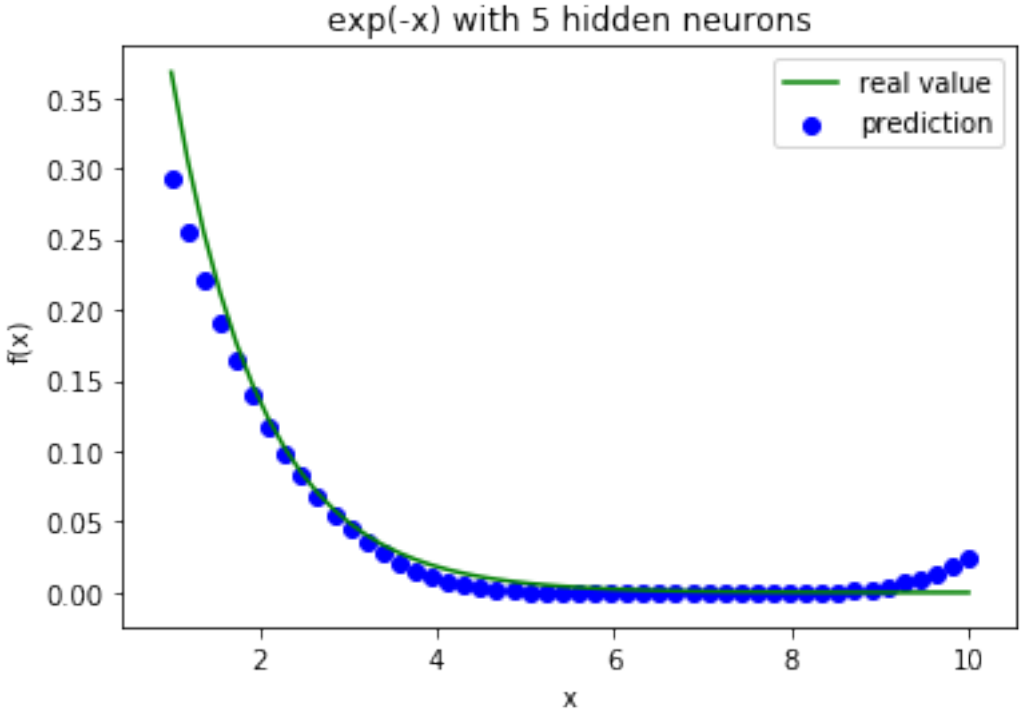

log_10(x) with 3 hidden neurons
real value
prediction
f(x)
x
0.0
0.5
1.0
1.5
2.0
2
4
6
8
10

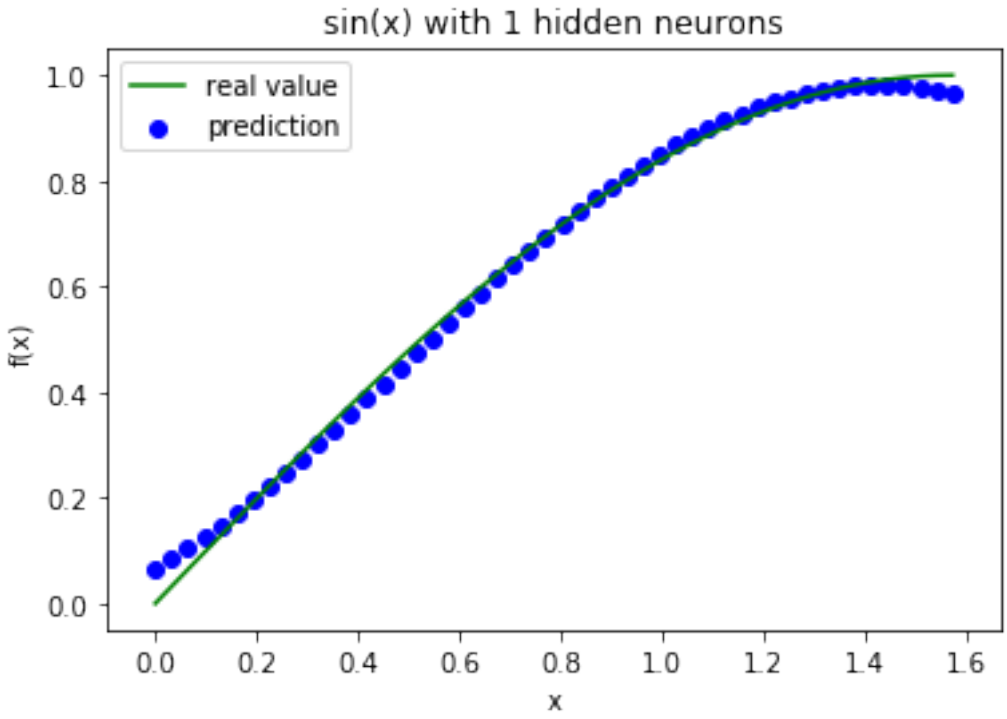

log_10(x) with 5 hidden neurons
real value
prediction
f(x)
x
0.0
0.5
1.0
1.5
2.0
2
4
6
8
10

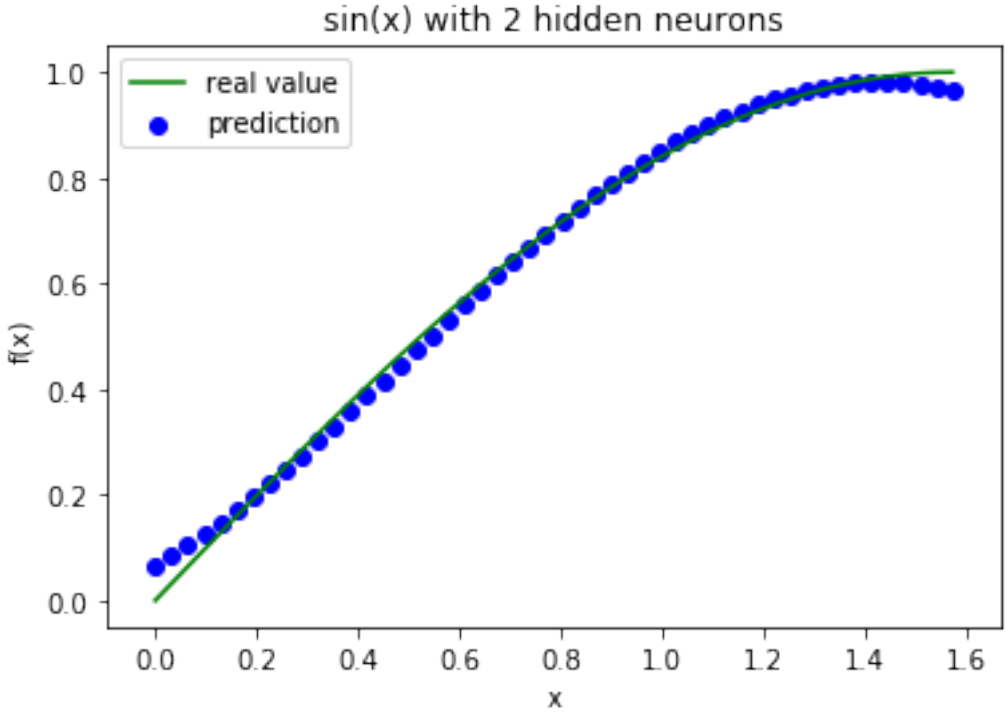

exp(-x) with 1 hidden neurons
real value
prediction
f(x)
x
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2
4
6
8
10

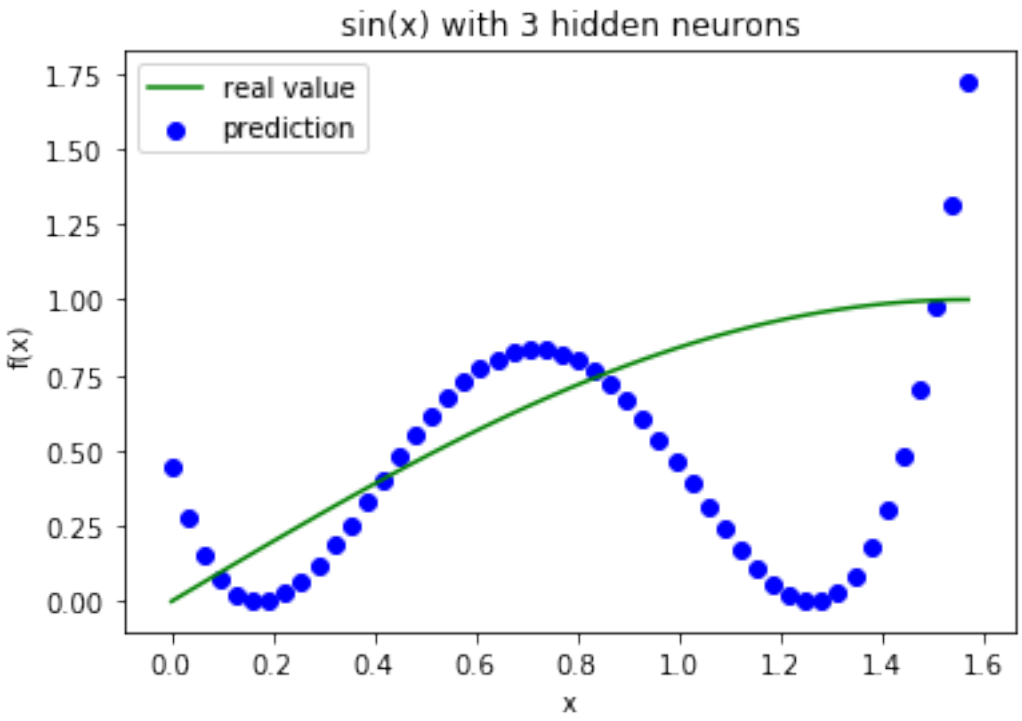

exp(-x) with 2 hidden neurons
real value
prediction
f(x)
x
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2
4
6
8
10

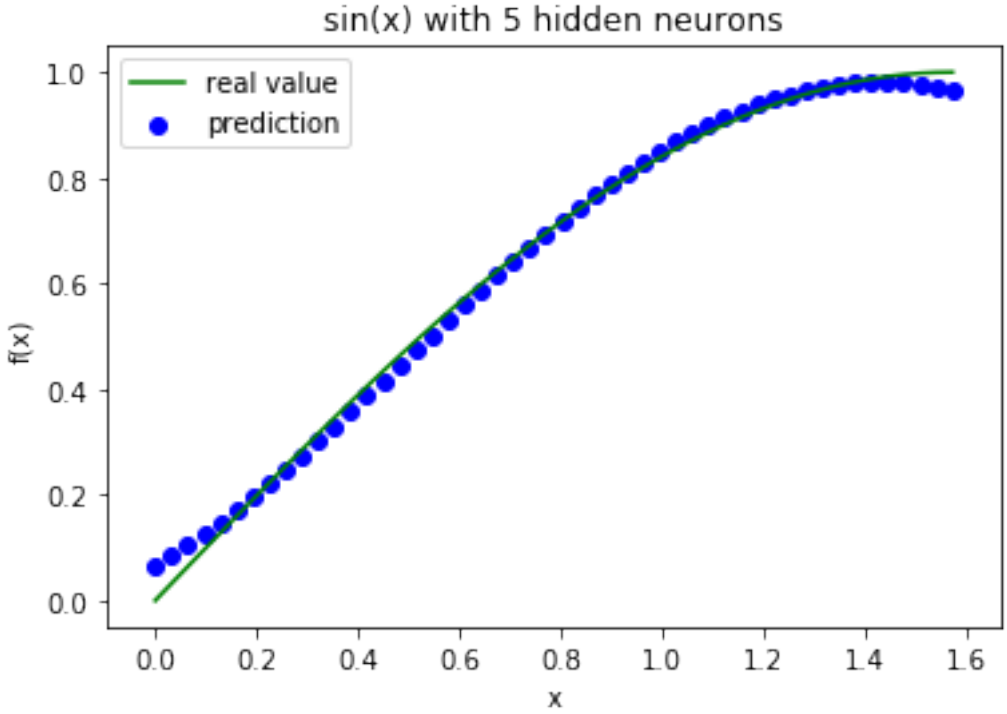

exp(-x) with 3 hidden neurons
real value
prediction
f(x)
x
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2
4
6
8
10


exp(-x) with 5 hidden neurons
real value
prediction
f(x)
x
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2
4
6
8
10


sin(x) with 1 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6


sin(x) with 2 hidden neurons
real value
prediction
f(x)
x
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6


sin(x) with 3 hidden neurons
real value
prediction
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
f(x)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
x


sin(x) with 5 hidden neurons
real value
prediction
1.0
0.8
0.6
0.4
0.2
0.0
f(x)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
x