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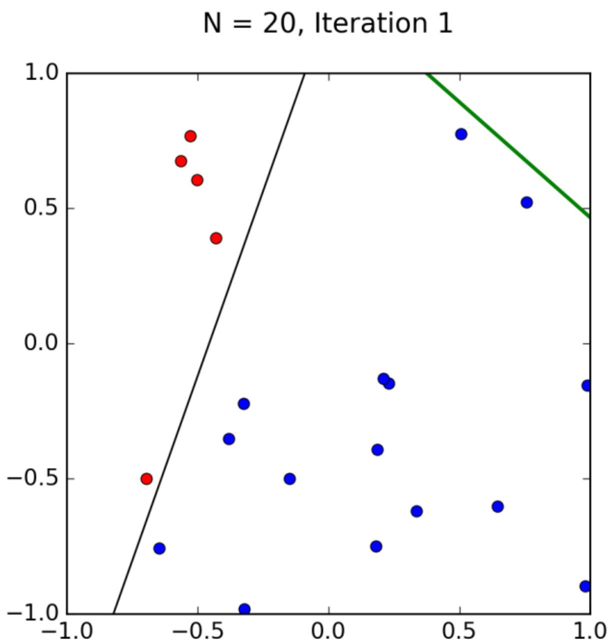
Artificial Intelligence

20 September 2016

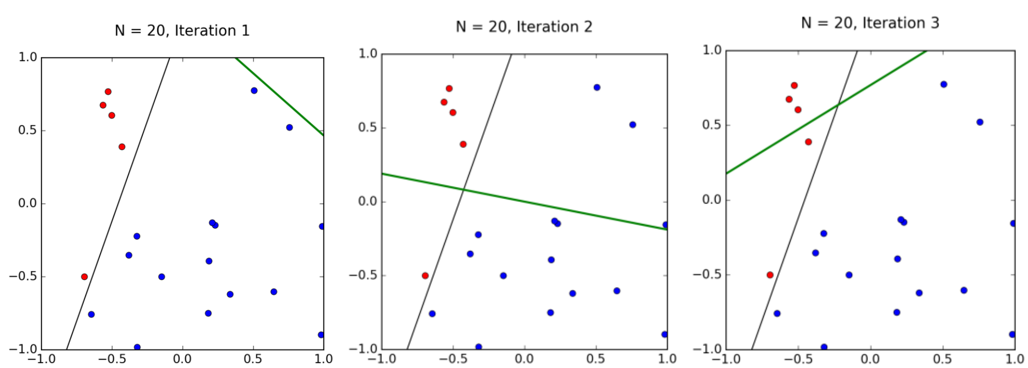
Homework 01

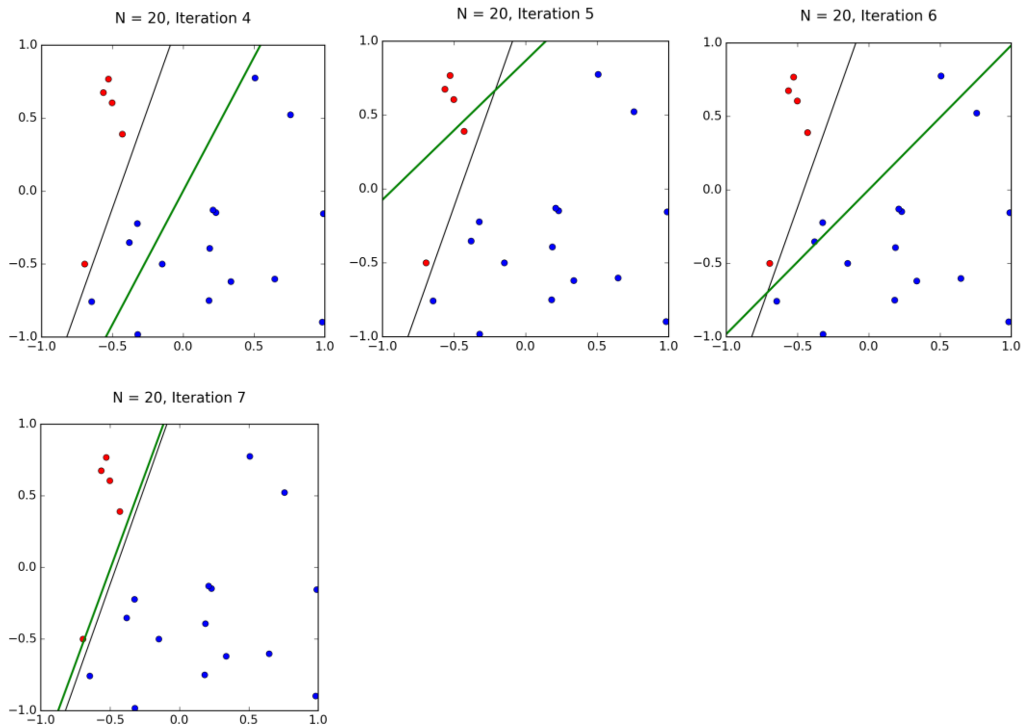
Problem 1.4

a.



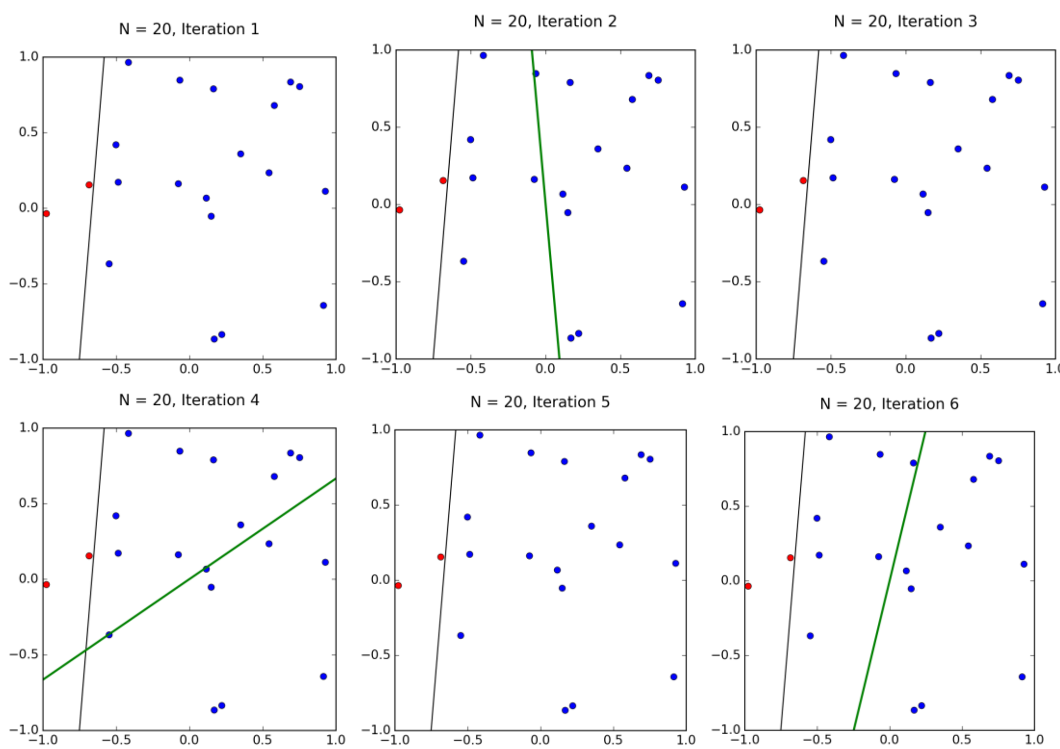

b.

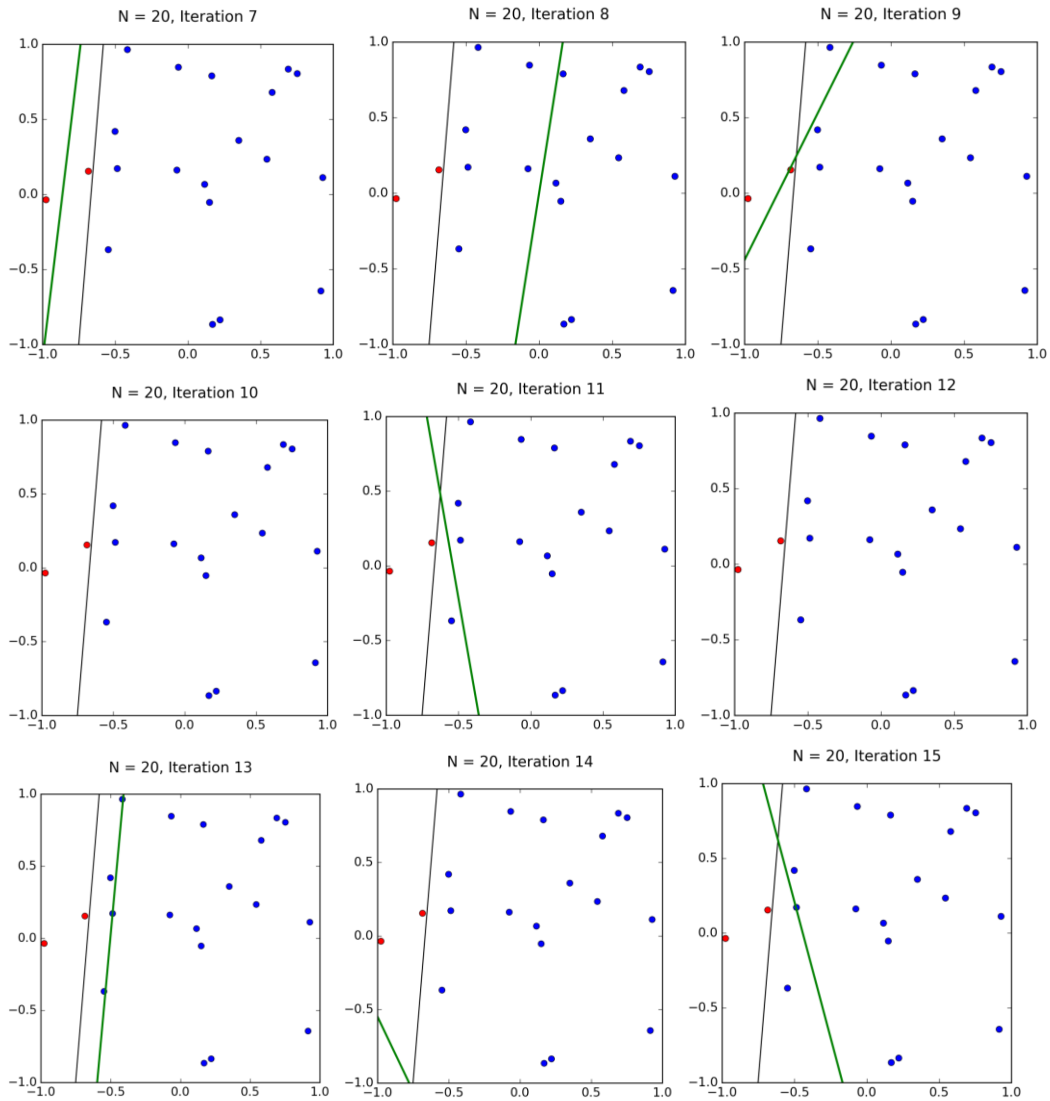


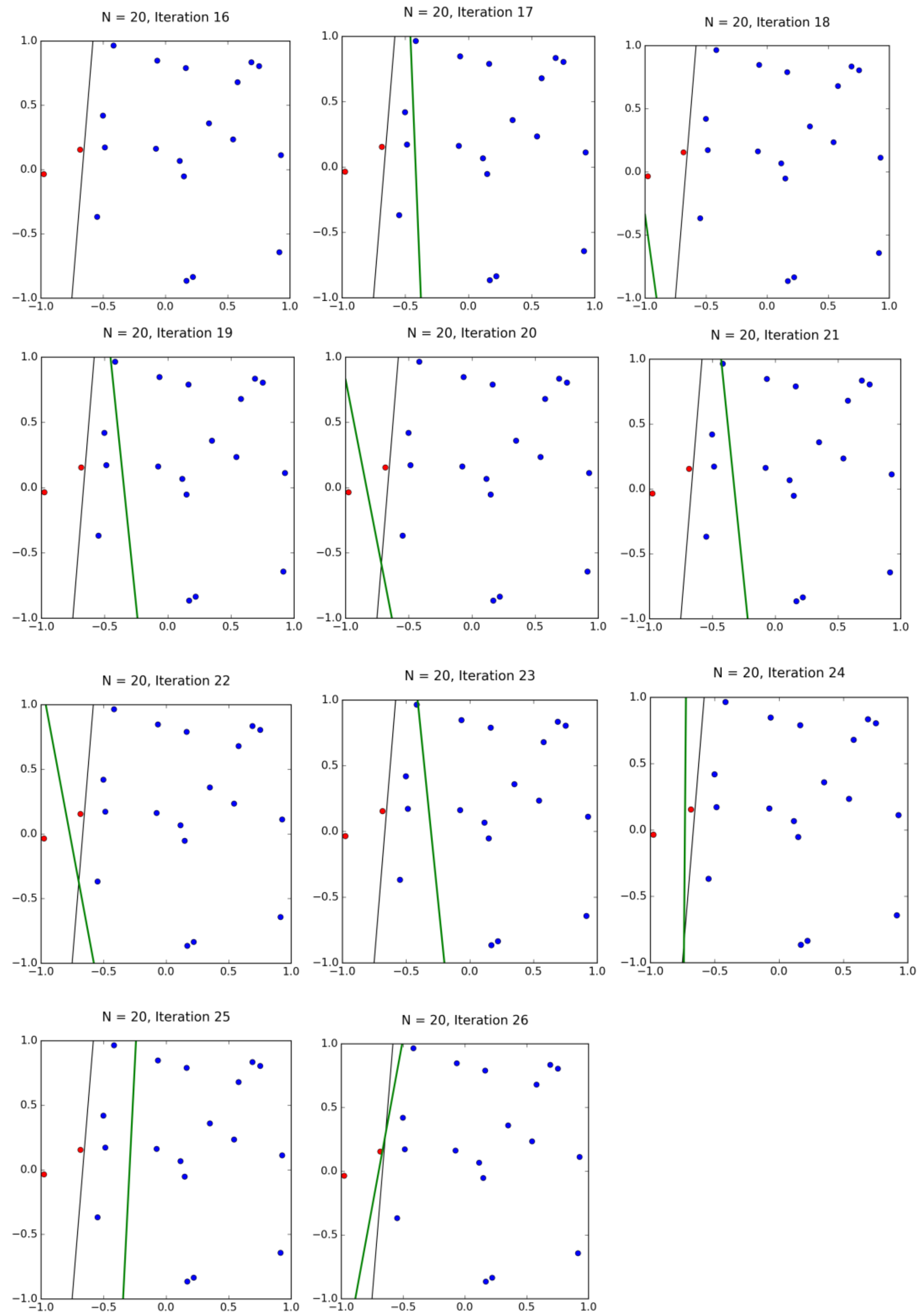



In this final iteration, *f* is reasonably close to *g*.

c.

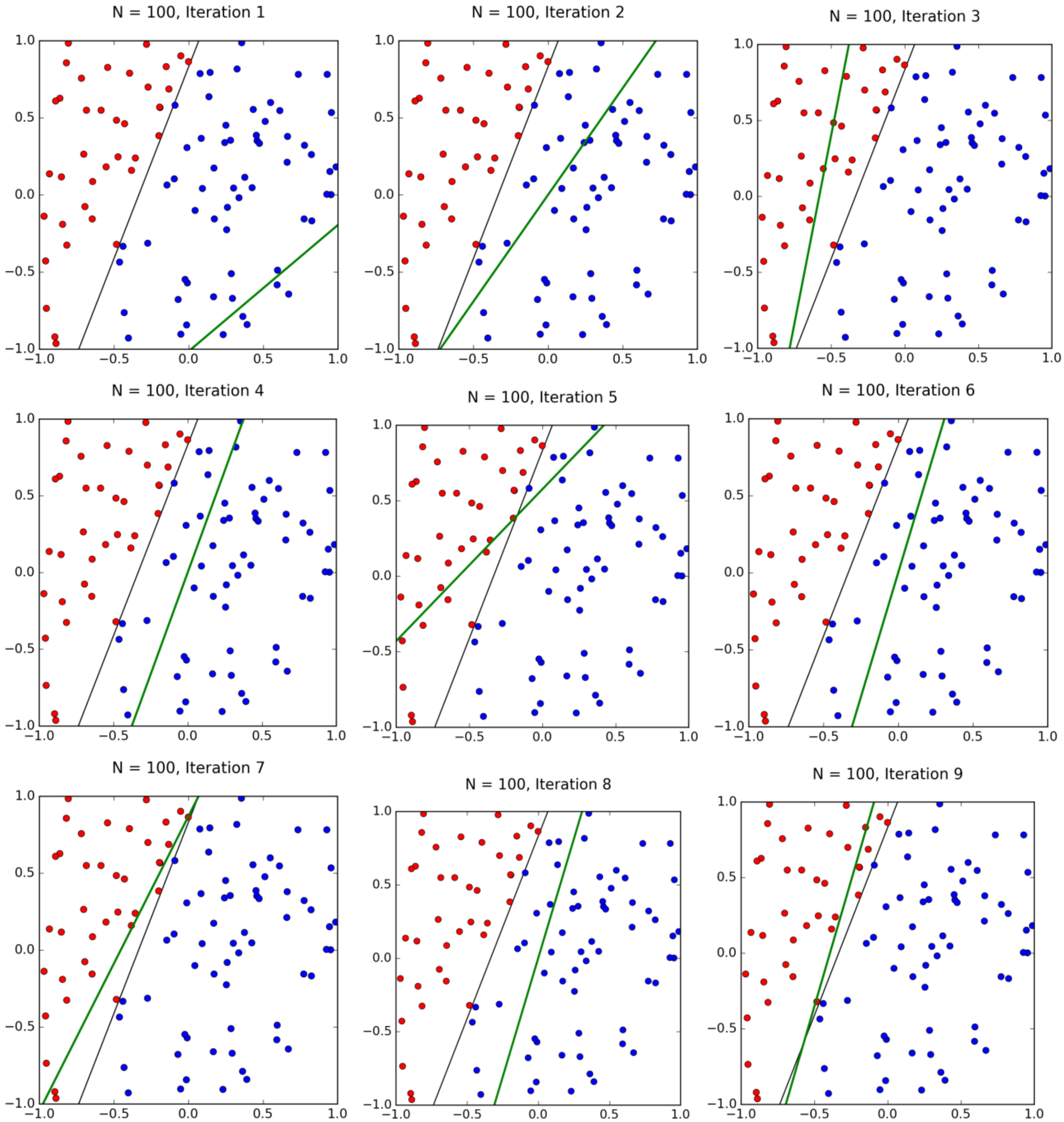


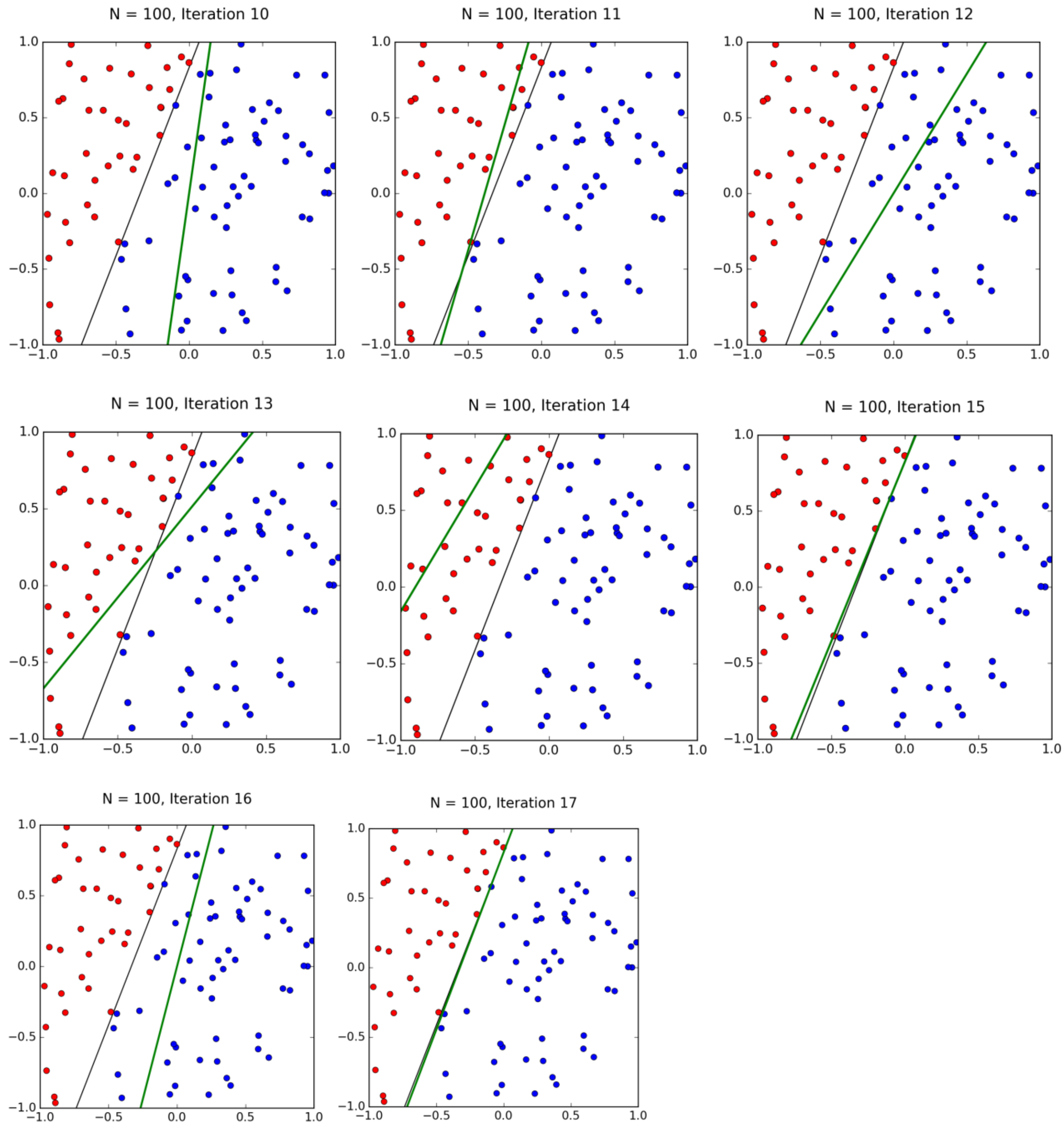

N = 20, Iteration 7
N = 20, Iteration 8
N = 20, Iteration 9
N = 20, Iteration 10
N = 20, Iteration 11
N = 20, Iteration 12
N = 20, Iteration 13
N = 20, Iteration 14
N = 20, Iteration 15




It took the perceptron algorithm significantly more iterations to reach a valid line separating the two classes, and *g* is not as close to *f* as it was in the first set.

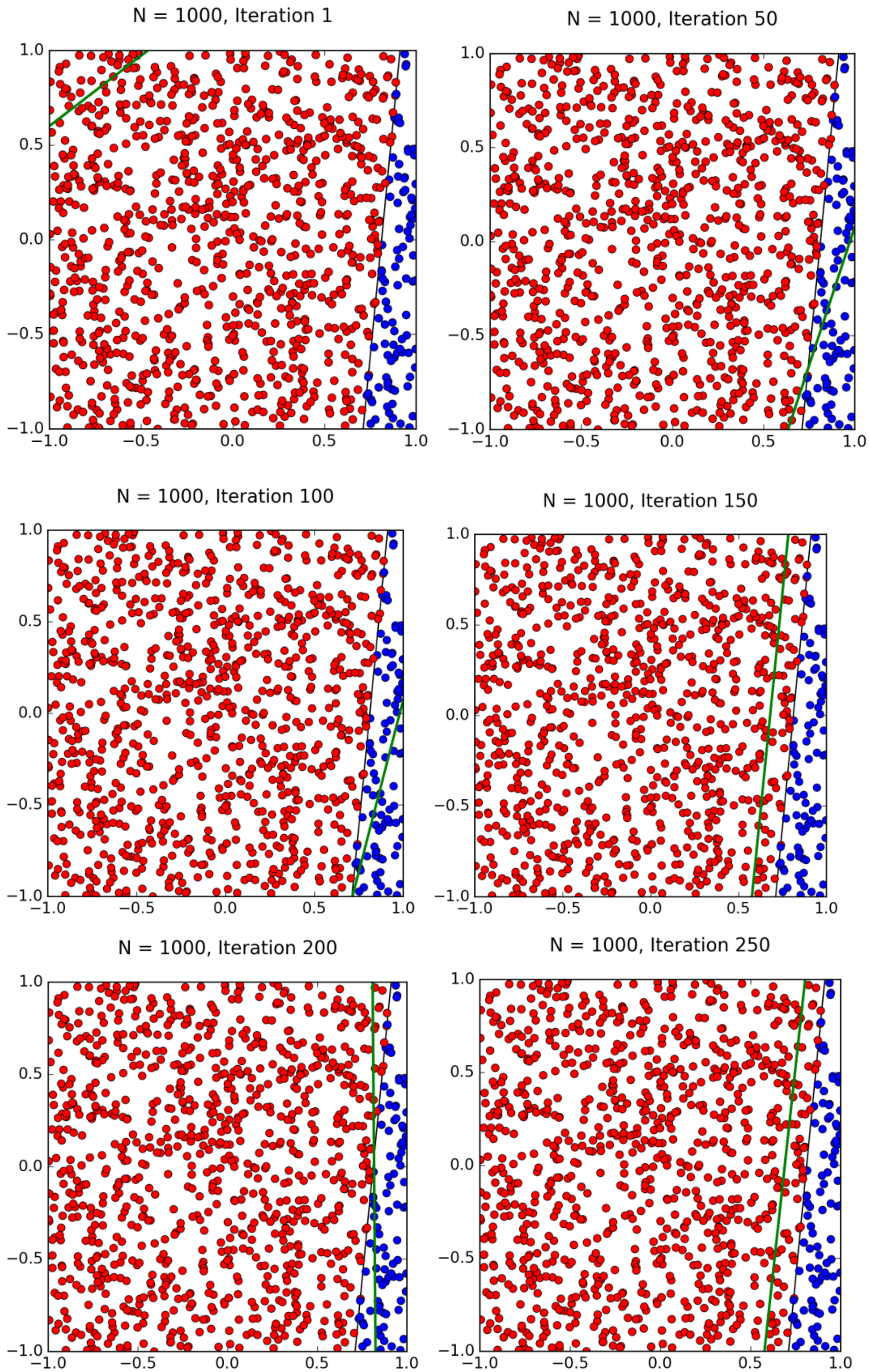
d.

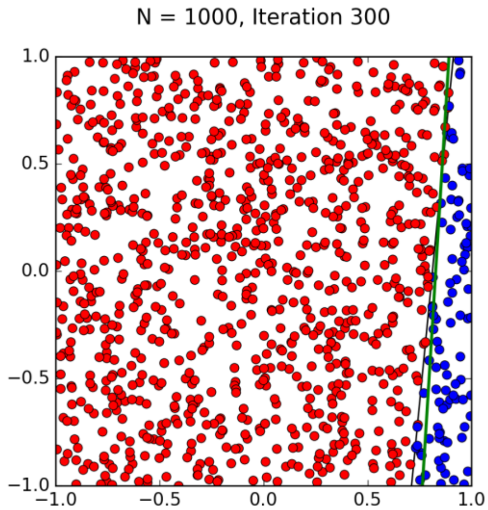

N = 100, Iteration 1
N = 100, Iteration 2
N = 100, Iteration 3
N = 100, Iteration 4
N = 100, Iteration 5
N = 100, Iteration 6
N = 100, Iteration 7
N = 100, Iteration 8
N = 100, Iteration 9

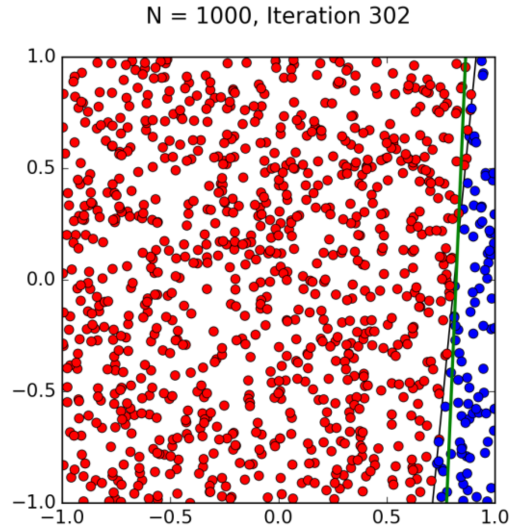



Surprisingly, the perceptron algorithm took only 17 iterations to compute a valid function for *g*, and it is very close to *f*.

e.


N = 1000, Iteration 1
N = 1000, Iteration 50
N = 1000, Iteration 100
N = 1000, Iteration 150
N = 1000, Iteration 200
N = 1000, Iteration 250




My computer just gave up after 302 iterations, but still got reasonably close to the target function.

f. & g.

I couldn't get my python code to work. Here is what I tried to do:

```
import numpy as np
import random
import os, subprocess
import matplotlib.pyplot as plt

class Perceptron:
  def __init__(self, N):
    # Random linearly separated data
    xA,yA,xB,yB = [random.uniform(-1, 1) for i in range(4)]
    self.V = np.array([xB*yA-xA*yB, yB-yA, xA-xB])
    self.X = self.generate_points(N)

  def generate_points(self, N):
    X = []
    for i in range(N):
      x1,x2,x3,x4,x5,x6,x7,x8,x9,x10 = [random.uniform(-1, 1) for i in range(2)]
      x = np.array([1,x1,x2,x3,x4,x5,x6,x7,x8,x9,x10])
      s = int(np.sign(self.V.T.dot(x)))
      X.append((x, s))
    return X

  def plot(self, mispts=None, vec=None, save=False):
    fig = plt.figure(figsize=(5,5))
```

```
        plt.xlim(-1,1)
        plt.ylim(-1,1)
        V = self.V
        a, b = -V[1]/V[2], -V[0]/V[2]
        l = np.linspace(-1,1)
        plt.plot(l, a*l+b, 'k-')
        cols = {1: 'r', -1: 'b'}
        for x,s in self.X:
            plt.plot(x[1], x[2], cols[s]+'o')
        if mispts:
            for x,s in mispts:
                plt.plot(x[1], x[2], cols[s]+'.')
        if vec != None:
            aa, bb = -vec[1]/vec[2], -vec[0]/vec[2]
            plt.plot(l, aa*l+bb, 'g-', lw=2)
        if save:
            if not mispts:
                plt.title('N = %s' % (str(len(self.X))))
            else:
                plt.title('N = %s with %s test points' \
                          % (str(len(self.X)),str(len(mispts))))
            plt.savefig('p_N%s' % (str(len(self.X))), \
                        dpi=200, bbox_inches='tight')

    def classification_error(self, vec, pts=None):
        # Error defined as fraction of misclassified points
        if not pts:
            pts = self.X
        M = len(pts)
        n_mispts = 0
        for x,s in pts:
            if int(np.sign(vec.T.dot(x))) != s:
                n_mispts += 1
        error = n_mispts / float(M)
        return error

    def choose_miscl_point(self, vec):
        # Choose a random point among the misclassified
        pts = self.X
        mispts = []
        for x,s in pts:
            if int(np.sign(vec.T.dot(x))) != s:
                mispts.append((x, s))
        return mispts[random.randrange(0,len(mispts))]
```

```
    def pla(self, save=False):
        # Initialize the weigths to zeros
        w = np.zeros(3)
        X, N = self.X, len(self.X)
        it = 0
        # Iterate until all points are correctly classified
        while self.classification_error(w) != 0:
            it += 1
            # Pick random misclassified point
            x, s = self.choose_miscl_point(w)
            # Update weights
            w += s*x
            if save:
                self.plot(vec=w)
                plt.title('N = %s, Iteration %s\n' \
                          % (str(N),str(it)))
                plt.savefig('p_N%s_it%s' % (str(N),str(it)), \
                            dpi=200, bbox_inches='tight')
        self.w = w

    def check_error(self, M, vec):
        check_pts = self.generate_points(M)
        return self.classification_error(vec, pts=check_pts)

p = Perceptron(20)
p.pla(save = True)
```

It’s a modified version of the code you told us to use in class.

h.

Based on the observations I was able to make, the accuracy (A) and running time (t) increase with the number of elements (N) and dimensions (d); meaning that accuracy and running time are directly correlated to number of elements and dimensions.

My educated guess for the formula would be:

$A = N^d / t$