IE510
HW#4
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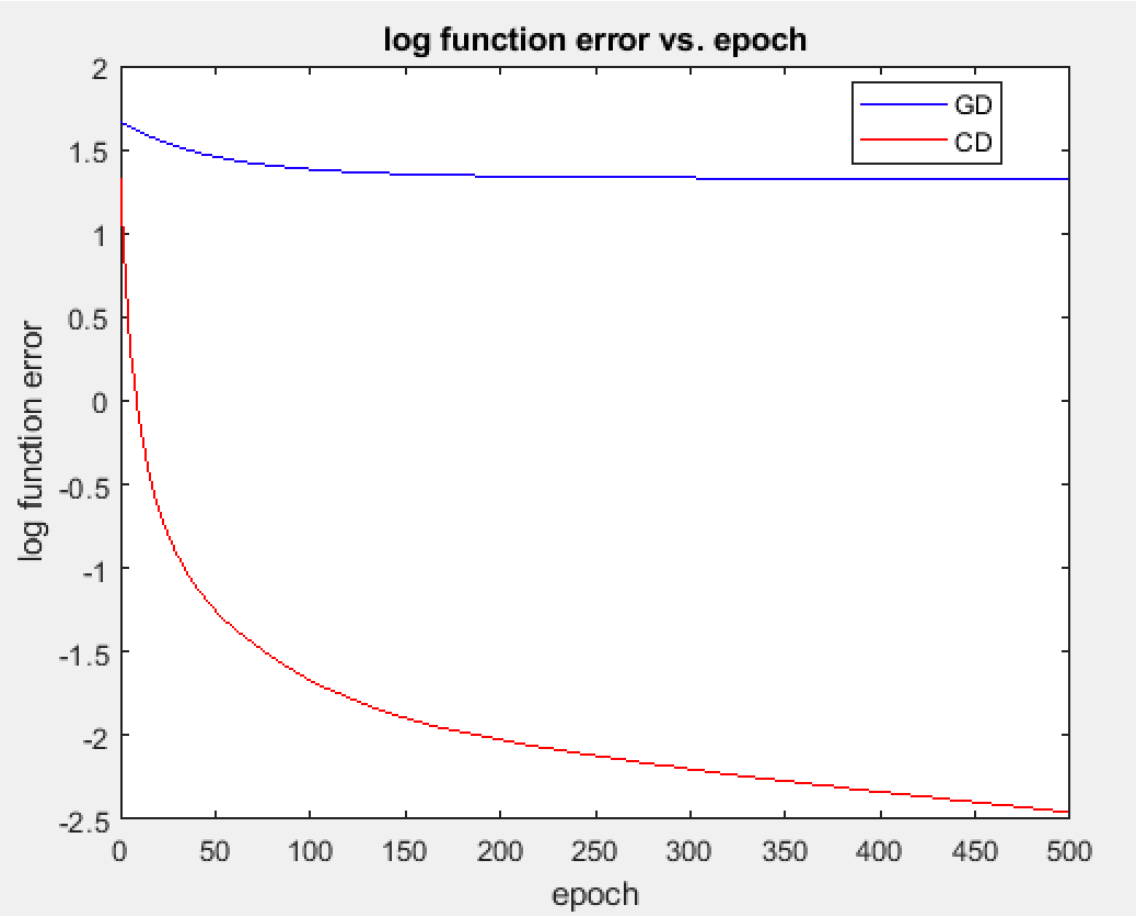
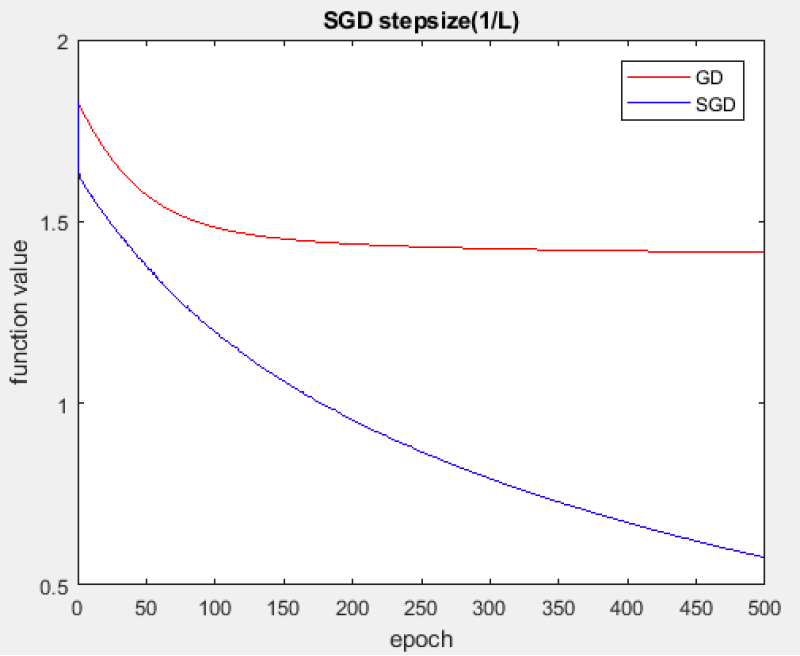
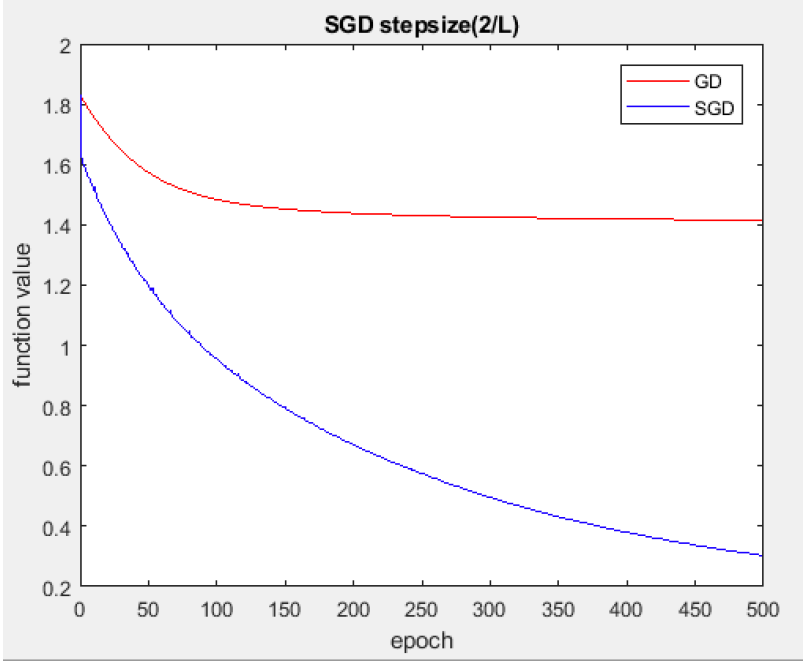
1. (a)



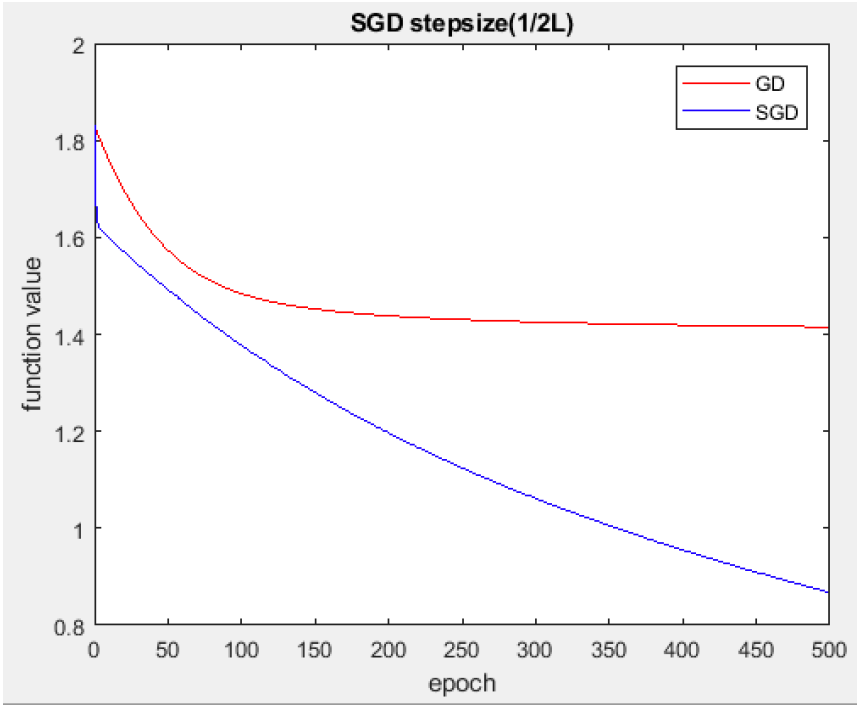
1.(c) SGD (stepsize = 1/L) vs. GD:



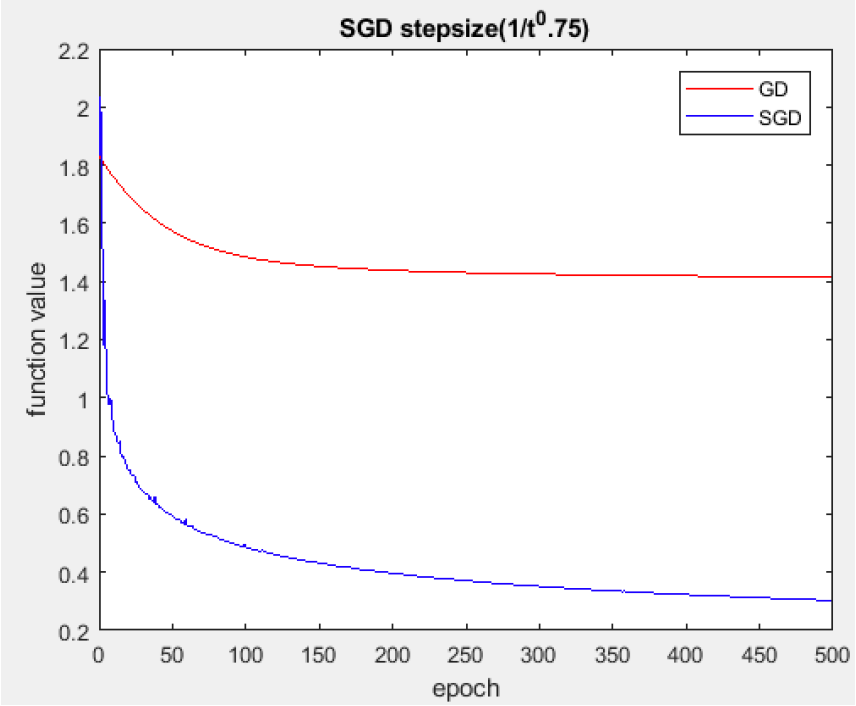
SGD (stepsize = 2/L) vs. GD:



SGD (stepsize = 1/2L) vs. GD:



SGD (stepsize = 1/t^0.75) vs. GD:



1.(a) code(gd vs. cd)

```
%s = rng;
rng(s);
n = 100;
B = rand(n, n);
A = zeros(n,n);
x = normrnd(0,1,[n,1]);
y = x;
for j = 1:n
    for i= 1:n
        A(i,j) = B(i,j)/norm(B(:,j));
    end
end

L = max(eig(A'*A));
alpha = 1/L;
func_gd = zeros(max_it + 1, 1);
func_gd(1) = log10((norm(A*x)^2));
max_it = 500;
ite = 1;
kappa = max(eig(A'*A))/min(eig(A'*A));
while(ite<=max_it)
    gradient = 2*(A'*A)*x;
    x = x - alpha*gradient;
    func_gd(ite+1) = log10((norm(A*x)^2));
    ite = ite +1;
end

%CD
func_cd = zeros(max_it + 1, 1);
func_cd(1) = log10(norm(A*x)^2);
ite = 1;
r = -A*y;

while(ite<=max_it)
    for j = 1:n
        i = randi([1 100]);
        x_old = y(i);
        y(i) = A(:,i)'*r /(A(:,i)'*A(:,i)) + y(i);
        r = r + A(:,i) * (x_old - y(i));
    end
    func_cd(ite+1) = log10(norm(A*y)^2);
    ite = ite +1;
end
figure;
plot_length = max_it;
plot_vec = 0:1:plot_length-1;
plot(plot_vec, func_gd(1:plot_length), 'b-');
hold on;
plot(plot_vec, func_cd(1:plot_length), 'r-');
xlabel('epoch');
ylabel('log function error');
legend('GD','CD')
title('log function error vs. epoch');
```

1.(c)sgd

```
%rng('default')
rng(s);
n = 100;
B = rand(n, n);
A = zeros(n,n);
x = normrnd(0,1,[n,1]);
y = x;
for j = 1:n
    for i= 1:n
        A(i,j) = B(i,j)/norm(B(:,j));
    end
end

%gd
L = max(eig(A'*A));
alpha = 1/L;
max_it = 500;
func_gd = zeros(max_it + 1, 1);
func_gd(1) = log10((norm(A*x)^2));
ite = 1;
while(ite<=max_it)
    gradient = 2*(A'*A)*x;
    x = x - alpha*gradient;
    func_gd(ite+1) = log10((norm(A*x)^2));
    ite = ite +1;
end

%sgd
alpha = 1/2/L;
func_sgd = zeros(max_it + 1, 1);
func_sgd(1) = log10(norm(A*y)^2);
ite = 1;

while(ite<=max_it)
    p = randperm(n);
    for i = 1:n
        gradient = 2*A(:,p(i))* A(:,p(i))' * y;
        y = y - 1/ite^0.75*gradient;
    end
    func_sgd(ite+1) = log10(norm(A*y)^2);
    ite = ite +1;
end

figure;
plot_length = max_it;
plot_vec = 0:1:plot_length-1;
plot(plot_vec, func_gd(1:plot_length), 'r-');
hold on;
plot(plot_vec, func_sgd(1:plot_length), 'b-');
xlabel('epoch');
ylabel('function value');
legend('GD','SGD')
title('SGD stepsize(1/t^0.75)');
```