Wet assignment

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# Part 0.

## Question 1.

For a single measurement we have:

Where:

Inserting into :

In a vector multiplication form:

And for the different measurements we can write in a vector form:

Where contains the measurements (which include the noise).

By aiming to minimize the following problem:

We try to find the coefficients which can ‘describe’ the measurements in a best way.

## Question 2.

Convexity:

* The problem is defined over the whole range , without constraints. This range is a convex set
* The objective function is a squared Euclidean distance, which is a smooth convex function.

To find the minimum analytically, we need to make derivative w.r.t **.**

is of rank , thus is a full rank matrix. So the inverse exists, and we can write:

Which is the analytical solution.

# Part 1.

## Question 3+4.

The function with the desired parameters was created, and the corresponding noise was added. The function was written which has estimated the vector, according to the analytical solution derived in Question 2. The graph is the following:

Chart, scatter chart

Description automatically generated

We can indeed see that the Estimated function is not completely equal to the True original function. But this function minimizes the objective function that was defined.

## Question 5+6.

The function was written that performs the Projected Gradient Descent algorithm with 2 possible step size calculations as described in the HW assignment. The graphs obtained are the following:

Chart, line chart

Description automatically generated

The additional operation of taking absolute value was added to the Error function.

We can indeed see that the AdaGrad step size converges much faster and gives a much smaller error over smaller number of iterations. The reason is that it takes into account all the previous gradients, and adapts the step size accordingly.

## Question 7.

We shall find the smoothness parameter L of the objective function.

From the definition of smoothness:

Reminder:

Inserting:

**To be continued…**

## Question 8.

The following graph was obtained:

Chart, line chart

Description automatically generated

We can see that for the constant step size of 1/L we have the best convergence, indeed as was proved in the lectures and tutorials.

For step size of 10/L the algorithm “jumps over” the minimum point. The ‘update’ step is moving in the direction of the negative gradient, but the step is too big.

For 1/10L the algorithm would also converge, but it will take longer, as we may observe.

## Question 9.

The graph obtained is the following:

Chart, line chart

Description automatically generated

**FILL EXPLANATION**