Data Analysis - 2021

Exercise sheet no 5: 23. November 2021
The least squares method

- `scipy.optimize.curve_fit`

Exercise 1: Least squares fit using Ohm's law (8 Points)

The file `current_measurements.txt`, contains a set of 6 measurements of the current as a function of the voltage to measure the resistance, R. The first column is the voltage value and the second column is the current value. The uncertainty for each measurement is 0.2A.

(a) Plot the current measurements as a function of the voltage.

(b) Write a function which calculates the χ^2 value for the central values as a function of the resistance, R. The fitted function should be Ohm's law.

(c) Plot this χ^2 function as a function of the resistance and use the plot to find the minimum value of the χ^2 and best fit value of R.

(d) Compare this best fit value to the one you obtain using the analytical formulae described in the lecture for linear regression. Do they agree?

(e) Read off the uncertainties on R by using the $\Delta(\chi^2) = 1$ rule. Does this agree with the analytical formula shown in the lecture?

Exercise 2: Least squares fit using Ohm's law (varying uncertainties) (12 Points)

Now its time to include varying uncertainties on the measurements. The file `current_measurements_uncertainties.txt`, contains a set of 6 measurements of the current as a function of the voltage to measure the resistance, R. The first column is the voltage value and the second column is the current value and **the third column is the uncertainty on the current**.

(a) Include the varying uncertainties in the χ^2 function.

(b) Plot this new χ^2 function as a function of the resistance and use the plot to find the minimum value of the χ^2 and best fit value of R.

(c) Overlay the best fit function on your plot of the measurements. Does it look like a good fit?

(d) Read off the uncertainties on R by using the $\Delta(\chi^2) = 1$ rule. Is the value compatible with the known value of $R = 2\,\Omega$?

(e) Modify your χ^2 function to add a fixed offset parameter $\epsilon_{bias} = 0.7\,A$ as shown in the lecture and recalculate the best fit R value with its uncertainty. Is it now compataible with $R = 2\,\Omega$?

(f) Compare the χ^2/ndf with and without the bias offset and calculate the goodness-of-fit probability for both cases.

(g) Use the `scipy.optimize.curve_fit` method to fit the function to the data and optimise both the R and ϵ_{bias} parameters simultaneously.

(h) Use the covariance matrix returned by the `scipy.optimize.curve_fit` to calculate the uncertainties on R and ϵ_{bias} and their correlation coefficient. How does the uncertainty on R compared to your answer in e)?

Deadline for submission: Friday, 3. December 2021 14:00
Form: Please submit your solutions to da@physik.uzh.ch. The solutions should be submitted as a single python script with answers to specific questions printed out.