LSQ Intro

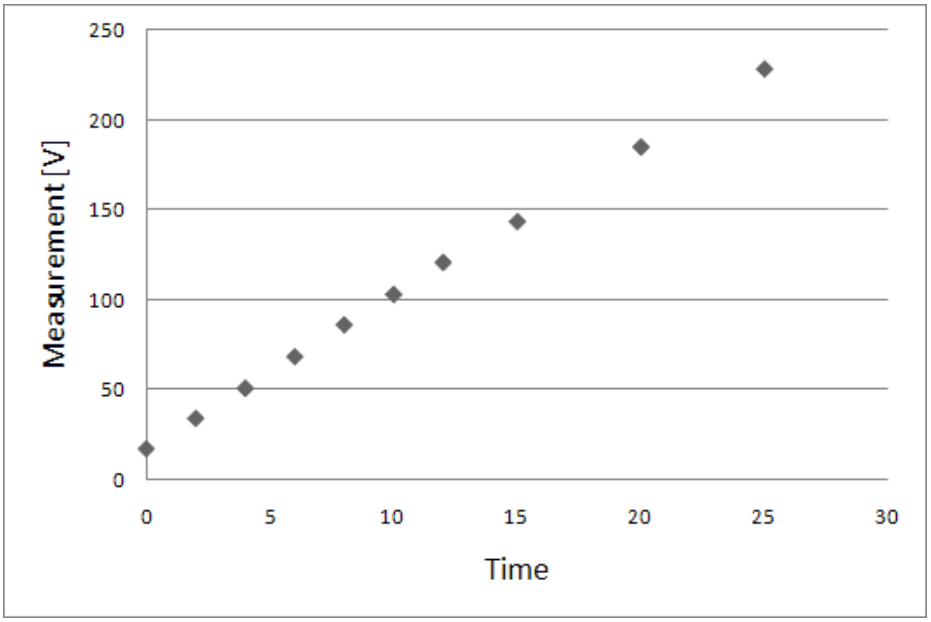
The LSQ application is a little tool to estimate parameters of a model.
To do this, you need to follow three basic steps:

- Guess a mathematical model
- Compute consequences
- Check residuals

The first step requires intuition and experience, but in some cases it is simple, as we will see.
The second step requires measurements from the real world to test our model.
And in the third step we analyse our calculations and check if our model fits the real world.

LSQ can help you with each step. For a better illustration, let's try to calculate the parameters of a simple model.

Step 1



As we can see in the picture, the data points appear to follow a linear pattern. As a result, we formulate our mathematical model as:

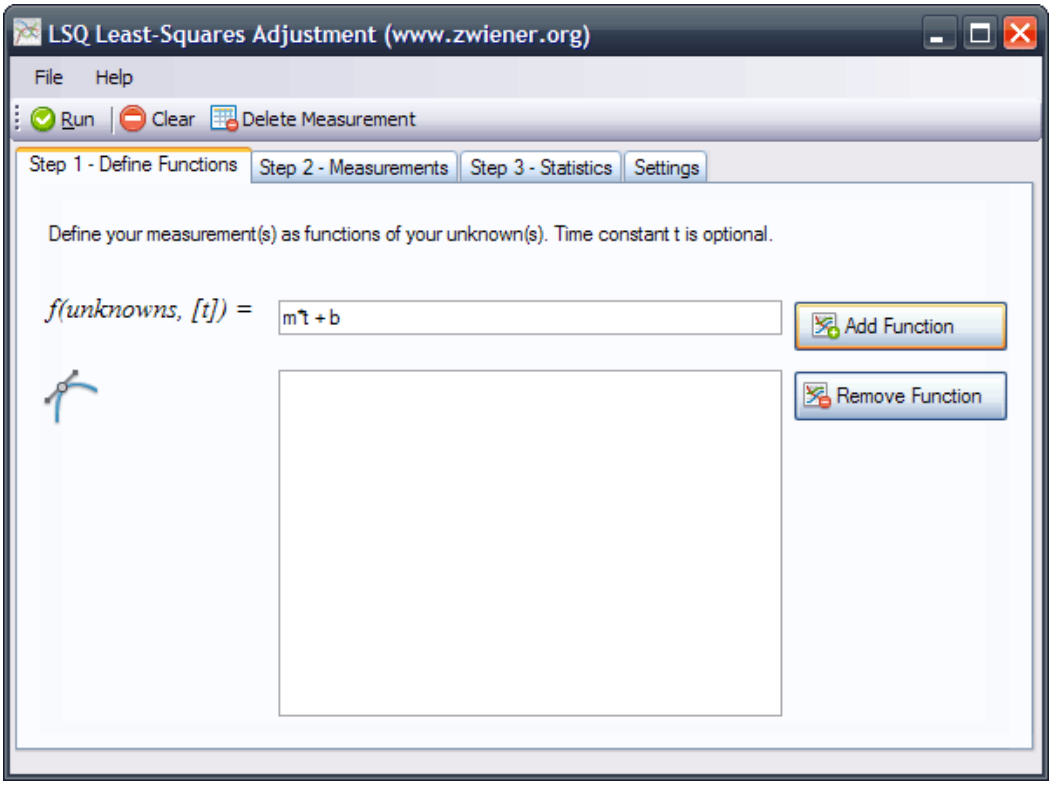
$$l = m \cdot t + b$$

Where l is the measurement, t is the time and m and b are the actual unknowns of our mathematical model.
Before we continue with step 2, it is important to outline the way you have to formulate your mathematical model, so that LSQ can understand and use it.

$$l + v = f(x_1, x_2, x_3, ..., x_n, [t])$$

This is the basic way you have to express your mathematical model. You can read it like this: you take your unknowns, put them into a function and as a result you get your measurement and a residual v.
The residual v comes from the fact that no real world measurement is error free.
As you can see in this equation, the parameter t is indicated as optional. Not every mathematical model needs a time constant.
But in our example here, the time constant t is quite useful.

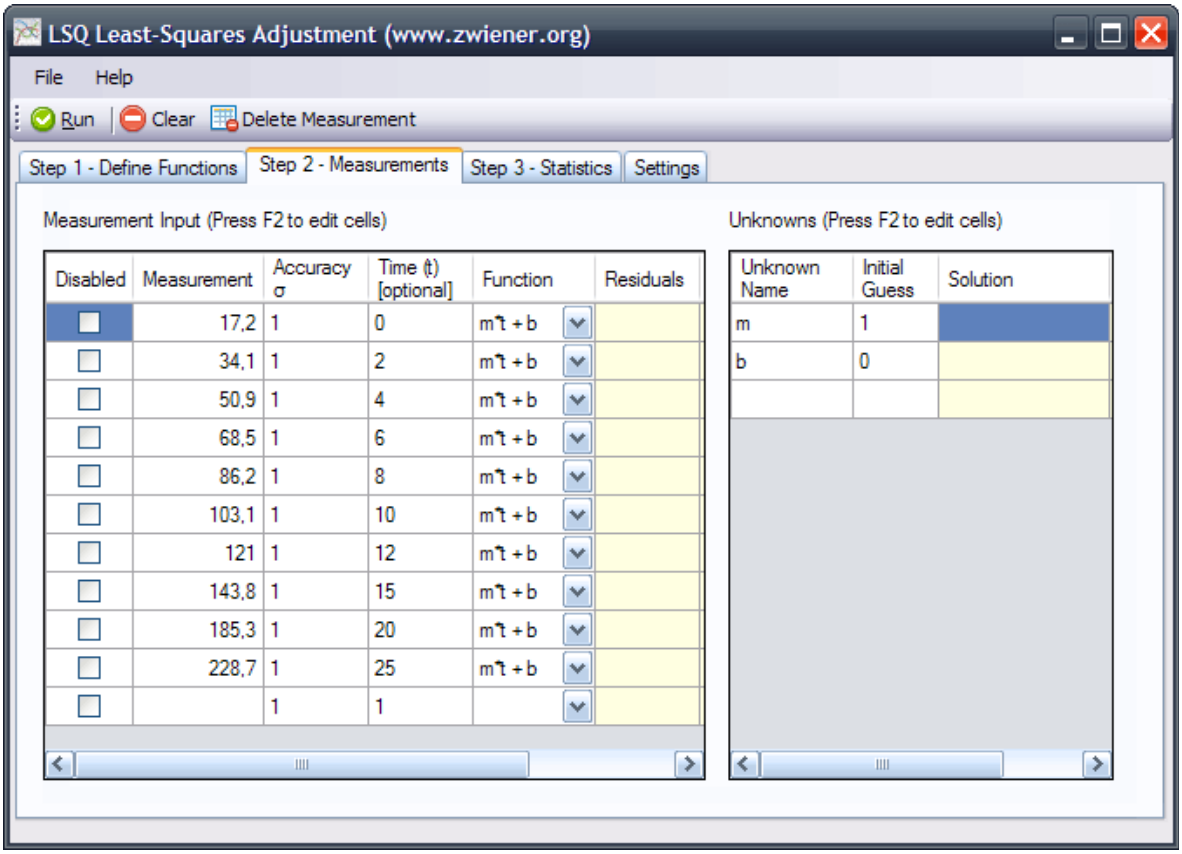
Let's start LSQ and go to the first tab:



We enter our mathematical model in the text box and click on the Add Function button. A more complex scenario could require more functions, but in this case one function is sufficient.

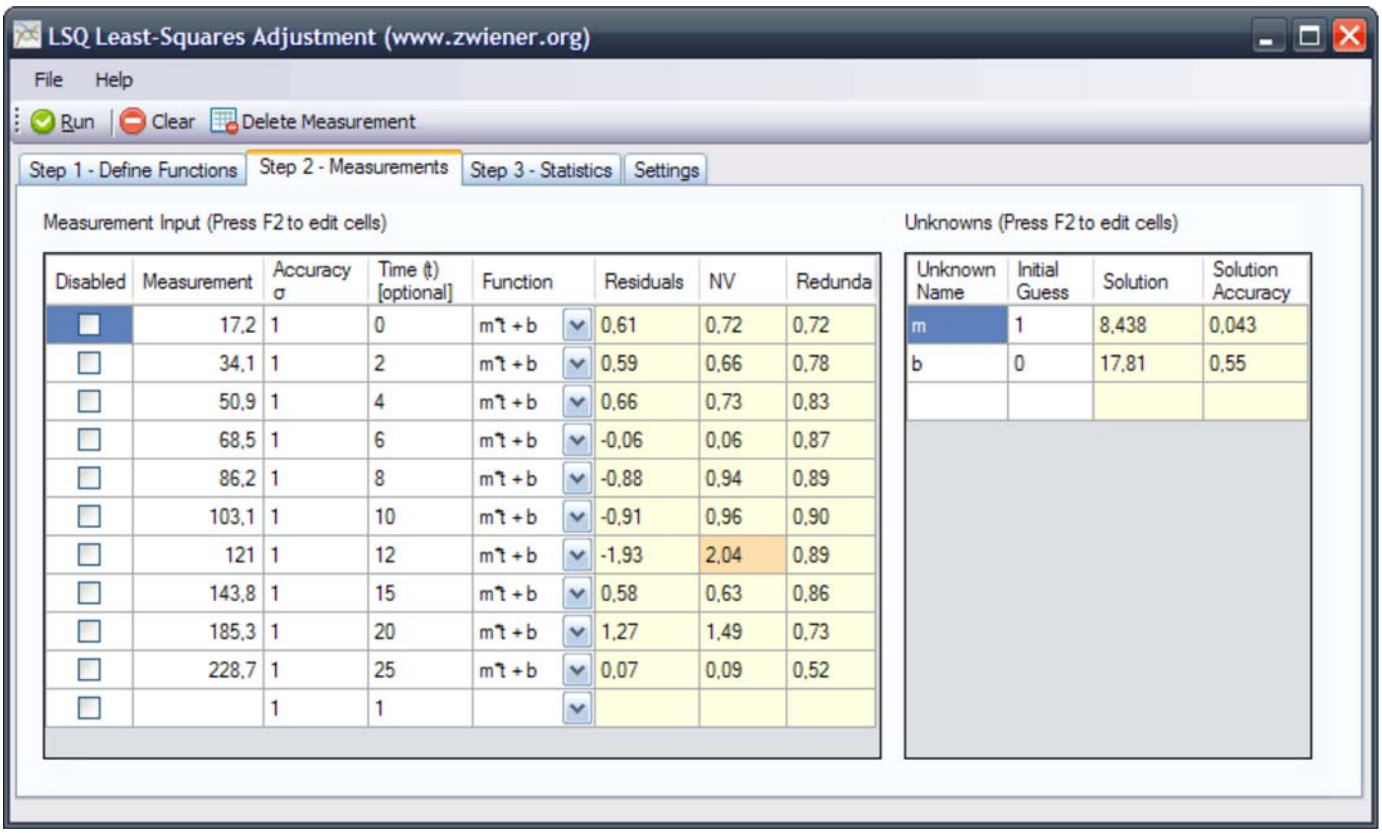
Step 2

To test our model, we have to enter all the measurements into LSQ and select the matching function:



As we have no information about our measurement accuracy, the accuracy column gets a standard value of 1.
Note that the accuracy column expects standard deviations.
Now we are ready to test our model. Click on the Run button to start the computation.

The following screen shows the least-squares adjustment results.

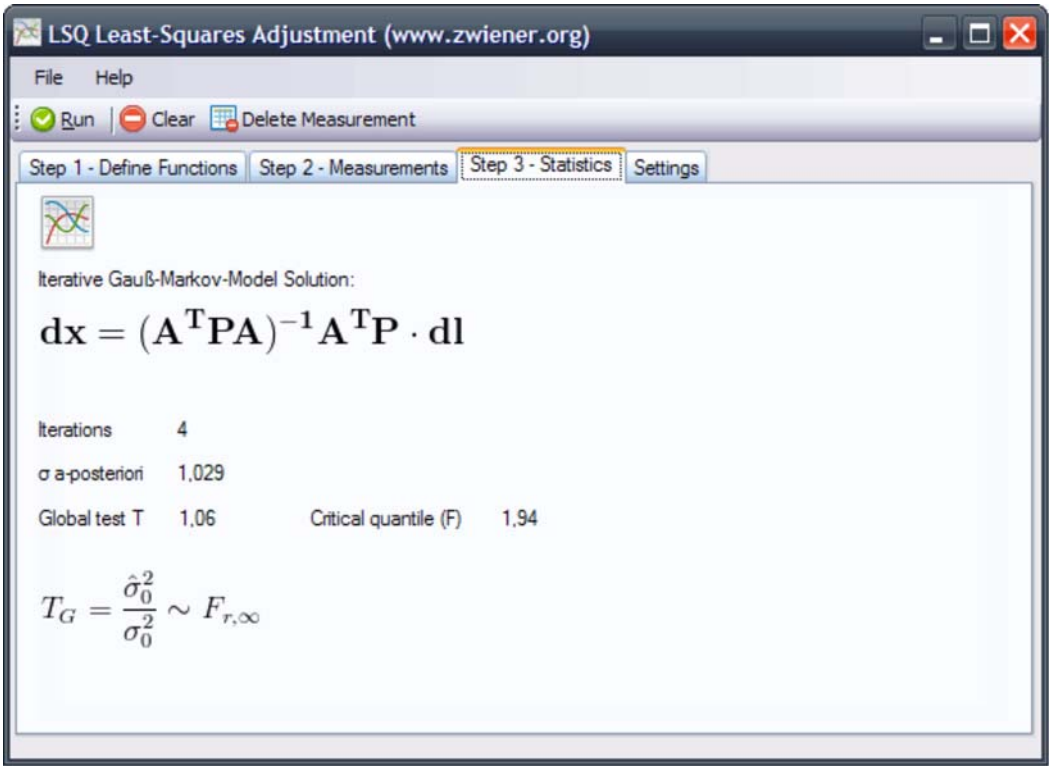


The estimated values for m and b are shown in the Solution column.
The accuracy (expressed as standard deviation) is displayed in the Solution Accuracy column.

Step 3

As you can see, the residuals are shown and next to the residuals is a column for the normalized residuals.
The normalized residuals (NV) are a good way to detect outliers.
So in this data, there is eventually an error in measurement 7.

In tab page 3, we can take a look at the so called global test.
The global test can be considered as a statistical hypothesis test.
If our test value is greater than the critical quantile, there is either a measurement error,
or our mathematical model is wrong.



Built in functions

Name	Argc.	Explanation
`sin`	1	sine function
`cos`	1	cosine function
`tan`	1	tangens function
`asin`	1	arcus sine function
`acos`	1	arcus cosine function
`atan`	1	arcus tangens function
`sinh`	1	hyperbolic sine function
`cosh`	1	hyperbolic cosine
`tanh`	1	hyperbolic tangens function
`asinh`	1	hyperbolic arcus sine function
`acosh`	1	hyperbolic arcus tangens function
`atanh`	1	hyperbolic arcus tangens function
`log2`	1	logarithm to the base 2
`log10`	1	logarithm to the base 10
`log`	1	logarithm to the base 10
`ln`	1	logarithm to base e (2.71828...)
`exp`	1	e raised to the power of x
`sqrt`	1	square root of a value
`sign`	1	sign function, -1 if x<0; 1 if x>0
`rint`	1	round to nearest integer
`abs`	1	absolute value
`min`	var.	min of all arguments
`max`	var.	max of all arguments
`sum`	var.	sum of all arguments
`avg`	var.	mean value of all arguments