

## Research and Practice on Teaching Mode of Error Theory and Data Processing

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**Abstract.** Error theory and data processing is a compulsory course for measuring and controlling technology and instrument specialty in Colleges and universities. Students can master data processing methods, correctly estimate the measured value and scientifically evaluate of measurement results by learning this course. The characters of error theory and data processing are wide range of knowledge, deep mathematical theory and strong applicability. Traditional teaching model teachers often focus on the basic theory, ignoring the applications, which will cause that work is not completed well, work efficiency is too low for students to engage in specific related work. In this paper, MATLAB as an example to explore the application of data analysis software in error theory and data processing courses.

### Introduction

SPOC is the abbreviation of English for small private online course; the Chinese meaning is "small-scale restricted online course". SPOC is a concept corresponding to the MOOC. SPOC mode applied to campus teaching, teachers share the learning resources to students, and students self-study before class. Teachers are no longer taught in class, only to communicate with students in order to solve the problem in this teach mode. Teachers can focus on the application of MATLAB, Excel and DPS to solve the problem of error theory and data processing[1-3].

### Application of MATLAB in Error Theory and Data Processing

**The Brief Introduction of MATLAB.** MATLAB is a commercial mathematics software produced by The MathWorks company, which has the characteristics of simple statement, high programming efficiency, user convenience, good interactivity and strong data visualization. With the upgrade version of the MATLAB, the perfect function, today, MATLAB has been developed into a powerful large-scale software which is suitable for a lot of subjects and many work platforms. It has been widely used in control, communication, signal processing and scientific computing.

**The Treatment of System Error.** The system error is in the same measurement conditions, for the same object of repeated measurements, the sign and magnitude of the error value (positive or negative) remain unchanged, or when condition change, which are changed according to certain rule<sup>[4,5]</sup>. Residual error observation method is simple, intuitive, which is mainly based on the measurement of the residual error in each column and the variation of the symbols, directly from the error graph to determine whether the system error is existing. MATLAB has powerful mapping function, and residual error of the measurement data can be mapped by using. Then the system error of regular variation can be judged from chart. Related commands are as follows.

- (1) average value: mean( )
- (2) drawing: plot( )

Example 1:

The thermostat temperature is measured 10 times, the measured data are as follows:

20.06, 20.07, 20.06, 20.08, 20.10, 20.12, 20.14, 20.18, 20.18, 20.21.

To determine whether there is a changed system error.

The program is as follows:

```
t=[20.06,20.07,20.06,20.08,20.10,20.12,20.14,20.18,20.18,20.21];
t_average=mean(t);
t_cancha=t-t_average;
plot(t_cancha)
```

The execution result is shown in Fig. 1.

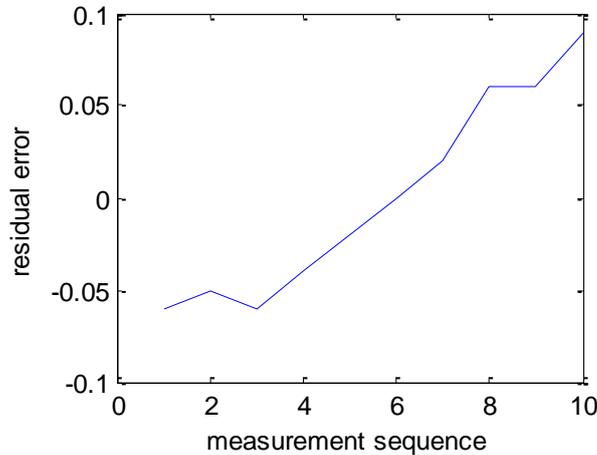


Figure 1. The curve of residual error

It can be seen from Fig. 1 that there is a system error of linear variation in the measurement data.

**Least Square Method Based on MATLAB.** The least squares method can solve the most reliable estimation of the parameters, the data processing of the combined measurement, and fitting the empirical formula with the experimental data, so the least square method has been widely used in many fields<sup>[6,7]</sup>. Least squares processing step is relatively cumbersome, but the application of MATLAB can simplify the complex. The relevant commands of least-squares method based on MATLAB for linear parameter are as follows:

Assuming that the measured data column vector is L, the coefficient matrix of the error equation is A, the number of equations is n, the number of unknowns is t.

- (1) the best estimate of parameters:  $X = \text{inv}(A' * A) * A' * L$
- (2) residual error:  $V = L - A * X$
- (3) accuracy estimation of measurement data:  $\sigma = \text{sqrt}(V' * V / (n - t))$
- (4) accuracy estimation of estimator

Example 2:

The measurement equation is as follows:

$$\begin{cases} 3x + y = 2.9 \\ x - 2y = 0.9 \\ 2x - 3y = 1.9 \end{cases}$$

Try to seek x, y least squares processing and its corresponding accuracy.

The program is as follows:

```
n=3;
t=2;
L=[2.9;0.9;1.9];
A=[3 1;1 -2;2 -3];
```

The execution result is as follows:

```
X =
    0.9626
    0.0152
Y =
    0.0109
```

0.0109

### Application of Excel in Error Theory and Data Processing

**The Brief Introduction of Excel.** Microsoft Excel is one of the components of office software Microsoft office for Microsoft Corp. Because Microsoft Excel has a lot of formula functions which can be choose to solve all kinds of problems, it can be processed, analyzed and decided support operations for various data. The use of Microsoft Excel can perform the calculation, analysis and management of electronic information form or web page data list data and charts, which can realize many convenient functions so that the data processing is more convenient. It is widely used in many areas of financial management, statistics, engineering and other fields.

**The Treatment of Random Error.** Random error is mutual offset of the error which is generated by small random fluctuations of a series of factors in the process of measuring[8,9]. The random error of single measurement is not regular, but the number of multiple measurements obeys the statistical law that random error in the column can be mutually offset. Therefore, the random error can be processed by calculating the arithmetic mean of the measuring column. Related commands are as follows.

- (1) Sum: SUM ()
- (2) Average value: AVERAGE ()
- (3) Standard deviation of single measurement: STDEV ()

Example 3:

Measure a dimension 10 times with a vernier caliper, assumed to eliminate system error and gross error, the data obtained and Calculation results are shown in Table 1.

Table 1 Treatment of Random Error

serial number	measured value [mm]	residual error [mm]	the sum of squares for residual error [mm]
1	75.01	-0.035	0.001225
2	75.04	-0.005	0.000025
3	75.07	0.025	0.000625
4	75.00	-0.045	0.002025
5	75.03	-0.015	0.000225
6	75.09	0.045	0.002025
7	75.06	0.015	0.000225
8	75.02	-0.025	0.000625
9	75.05	0.005	0.000025
10	75.08	0.035	0.001225
results	AVERAGE= 75.045	sum=0	sum=0.008250
		STDEV=0.030276504	

### Application of DPS in Error Theory and Data Processing

**The Brief Introduction of DPS.** DPS is a large-scale, general-purpose, multi-purpose data processing and analysis application software developed by Professor Tang Qiyyi of Zhejiang University. Its operating environment is Chinese Windows 98/2000 / XP, which has friendly interface, simple

operation and easy to handle data processing system. DPS integrates numerical calculation, statistical analysis, model simulation and drawing line drawing. It can be widely used in teaching, engineering and production.

**The Treatment of Gross Error.** The treatment of gross error is often encountered in the project, the commonly used discriminant methods are Laiyite criterion (3S method), Grubbs and Dixon guidelines<sup>[10]</sup>. The Laiyite criterion (3S method) is simple to use, without looking up the table, has been relatively wide range of applications. The gross error can be dealt with above method based on DPS.

## Conclusions

In order to solve the problem of the large amount of calculation and the complicated process in the teaching and practical work for error theory and data processing, this paper uses SPOC teaching mode, and puts forward the data error processing based on Excel, MATLAB and DPS software. Based on the analysis of the software, the system error, random error and coarse error itself are combined, and the errors of different properties are processed by different software. What's more, the least squares method, which is widely used in production and scientific experiments, is applied to deal with MATLAB. From the example, it can be seen that the application of computer software to deal with errors and analyze the data can improve the accuracy of calculation and calculation efficiency.

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