PC'S INDUSTRIAL RESEARCH, QUALITY CONTROL AND EDUCATION

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Abstract

Some examples of computer applications in the fields of building materials research, quality control, tertiary technical education and post-graduate computer training are introduced.

1. Routines computing the statistical parameters of probabilistic variables.
2. Fitting distribution functions on oblique distributed samples.
3. The development of experimental quality functions from organised samples.
4. Factor analysis of the full experiment.
5. Using the spline-technique for describing the behaviour of materials.
6. Building Materials — Data Bank.
7. The reviewing of quality control systems using the Monte Carlo Method.
8. Computer assisted industrial quality control systems.
9. The help for tertiary technical education using advanced graphics programs.
10. Post-graduate computer training.

These examples are connected to the building material industry but methods are applicable in other technical fields also.

1. Introduction

The author of this paper has been continuously working on the application of PC's in the construction industry since the pocket calculator appeared. The first tool was a programmable pocket calculator appeared. The first tool was a programmable pocket calculator, then a hobby computer and finally a PC.

Firstly, some simple calculation routines, then a few data processing and logging programs were developed and finally, complex research and quality control packages were written.

The author works in four main areas:

1. Processing and probabilistic valuation of test data in Civil Engineering research.

2. Development and application of complex industrial quality control systems (mainly based on nondestructive strength tests).

3. Demonstrating and helping tertiary technical education.

4. Lecturing on computing in post-graduate training. In this case the PC is the object and the tool of education.

Some of the results from the last ten years work are described in this paper.

2. Application of PC's in research

2.1 *Fitting of distribution functions*

The numbers expressing the qualities of building materials are probabilistic functions. Finding the probabilistic and distribution fuctions that fit closest to the measured data is a constant problem for researchers. Even simple programmable pocket calculators are a great help to solve these problems. Several programs other than custom made factory software were written fos different distribution functions eg. binominal, gamma, Weilbul and Gauss distributions.

A valuation method based on analysing the "obliquity" factor of samples

$$\gamma = \frac{\frac{\Sigma x_i^3}{n} - 3m\frac{\Sigma x_i^2}{n} + 2m^3}{S^3} \qquad \text{where} \qquad m = \frac{\Sigma x_i}{n}$$

and

$$s = \left(\frac{\Sigma x_i^2}{n-1} - m\right)^{1/2},$$

n is the number of samples and x_i the value of each sample.

It is known that if the number of factors influencing test results tends to infinity, their effects are independent and their weights are identical, then Gauss normal distribution is applicable. In industrial production there are some factors more important as they have a larger influence on the measured results. Thus time asymmetric distribution occurs. The "obliquity" factor is the first tool to find the effects which are more important than others.

The author developed a new procedure to fit distribution functions. The experimental distribution function is substituted by a continuous distribution function which is symmetric. The mean value of the new function is equal to the average value of the samples, the deviation is equal to the corrected deviation of the samples, the "obliquity" factors are identical and the inflection point of the new distribution is lower or higher than $F(x) = 0.5$ depending on the "obliquity" factor. Curves under or above the inflection point follow the normal distribution.

This type of fitting procedure does not require the predetermination of the shape of the distribution function thus fitting is always better than if the normal distribution is used and it is usually better than other types of asymmetric distributions. At the same time not all the characteristics of normal distribution are lost. When the "obliquity" factor is 0 then automatically normal distribution is used.

The distribution of strength values of industrial concrete and bricks and relaxation parameters of steels have been analysed using the described method.

2.2 *Experimental relationship functions of probabilistic variables*

During any technological research there may have to be found a relationship, expressed as a function, between the probabilistic variables. The traditional method is regression analysis with special conditions. The author developed a procedure from Reimann's theoretical work. Reimann proved that if two probabilistic variables (x and y) and $F(x)$, $G(x)$ and $E(x, y)$ distribution functions are known, then the qualities of the two probabilistic fuctions determine a continuous function which expresses the relationship of the two probabilistic variables.

This idea was estended to experimental distribution functions drawn from accidentally arranged samples. The same numbered elements from both arranged samples are selected and the data pairs as co-ordinates create a continuously increasing (or decreasing) point sequence. The point sequence is the best possible approach of the theoretically existing function. Connecting the points results in a polygon which is not the parametric function but helps in finding it.

The probability base of the procedure is that all variables of the established function are probabilistic variables. This means that an actual experimental result pair can only appear by chance. The arranged sample follows general statistical laws but their elements depend on each other, thus this relationship is not accidental. The identical quantities of stochastic distribution funcions are selected.

For data processing, evaluating the results and for demonstrating distribution functions and quantile functions, computer programs were written using BASIC language. With the help of these programs some new relationships were found.

2.3 *Factor analysis of the full experiments*

A method was developed for fitting experimental functions on organized samples and this method was applied to the factor analysis of experiments. With the selection of 2—3 levels of 9 factors an experimental plan was set up. All levels of every factor were created in every possible variation. Therefore, the experiment is completed. Altogether 1152 experimental presentations were accounted for. The effects of factors and the system of mutual effects were tested as follows. Firstly, all the results of every presentation were evaluated.

An experimental polygon was drawn to express the fundamental relationship of the two examined probabilistic variables. Using those code numbers of levels of each factor the organised samples were selected according to factor levels, then the experimental polygon was drawn on the results. The deviation of the polygon corresponds to the effects of factors. Some of the examined factors may have no effect on the related functions but the effect can be independent or dependent of the values of the variables.

One useful fact is that there are no preconditions for the shape of the polygon. The mutual effects of factors were analysed with varying factor levels. In the case of 2—2 levels of 2 factors there are already four ways to select the results, thus four different polygons are drawn. According to this theory there is the possibility of selecting three or more factor levels at the same time. There were more than 3500 variations in the esperiment completed.

To find the relationship between the properties of non-destructive testing methods the polygons of 1000—1000 functions were drawn. With certain transformations of the polygons (taking the logarithms of the variables) it was possible to record some regularities in the tendency of the curves. It was also possible to determine the distribution of the function field of connections by a statistical analysis of the paramters of the curve field. If each variable is a probabilistic variable and the factor levels also are, the parameters of the experimental functions are also probabilistic variables.

By the complex analysis of tunction fields the relationship estimating coherences of non-destructive strengths was found with the previously described method. Computer programs were run on a Texas Ti 59, Spectrum, C 64 and IBM PC/XT computers. The dBASE III software package was also used for data processing.

2.4 *Spline technique in research*

It is possible to describe the relationships between the properties of building materials using the spline-technique. One application of the spline-technique desribes the failure mechanism and is reported in an other article, also in Periodica Polytechnica.

2.5 *Building material database*

The Building Materials Department at the Technical University of Budapest is involved in establishing a uniform material information system and data bank. There are 12 material groups and 9 "qualities" groups and filing is under way using dBASE III data processing software.

3. Quality control

3.1 *Analysing the effectiveness of quality control systems*

The standards of quality control also consider that the property to be determined is a probabilistic variable. Classing is completed by the evaluation of the probabilistic qualities of the samples. Estimation of the 5% conditional probabilities was done by analysing actual industrial strength test results. The results of several hundreds of standard classings were analysed. The values of the 5% conditional probabilities were calculated according to the appropriate standards and according to the leaning (oblique) distributions fitted to the samples.

It was stated that this standard contradicted its own internal principles and a modification would be reasonable. The effectiveness of the brick classing standard was checked using the Monte Carlo method. The program was on a C64 and in BASIC with an additional Simon's software. Large numbers of samples from several idealized and real industrial test data were taken. The real and the classed values of the samples were statistically compared. This comparison showed that at least 40% of the individual cases led to faulty classing of materials.

3.2 *Industrial quality control systems*

Several Hungarian construction companies ordered industrial quality control systems, usually combined with a non-destructive method. Personal computers had a major role in these systems. Computers proved very useful in the administration and also in storing and statistically analysing data.

4. Helping technical education

The personal computer is a tool which assists in the teaching of technical subjects. The subject of Building Materials comprises several sciences. Students must understand general and special mathematics, geology-geotechniques, biology and also technology, construction, economics and lately, computing also. Special programs in computer animation help three dimensional presentation (axonometrics and perspective) and other "anaglif" drawings. These programs run on spectrum, C64 and KBM PC/XT computers.

5. Computing in practice

The author is involved in post-graduate training at the TUB. There have been several computing courses organized by the TUB Institution of Further Education of Engineers and the Industrial, Professional Further Education Institution. The participants of these courses are usually well-trained professional who would like to include computers into their daily engineering routine. It is also important from the technical point of view. New knowledge has to be based on the existing knowledge.

One passibility is to start with simple algorithms and develop more and more complicated systems. Buch programs were developed for Texas Ti 59. BASIC programming also is important. Education programs were written comprising the simplest BASIC commands, data processing and some graphic functions.

The data processing program is dBASE III. This program has its own educational demonstration program. The menu driven operations can be observed in the information line. The menu also gives all the commands that can be used. Commands can form a program and finally can be compiled into an executable program.

The author of this article is currently writing the dBASE plus notebook. It introduces the reader to the special knowledge of this programming. Demonstration programs written in dBASE III plus also help the students.

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