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USER INTERFACE FOR ANALYSIS OF EXPERIMENTAL DATA

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ABSTRACT
The nature and the characteristics of the data obtained in scientific experiments is analyzed. The general regularities are formalized and the requirements for the user interface are formulated. Data structures TExperiment and TBasePoint, according to the requirements of Object-oriented programming, are proposed. The approach is implemented with the software Korelia-Ident for identification of experimental data.

Key words: data structures, modeling, data processing, object-oriented programming

INTRODUCTION

The experiment is purposeful activity to obtain data about the nature and behavior of the studied systems. It is implemented in strict conditions which guarantee controlled impact on the system and abilities to receive the result. The impact force is implemented with the parameters that cannot be changed by the system. That is why they are called "independent parameters". The system responds to the force by changing some of its inherent characteristics, which are called "dependent variables". The experimental data can be processed and evaluated with different applied software, which contributes to the freedom and the adaptability of the investigation. The modern devices used in researches can transmit data to computers. The external devices that produce the primary data are known as Data Circuit terminating Equipment (DCE), and the computer and the software that accept and process the data from the devices will be referred to as Data Terminal Equipment (DTE). DCE and DTE are connected by an interface for data transmission: RS 232, USB or LAN. A system for interactive description of the protocols for data transmission from DCE and their acceptance from the user software is described in [1]. In many cases, DCE does not have an interface which can be connected to the DTE. Another reason for the lack of such an interface is the methodology of the study. These are classes of studies that are collected in a long time intervals. In such cases it is appropriate to develop interactive tools for their input.

The purpose of the experiment is to determine and describe the causality between the independent and dependent parameters. It is therefore important to analyze the nature and the characteristics of the independent and dependent variables in different in nature experiments, to establish and formalize the general laws. Formalization will aid in the creation of generalized data structures, and therefore in the creation of dialog procedures for the data input into the programming system.

The purpose of this work is to identify and formalize the general regularities in describing the results of the experiment. This will help create generalized data structures and user-friendly interface of the programming system.

FORMAL DESCRIPTION OF THE EXPERIMENT

Experimental studies, regardless of the method of conducting and nature of the object of study, have common characteristics. These characteristics may be formalized into procedures which follow a precondition for unification of post-processing and an analysis of the results.

1. The system $\boldsymbol{S}$ is the studied object. The system is treated with an independent variable $\boldsymbol{\Gamma}$ - input influence.

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2. The reaction Λ of the system S is:

$$\Lambda = S(\Gamma) \quad (1)$$

3. The independent variable Γ has a set of bounded real values $X_\Gamma \subset R$.
4. The dependent variable Λ has a co-domain $Y_\Lambda \subset R$, belonging to the real numbers.
5. The set X_Γ possess an extreme additive measure μ, such that:

$$\begin{aligned} &\mu_\Gamma(X_\Gamma) \geq 0 \\ &\mu_\Gamma(x_i + x_j) = \mu_\Gamma(x_i) + \mu_\Gamma(x_j) \\ &\mu_\Gamma(\circ) = 0 \\ &x_i \in X_\Gamma, x_j \in X_\Gamma \end{aligned}$$

4. For the set of values X_Γ of the independent variable is defined a standard e_Γ. Thus for $\forall x \in X_\Gamma$ a real number a is assigned :

$$\mu_\Gamma(x) = a.e_\Gamma \quad (2)$$

5. The standard e_Γ and the measure μ are applied to obtain N discrete values which will be used to influence the system and observe its behavior. For this purpose N distinct real numbers $a_1, a_2, ..., a_N$ are chosen to receive the input's effects:

$$\begin{aligned} &x_1 = a_1.e_\Gamma;\ x_2 = a_2.e_\Gamma;\ ...;\ x_N = a_N.e_\Gamma \\ &x_i \in X_\Gamma,\ i = 1,2,...,N \end{aligned} \quad (3)$$

6. With the selected relation $\Re$, the scheme (3) allows to arrange the elements in the set X_Γ, and they may be numbered according to their position in the order:

$$\begin{aligned} &X_\Gamma = \{ x_1, x_2, x_3, ..., x_{N-1}, x_N \} \\ &\Re : [1:N] \rightarrow X_\Gamma \end{aligned}$$

The most commonly used relation is '<'.

$$<:\ x_1 < x_2 < x_3 < ... < x_{N-1} < x_N$$

Thus the domain of X_Γ is $[x_1, x_N]$.

7. There is no requirement for equality of the intervals between the values of the independent parameter, i.e. in general:

$$(x_2 - x_1) \neq (x_3 - x_2) \neq ... \neq (x_N - x_{N-1})$$

8. For each value $x_i \in X_\Gamma$, $m_i = |x_i|$ a number of effects are applied to the system:

$$x_{i1}, x_{i2}, x_{i3}, x_{i4}..., x_{i(m_i-1)}, x_{im_i} \quad (4)$$

The aim is to explore the statistical parameters of the system's response to a unique value of the input impact. Because of that, almost always assume that the elements of the row (4) are equal. However, this assumption cannot exist in reality. There is a natural dispersion of the independent parameter. This necessitates statistical evaluation of the input values. I.e. the independent parameter is represented by the ordered pair of mean and standard deviation: $(\bar{x}_i, \sigma_{xi})$. Thus, as a result of conducting an experiment was prepared by a number of ordered pairs representing the independent variable:

$$(\bar{x}_1, \sigma_{x,1}), (\bar{x}_2, \sigma_{x,2}), (\bar{x}_3, \sigma_{x,3}), ..., (\bar{x}_{N-1}, \sigma_{x,N-1}), (\bar{x}_N, \sigma_{x,N}) \quad (5)$$

9. For each member of the row (5), m_i reactions y_i are measured. That is the dependent parameter of the system:

$$\begin{aligned} &y_{i,m_i} = S(x_{i,m_i}) \\ &i = 1,2,...,N,\ m_i = 1,2,...,|x_i| \end{aligned}$$

That way for the i-th input impact x_i a row of output responses is received:

$$y_{i,1}, y_{i,2}, ..., y_{i,m_i-1}, y_{i,m_i} \in Y_i \subset Y_\Lambda \quad (6)$$

Y_i - range of the i-th dependent parameter.

It is assumed that the values in the row (6) have a Gaussian distribution and can be presented with an average value $\bar{y}_i$ and a standard deviation σ_{yi}. These two variables form the ordered pair $(\bar{y}_i, \sigma_{yi})$ represent the result of the i-th experiment.

The corresponding row of (5) experimental data is:

$$(\bar{y}_1, \sigma_{y1}), (\bar{y}_2, \sigma_{y2}), (\bar{y}_3, \sigma_{y3}), ..., (\bar{y}_{N-1}, \sigma_{yN-1}), (\bar{y}_N, \sigma_{yN})$$

Based on the aforesaid, an experiment E can be defined as a relation

$$\text{E:} \quad \begin{aligned} &S:\ (\bar{x}_i, \sigma_{ix}) \rightarrow (\bar{y}_i, \sigma_{iy}) \\ &x_i \in X_\Gamma \subseteq [\bar{x}_1 \pm \sigma_{x1}, \bar{x}_N \pm \sigma_{xN}], \\ &y_i \in Y_\Lambda \subseteq [\inf(\bar{y}_i \pm \sigma_{yi}), \sup(\bar{y}_i \pm \sigma_{yi})] \\ &\text{i=1,2,...,N} \end{aligned} \quad (7)$$

The ordered quaternion:

$$((\bar{x}_i, \sigma_{ix}), (\bar{y}_i, \sigma_{iy})) \quad (8)$$

will be called ***experimental base point*** or ***base element.***

OBJECT-ORIENTED STRUCTURE OF THE INTERFACE MODEL

When creating a model of experiment, the possible data categories which the model must reflect have to be considered. These are mainly graphical and non-graphical data. Graphics present experimental data in Euclidean space [2]. Non-graphical data is data of general type, as well as data which characterizes each copy of the experiment. It complements the graphical data. Most frequently, the data is either numeric or symbolic. The creation of an object-oriented structure "class of experiment" must take in account these two categories. Data-oriented graphical visualization is described in the abstract class ***TMicroGraph***. ***TMicroGraph*** is defined in [3] as an abstract class-ancestor of graphical classes. It has been created as a successor of the base class ***TObject*** **(Figura 1).**

```
TMicroGraph =  class(TObject)
        UnicCode : longint;          // Unic identification code of the
                                     object
        UserIdent : string;          // User defined identificator
        MicroGraphValid : byte;      // validity flag
        LinearMetric:                // Pixel, Millimeter, Centimeter,
        TLinearMetric;               Meter
        AngleMetric :                // Degree, Radian
        TAngleMetric;
        FVisible : boolean;          // visibility
        ObjColor : TColor;           // object color
        . . . . . .
```

Figure 1. Abstract graphical class-ancestor

Because this class contains the basic elements needed for identification and visualization of the exemplar, it is appropriate to be used as a class-ancestor of experimental data. This will ensure compatibility with the object-oriented graphical extension.

For the category experiment ***E*** (7), a class-header ***TExperiment*** **(Figure 2)** as a successor of ***TMicroGraph*** is defined.

```
TExperiment=class(TMicroGraph)
    N : integer                  // Number of samples
    X_Dim,                       // Dimension of independent
    Y_Dim : string               variable
                                 // Dimension of dependent
                                 variable
    X_1, X_N : real;             // Domain range of independent
                                 values
    Y_min,Y_max : real;          // Range of dependent values
    Data_format : string;        // Numeric display format
    Form : set_of_forms;         // Form of base points
    Color : TColor;              //Color of base points
    Size : integer;              // Size of base points in pixels
    Base_points :TBasePoint;     // Pointer to list of base points
    . . . . . .
```

Figure 2. Data definition of Experiment

The pointer ***Base_points*** is the header **(Figure 3)** of a double-linked list with experimental base points:

```
TBasePoint = class(TObject)
    M : integer                 // Serial number of base point
    X, X_SD,                    // Average value, standard
                                deviation for X
    Y, Y_SD : real;             // Average value, standard
                                deviation for Y
    SKF : real;                 // approximation coefficient
    Visible,                    // visible/unvisible point
    Active : boolean;           // active / inactive point
    NextPoint,                  // pointer to next base point
    PrevPoint : TBasePoint;     // pointer to previous base point
    . . . . . .
```

Figure 3. Header-class TBasePoint

Besides the values of the ordered quaternion (8), ***TBasePoint*** contains approximation and visualization parameters for each base point. The boolean parameter "***Active***" determines whether the base point must be used in the calculation procedures (eg. approximation, differentiation, integration).

Each data class should have the realization part and interface part. The methods for data manipulation are described in the realization part. The interface part proposes a set of operations to access and modify the class properties.

- ✓ **Create and Destroy Methods.** The constructor 'Create' allocates memory to instantiate the object and initializes its data. The "Destroy" method destroys the class and releases the memory allocated to it.
- ✓ **GET operators.** They are a necessary part to realize the class interface because of its encapsulation. They ensure access to the parameters of a concrete object in the program.
- ✓ **SET operators.** These operators modify the properties of the classes.
- ✓ **File operations.** They enable the writing in/reading from a file of experimental data. The possible data formats are ASCII, CSV, Paradox, SSP [1].

The structure of the formulated classes for presenting the experimental data is shown on **Figure 4.**

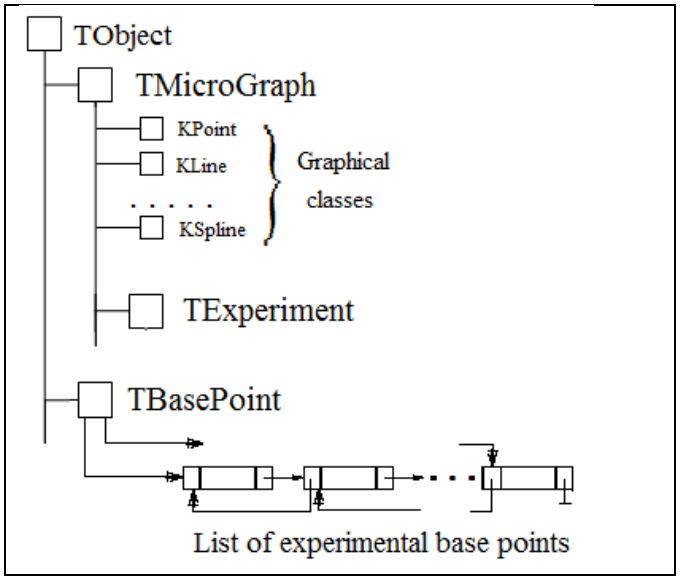

Figure 4. Class hierarchy of experimental data

SOFTWARE REALIZATION

The formulated requirements to the user interface and the supporting data structures are implemented in the program ***Korelia-Ident***. The program offers opportunities for data processing [4], identification [5], modeling, and studying of dynamic processes. With its

user-friendly interface [6, 7], it is preferred by humanities scholars [8, 9, 10].

In [11], how bread crust color changes during baking is modeled (with permission from m-r Zl. Zlatev). Figure 5 shows a dialog with the data of the color components of the XYZ-model. In the same paper, the author uses ***Korelia-Ident*** to identify the color changes during baking.

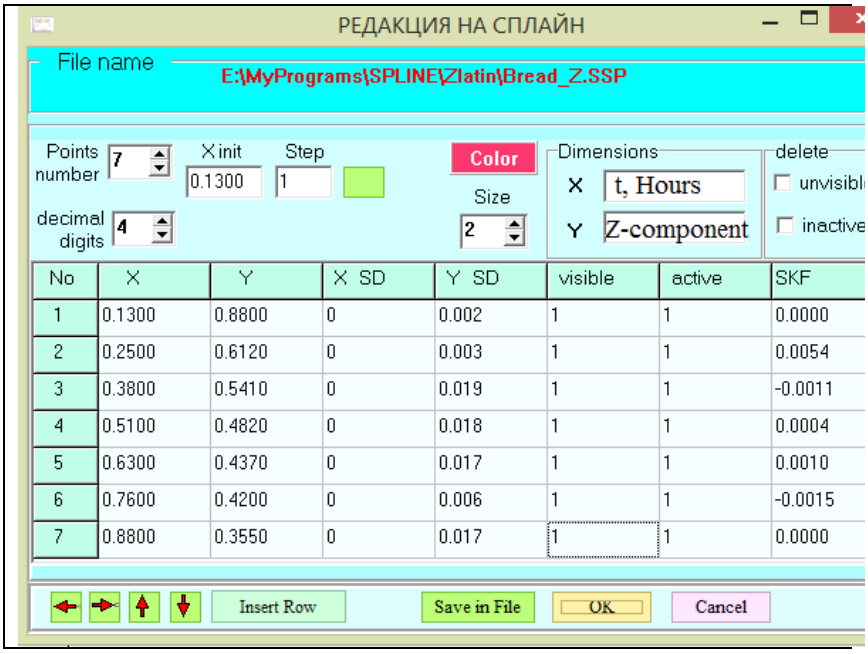

Figure 5. Data entry window

CONCLUSIONS

The article analyzes the nature and characteristics of the data obtained in scientific experiments. It was found that subject of statistics are not only the dependent, but also the independent variables. General laws and proposed dynamic structures for images and non-graphical data according to the requirements of Object-oriented programming are formalized.

A user-friendly interface for receiving and transforming data from DCE is developed, as well as interactive input of data into the computer system, accompanied by statistical processing and evaluation of data.

Basic structures are organized in classes according to the requirements of object-oriented programming. Abstract base class is ***TMicrograph***. It is an ancestor of the ***TExperiment*** and ***TBasePoint*** classes. The last class forms dynamic double-linked list containing experimental base points.

The approach is implemented with the software Korelia-Ident. Korelia-Ident is intended to provide a highly interactive environment for researchers to identify, model and simulate the properties of dynamic experimental systems.

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