EXPERT SYSTEMS USED FOR MONITORING THE BEHAVIOR OF HYDROTECHNICAL CONSTRUCTIONS

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***Abstract**: Hydrotechnical construction monitoring is based on the comparison of predicted behavior with actual behavior.*

By the centralization and database composition with long-time behavior of the constructions we can bring significant improvements even from the project stage of a structure.

In recent years, there is a worldwide tendency to continuously examine the movements of hydrotechnical constructions through continuous monitoring. Due to systems automation, the graphics and also the other components of a classic UCC documentation it can be obtained in real time or at any time predefined by the beneficiary.

***Keywords:** Hydrotechnical constructions, monitoring the behaviour of constructions, dam, expert systems*

1. Introduction

Expert Systems

Globally, Artificial Intelligence has developed over the last two decades as a distinct field of "information age". Expert systems, as part of the Artificial Intelligence and given the very promising prospects for their application have attracted the interest of specialists.

Even if the final option in adopting a variant and implementing the decision falls on the one who decides or on the expert, however, covering in an useful time and with minimum cost some "previous sequence" from the structure of the decisional process and the evaluation of thousands of possible combinations between the variables of a problem are not possible without the support of the PC. Initially, some believed that the development of expert systems could replace the experts in various fields, in this case the field of monitoring the hydrotechnical construction. In fact, things are totally different; best experts were and are required, and without these experts the very development of expert systems (with application in this area) would be in doubt.

But, beside the expert's assistance in making some unique strategic decisions or of high value for the addressed project, the most promising prospects of applying this type of information technology lies in the possibility offered to an employee with general training to perform specific activities for some distinct specializations.

How can a program assist a specialist to interpret the data collected, namely to help him decide? There are two main ways of approaching this problem:

Firstly, it is considered the fact that in the process of making a decision, although all data were collected, several variants occur. Thus, we can put up a program which suggests the most plausible decisional variant. It can be verified by more advanced (and expensive) methods. If invalidated, the program can suggest another possibility. Obviously, the final decision is left exclusively to the specialist. Although, at first glance, this problem is widespread, the applicability cases are very rare. This model has no mathematical basis; it encapsulates in a matrix the knowledge from books, articles and personal experiences in an empirical way.

A second way to approach a program assisting an expert is the simulation of the specialist's reasoning. A program similar to an automated theorem demonstrator which, based on assumptions, through inference mechanisms, infers the decision, is build. The program should incorporate pieces of knowledge needed to develop the reasoning. This type of program has been called knowledge-based system (KBS). KBS name is primarily used in Britain ant the U.S.; these programs were known as expert systems. For KBS, the first models were influenced by programming languages existent during 1955-1970 (FORTRAN, COBOL). For this, the most common model was, at that time, the Flowchart. Data structure used in this case is an orientated graph over which is applied a chain logical evaluation mechanism (branch chain logic). The graph nodes may contain pieces of knowledge (symbols, sentences) and/or logic operations. A node may have one or more entries (arcs oriented towards that node) and one "exit" which can be multiplied. Through arcs, the nodes transmit to each other the truth values (True/False).

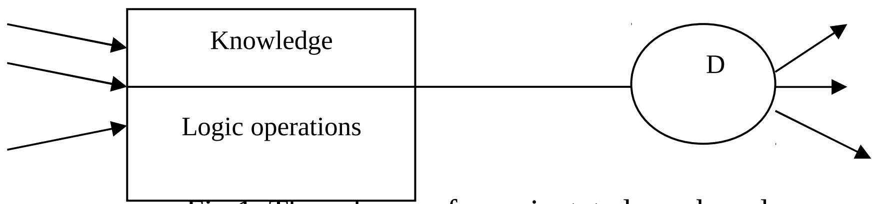

Fig.1. The scheme of an orientated graph node.

The presented system works properly only if the output will show a single True value and the rest will be False, in all cases of use (possible sets of assumptions). The disadvantage of this model lies in the complexity that the graph can reach for a larger set of pieces of knowledge. Inevitably, this complexity leads to errors in operation (there is no decision or there are more decisions occurring) that are very difficult to debug. Adding new nodes can lead to unexpected behavior of the system.

An Expert System (ES) is a program that provides solutions at the quality offered by a specialist for problems from a narrow field. Building such programs involves extracting information from specialists in the field and codifying them into a language compatible with the computer.

An Expert System has two important features:

a. Transparency: requires that the performed reasoning can be followed by the user, which allows him to intervene for choosing a preferred route.

b. Slight Change: refers to the possibility of simple knowledge foundation updating and the use of the same nucleus for different knowledge foundations (which, however, have the same structure).

Expert Systems are called knowledge-based systems because of the nature of processed information. Knowledge can be represented by rules, semantic networks, neural networks and hybrid models. Using the rules is the most widespread method of representation. The most important aspect within the presented architecture is the separation of Inference Machine from the processed information thus allowing the Expert System's Nucleus to be used for knowledge from various fields.

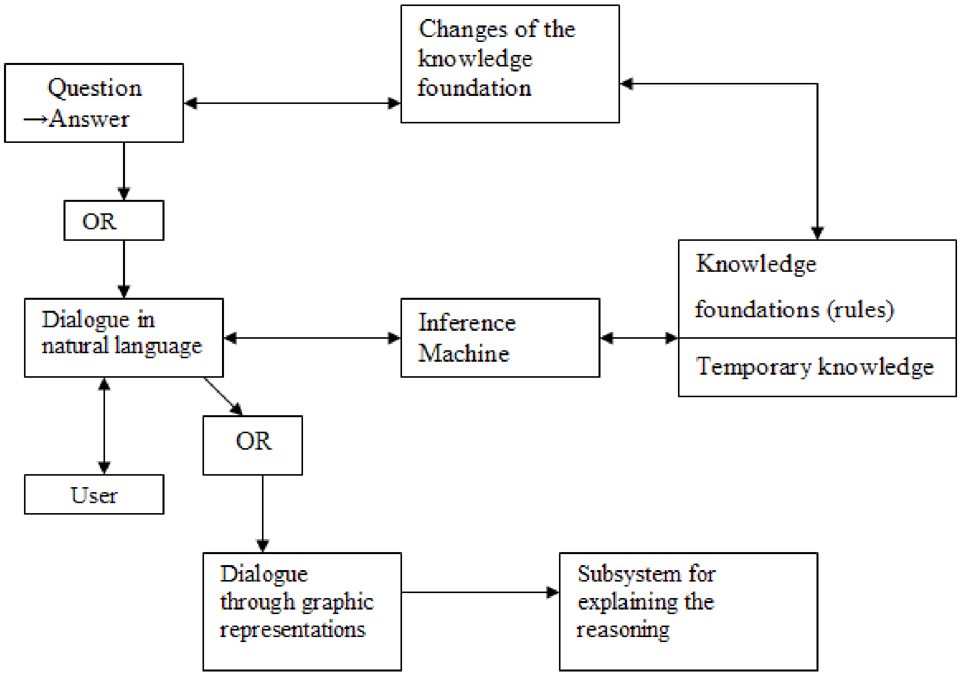

Fig.2. The Structure of an Expert System

2. Advantages and restrictions of the Expert Systems:

Advantages

Expert Systems work faster than human experts, making faster decisions. Expert Systems contain consistent information (structured in the same way) about an environment subject to hazard; they make the distribution of information to more people at different places possible. Expert Systems don't get bored, don't forget, are not tired and in addition, they enhance the knowledge of the best experts. The Experts Systems can be multiplied, while the formation of new human expert takes time and money. They can be integrated with other systems, can work with incomplete information. Expert Systems are not influenced by the novelty of information. They can provide all data anytime. Fraud and errors can be minimized. Using an Expert System may be a step – or more – ahead of the competition.

The applications of Expert Systems reduce the companies' costs, increase the quality of decision making process, store organizational know-how, resolve the management crises and stimulate the innovation.

Restrictions

Necessary information is not always available. Data collection from experts is difficult. Many experts can have many different, but right, approaches to the same problem. The Expert System users are not accustomed with them, it is possible they might not know the terminology and maybe they can not trust the system and process. When the time is short, the difficulty of assessing the situation occurs. Conclusions can not be verified in terms of fairness. Experts have more common sense, are more creative in unusual situations, they adapt fast to environmental changes. Expert Systems do not realize the situation when there is no solution.

3. Automatic methods of collecting and processing the measurements for determining the displacement and strain of the horizontal, vertical and spatial vectors used by the Expert Systems.

The need for more detailed knowledge about the changes in geometric shapes and constructions' space positions, both during the preparation of the projects, for testing the construction components and structures, as well as during implementation and exploitation of buildings, over time, has led to finding and studying the ways that these changes can be determined and advanced. Determining the changes occurred during the operation of a construction is essential for both its safe operation, and for the design of other constructions.

Current technological development allows us to dispose of high precision devices that apply various corrections even when collecting data (temperature, atmospheric pressure, etc.) that allows us to have very accurate data, even from the field phase, for further processing.

Combining GPS technology with the accurate observations of total stations and high precision electronic levels, of gradient sensor, devices for transmitting information via radio waves led to the emergence of some powerful, flexible and interactive monitoring systems for massive constructions, reducing the time for observations and increasing their accuracy.

One of these monitoring expert systems is presented in the following; it is implemented for monitoring the deformations occurring in the body of a dam, and it is also applied for other massive constructions.

The monitoring system consists of:

a) Software for data acquisition and processing;

b) Geodetic Equipment;

c) Measuring and Control Devices (M.C.D.).

Automatic monitoring systems were developed over time by companies producing geodesic equipment. Such a system is based on software that retrieves and processes data from both the M.C.D. installed within and around the dam and from the geodetic robotic instruments. Mainly, the software must meet the following requirements:

- to run under the most common operating system;
- to store data in a relational database;
- to support operations automatically, semi-automatically or on demand;
- to be compatible with data from a variety of sensors.

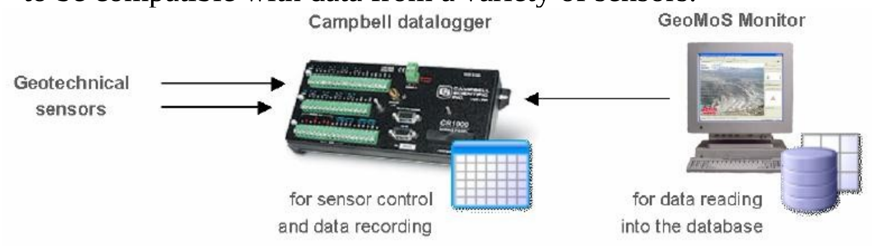

Fig.3. The interface for data acquisition

- to be remotely accesible both in terms of commands and collected data;

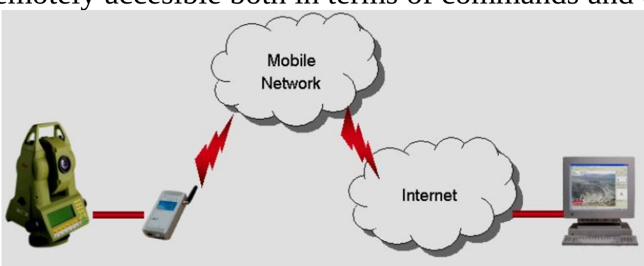

Fig.4. Remotely transmitting the data

- to be able to transfer data between different computers;

Fig.5. The network system's accessibility

- to be able to automatically restart in case of a blackout;
- to be able to automatically start and stop the sensors and devices that it controls at the beginning and end of each measurements series;

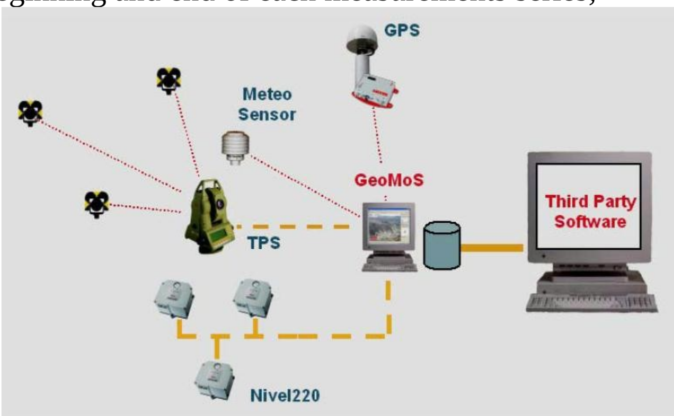

Fig.6. Automatic control system

- to be able to retrieve video images in real time from the monitored location.

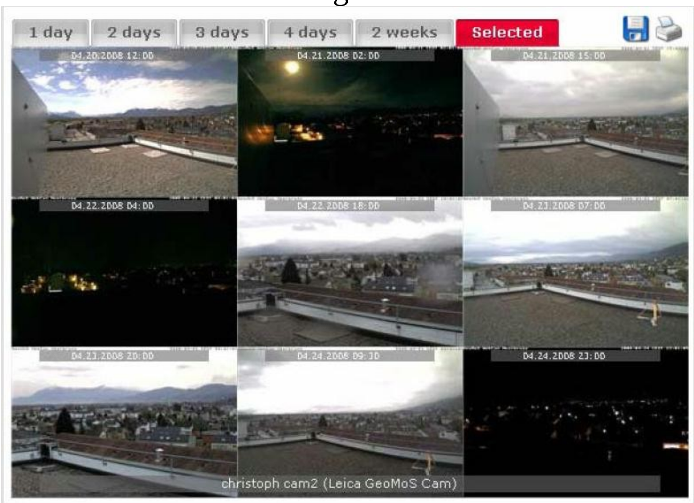

Fig.7 Video monitoring

Data collected at each measurement cycle consist of directions and angles provided by automatic total stations installed on the pilasters materializing the dam's monitoring network.

Temperature, atmospheric pressure and humidity are also collected and used for the corrections applied to measurements. Intervals at which the automatic measurements are performed are defined by the administrator of the monitoring system according to construction type.

Within the calculation program, the first step is to check the stability of the monitoring network, excluding from the beginning the possibility of obtaining inaccurate coordinates due to the movement of deemed fixed points, and just then calculating the final coordinates.

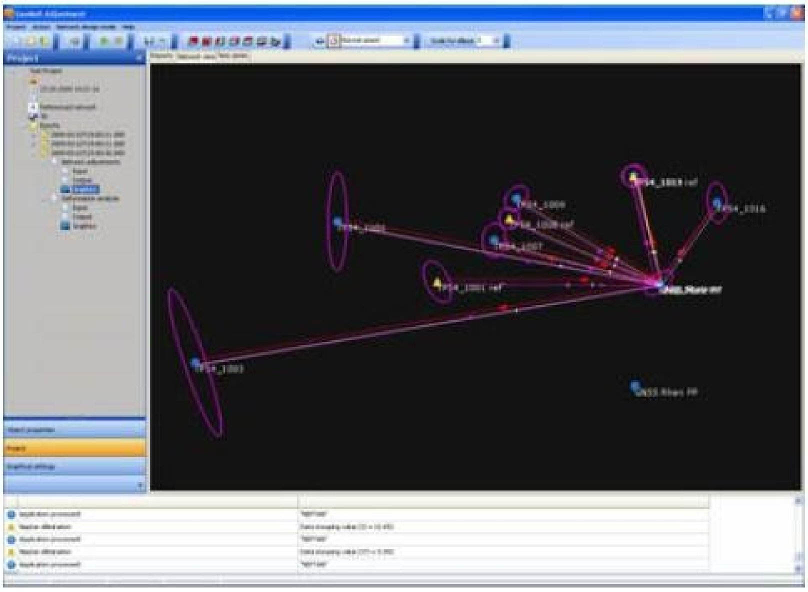

Fig.8. The software for processing geodetic data

The results are provided in the form of graphs in which are represented the last cycles of measurements, in terms of vertical and horizontal movements of the studied building.

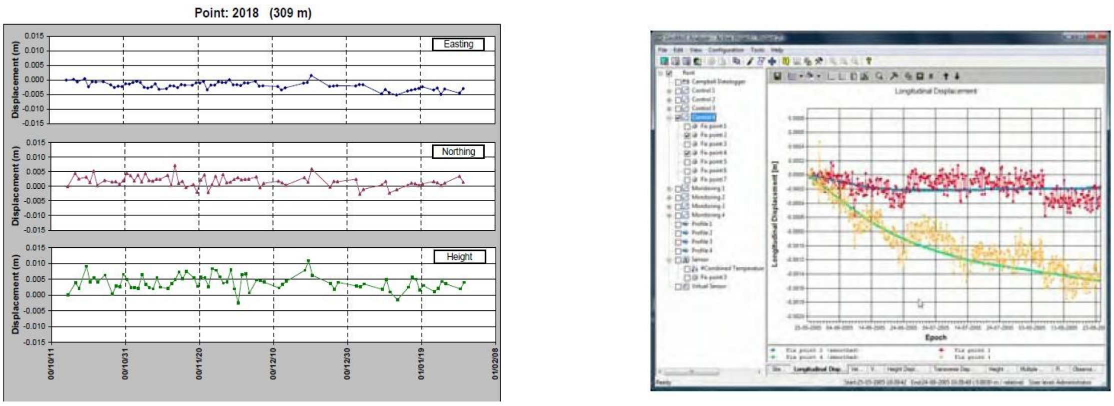

Fig.9. Graphical representation of movements

The program is also able to provide information on real time movements of the construction when it is required by the building administrator. In the case of dams this may be necessary during the lake’s drain – fill maneuvers.

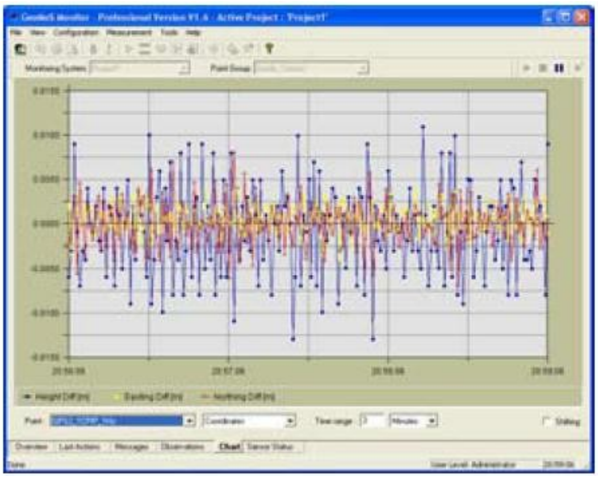

Fig.10. Graphical representation of real time movements

Geodetic equipment which are part of the monitoring system are:
- Robotic total station
- High precision digital levels
- GPS receivers

A completely automated monitoring system includes all three types of geodetic equipment mentioned above plus M.C.D. devices which transmit digital data in a numeric format.

For measuring the angles and distances robotic total stations with automatic recognition of the prism, mounted on the concrete pilasters are used. They are protected by "shelters" with special glass walls allowing the observations; the power supply necessary for the functioning is made from photovoltaic panels.

Fig.11. Fixed robotic total stations

The commands towards the total station but also the measured data are transmitted via radio waves using modems specially designed for this purpose.

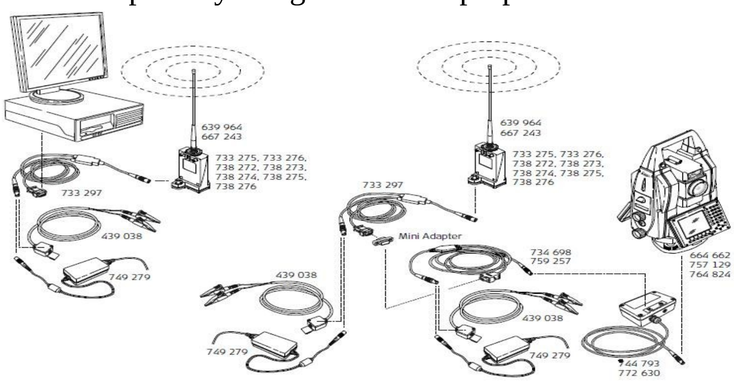

Fig.12. Components of the system

In the monitoring points on the dam’s body are embedded prisms which are sighted by total stations automatically commanded by data collection software.

Fig.13. Prisms installed within the dam’s body

High accuracy levels are used for measuring the subsidence which, as the total stations, run measurement cycles pre-established in data collecting and processing software.

Moreover, for a more precisely calculation, within the monitoring system GPS receivers can be used; at least one of those must be placed at a greater distance from the dam, but not more than three kilometers. The role of GPS receivers is to “awaken” the monitoring system if major movements are detected. The signal from the GPS receiver will “alarm” the monitoring software that will command one or more measurement cycles from which will result the actual movements of the construction.

The GPS receivers work continuously and are also powered by photovoltaic cells.

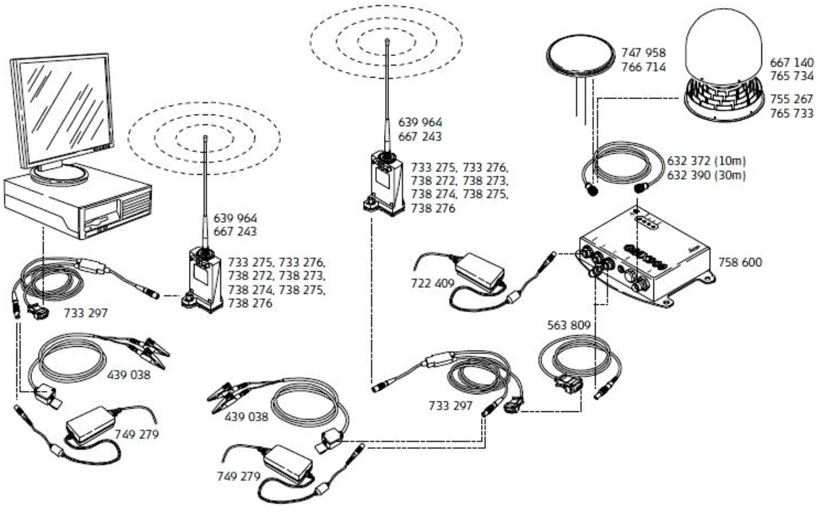

Fig.14. Alarming system with the help of GPS technology

Corroborating the information provided by all sensors installed on the monitored construction, the monitoring software can generate three levels of alarm by comparing the data obtained with the limitations imposed by the beneficiary.

Thus, if the first alarming level is exceeded, a text message can be sent to the person in charge of the system which, in turn, can verify.

If the second alarm level is exceeded, the optical and acoustic warning systems can be switched on, and the person in charge of the system must decide what measures should be taken.

If the third alarm level is exceeded, an alarm siren will be operated, the area will be evacuated and, after verifying the data again, the person in charge of the system may inform other authorized agents responsible for the safety of the local population.

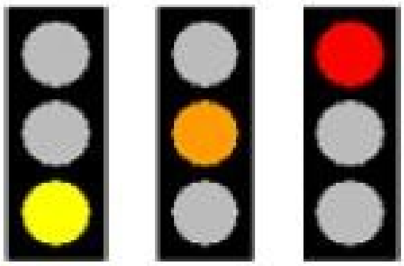

Fig.15. Intuitive alarming system

All geodetic equipment described above together with the monitoring software form a complex system that has many advantages compared with the traditional methods of performing a monitoring of the constructions' behavior. The benefits are:
- High precision due to the almost entirely elimination of the human error;
- The possibility of accessing the system from great distance;
- The possibility to perform measurement cycles at much shorter intervals;
- The determination of movements in a very short time and the immediate alarm in case of danger;
- Obtaining and processing data in real time;
- Correlating the geodetic measurements with those provided by the M.C.D.s;
- Lowering the costs with UCC activity.

Considering the above mentioned, the presented system represents a viable alternative of both technical and economical for the traditional system of performing a monitoring of the construction's behavior, and it is recommended for large constructions with a high level of risk if they break down.

4. Conclusions

Increasing the complexity of the decision and the emergence of situations where decision makers must ground optimal decisions in short time using both personal experience and specific methods, but also the available information about the work conducted has raised the question of using a PC in a manner which ensures the obtaining of new knowledge starting from an existent knowledge portfolio. Thus, there emerged the first attempts to use computers for the development and implementation of specific IT systems known as **expert systems (ES)**. **Upgrading the geodetic equipment to its total automation allowed its integration in these expert systems**.

Expert systems are characterized by the management of knowledge, different from databases by the nature of the managed objects, represented by knowledge whose meaning do not come out from the value of stored data, but from their aggregation into a complex structure of summary information. Today, these decisional instruments take the shape of intelligent systems for diagnosis, analysis and decision assistance.

5. References

1. *Szostak-Chrzanowskii, A., Chrzanowskii, A., Massiera, M. - Behavior of Large Earth Dam Combining Monitoring and Finite Element Results;*

2. *Bobocu, D. - Evaluarea sigurantei barajelor pentru acumulari de apa pe baza prelucrarii statistice ale datelor furnizate de aparatura de supraveghere, Bucharest, 2008;*
3. *Botez, M. - Geodezie, Didactic and Pedagogic Publishing House, Bucharest, 1969;*
4. *Cosarca, C-tin. – Topografie Inginereasca, MatrixRom Publishing House, Bucharest, 2003;*
5. *Cristescu, N. - Topogrqfie Inginereasca, Didactic and Pedagogic Publishing House, Bucharest;*
6. *Dima, N. - Geodezie, Universitas Publishing House, Petroşani, 2005;*
7. *Dima, N., Herbei, O., Veres, I. - Teoria erorilor si metoda celor mai micipatrate, Universitas Publishing House, Petrosani, 1999;*
8. *Ghitau, D.- Geodezie şi gravimetrie geodezica, Didactic and Pedagogic Publishing House, Bucharest, 1983;*
9. *Moldoveanu, C. - Reţele geodezice de sprijin - curs postuniversitar, modulul "Sisteme de .referinţă şi de coordonate", Conspress Publishing House, Bucharest, 2004;*
10. *Moldoveanu, C. - Geodezie, Matrix Rom Publishing House, Bucharest, 2002;*
11. *Nistor, Gh. – Geodezie aplicată la studiul construcţiilor, Gh. Asachi Publishing House, Iaşi, 1993;*
12. *Nistor, Gh. – Teoria prelucrării măsurătorilor geodezice, Technical University, Iaşi, 1996;*
13. *Nistor, Gh. – Topografie – curs – I.P. Iaşi, 1981;*
14. *Nistor, Gh. – Topografie-lucrări practice – I.P. Iaşi, 1982;*
15. *Oprescu, N. et. all – Manualul inginerului geodez, vol. I, II and III – Technical Publishing House, Bucharest, 1972, 1973, 1974;*
16. *Ortelecan, M., Pop, N. – Metode topografice de urmarire a comportarii constructiilor si terenurilor inconjuratoare, AcademicPres Publishing House, Cluj-Napoca, 2005;*
17. *Rus, T. - Reţele geodezice de sprijin - curs postuniversitar, modulul "Proiectarea şi efectuarea măsurătorilor geodezice", Conspress Publishing House, Bucharest, 2004.*