MODERN REMOTE SENSING AND THE CHALLENGES FACING EDUCATION SYSTEMS IN TERMS OF ITS TEACHING

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Abstract

Currently the fastest growing area of geodesy is undoubtedly remote sensing. The importance that it has recently conducted on the effectiveness of worldwide research determines its huge success. Examination of the specific characteristics of objects without direct contact with them is a key feature that has opened the way to the new very interesting areas of contemporary research. In this light, it seems reasonable to say that there is a need that the modern methods of collecting and analysing remote sensing data currently widely used in the world of science and technology needs implement in the programs of teaching students, that they would be familiar with the level at which primarily remote sensing now is, and about its interdisciplinary nature. Modern remote sensing meets the expectations and provides methods from different fields of science, the one thing common is remote test of characteristic features of interested objects. This article presents the ways in which universities are trying to meet this need.

Keywords: remote sensing, education of engineers, high school education.

1 INTRODUCTION

Great progress that we may observe in the field of precise measurements stimulate us to think about the problem of smooth transmission of knowledge from this field to our students. The dynamics of this process causes that universities must communicate the latest developments in this area for students to meet the needs of today's labour markets, which are focused on advanced methods of measuring and precision instruments. It seems necessary to conduct also scientific research focused on the use of modern techniques of observation and measurement. Surveying and Remote Sensing in particular are very good place to implement these methods. Thanks to such devices as laser scanners, cameras or spectral cameras. Speed cameras are able to acquire information about the characteristics of previously inaccessible interested us objects. 3D modelling, which is currently one of the very dynamically developing directions of research in the world, can enter the next level with laser scanning where through precise measurements will achieve the next level of detail constructed models. Spectral imaging enables the collection of such characteristics of objects that are in the areas of our interest, we are not able to obtain by other methods as remote sensing [28,34,38]. Often we are the observers of fast phenomena that may occur so fast that we cannot see them with the naked eye. Using a technology called high-speed cameras that allow registrations at speeds up to several hundred thousand frames per second, we can discover regularities in those phenomena. In this paper, our team would like to bring experiments that will illustrate these methods and measurement techniques implemented on the faculties of our universities. Our work is focused on the implementation of well-known doctrine of Pasteur's quadrant which describes fragile equilibrium between Applied and Basics Research which in our opinion is fundamental in the field of technical sciences.

2 SELECTED MODERN MEASUREMENT TECHNOLOGIES IN EDUCATION OF ENGINEERS OF THE FUTURE

Let us start from the laser scanning and high-speed cameras in engineering.
2.1 Fast camera

Opportunities that involve the use of laser scanning slowly reach other groups of scientists. An example might be the use of high-speed cameras and laser scanner for materials research. The presented tests allow for look inside the dynamics of the observed phenomena and describing the changes taking place as entirely new categories. As an illustration we can cite the experience of concrete blocks strength test (Fig. 1). By registering a strength test using a high speed camera, we are able to trace the entire process of destruction of concrete samples, and see very subtle changes (apart from very violent) that occur during this time.

Fig. 1. Destruction registration of concrete blocks using high speed camera.

Fig 2 shows the stresses of the coating material applied to the object, such as the Forest Opera in Sopot. From the right side we see the beginning of the trial, the middle image shows the final phase of the trial for a moment before breaking material. The characteristic feature is a very big stretch of the sample so that the upper jaw of the test rig has extended far beyond image. The last picture shows the moment in which the sample was torn. Recording speed in this case was set to 20 000 frames / sec. It was necessary to use so large frame rate to allow to observe the moment of rupture and trace the entire process.

Fig. 2. Registration of the stages of the destruction of covering technical material from Forest Opera by using high-speed camera.
Used in the course of experiments software let us apply implemented filters to detect edges. Such image of processed frame by Prewitt filter is shown in Fig 3.

![Processed Image](image-url)

**Fig. 3. Analysis of changes in the geometry of the technical material during stretching, based on the film frame preprocessed by the Prewitt's filter.**

Thanks to the implemented filters, we can use a variety of methods for image analysis. Because we are dealing with the phenomenon of rapidly varying one of the most suitable for this type of phenomena it is anemometry imaging method that gives us the opportunity to identify some elements of images and track changes their position during the entire observation period. Knowing the position of selected points in each moment of time we are able to plot the trajectories of movement. This in turn allows us to determine the direction and speed of the points identified at any time of observation. With this method, we are able to determine the displacement of the selected points as a result of deformation of selected components. Calculation of moments of shear and other important statistics from the point of view of structural strength or material engineering.

To register we have used Phantom Miro LC310 M camera (Fig. 4 and 5) [9]. It is an example of small and light camera located in applications include motor vehicle crash tests. This equipment has a capacity of 3.2 gigapiksela per second, which means that it is able to capture an image at a resolution of 1280x800 pixels at a speed of 3200 frames per second.

![Camera Image](image-url)

**Fig. 4. M310 Phantom Camera during the measurement.**

The matrix consists of more than 1 million pixel size of 20 microns each, records at the same time in the 12 bits of color depth (therefore one pixel is able to produce 4,096 different colors). Minimum time of exposure to light is 1 ms for speed recording more than 650 000 frames per second. The time
measurement accuracy of 20 ns, and the selection start or end of the measurement can be selected by the user. In case of registration of measurements made by the author of this study we used a feature-trigger recording, which consisted in the fact that the camera continuously records the picture (and write down it on an internal hard disk with a capacity of 12 GB) and finished recording when you press the trigger (trigger) by the user.

Fig. 5. Comparison of sample image for a moment before the fracture (left) and after fracture (right).

2.2 Laser scanning

Laser scanning is the technology that simply combines remote sensing and photogrammetry tasks. In the process of training engineers use this technology must occupy a very important place. Attention must be paid to the introduction into the teaching process as well measurement technology, as methods of filtering the data. Another direction of research, which is reflected on our universities is to use laser measurement techniques. Airborne laser scanning (LSL) is a modern measurement technology used in the work of surveying to create cartographic studies. LSL measurement result is a collection of observations, which, because of their numbers is called a "point cloud". Most often used for further studies are appointed on the basis of observations of X, Y, Z, this set. Based on the coordinates it is built digital terrain model (DTM). The scanning process can be conventionally divided into the following stages: acquisition of data (measured LSL), filtration, or subject to slightly different set of segmentation rules, the main processing (mapping and cartographic specialist), printing maps and its use in specialized analyzes. The result of the filtration process is a subset of points, which are the physical image of the ground surface. These points are then used to create the DTM. In the literature it suggested a number of algorithms to implement filtering point cloud. The work addressing the problem of filtration include: [1,3-6,11,13,16,22,29,32,35,38-43,44,47].

In the work cited in this study highlighted one of the methods enabling the filtration process based on the principles of M - estimation. The problems of geodetic calculations M - estimation most often identified with the estimation resistant may appear in the results of measurement errors thick (outliers). This method can also be used in determining displacements and deformations of engineering. As already mentioned above, the main task of $M$ - estimation is to eliminate from the data set of these results, which are suspected to load thick errors or indication of the points that have been displaced. Property that can be used in the filtration process set LSL and treat, as outliers these points, which are
images detail situational or reflections of the laser beam of vegetation (high, medium, low) and do not belong to the topographic surface area. However, the remaining after filtering the data you can be considered as items reflected from the ground and used to build the DTM. Issues relating to methods of proof presented among other works: [14,15,26,27,29,30,25,45,46]. In presented further analyzes the results of a set of LSL filtration method M - estimation using weighting factors Huber function, as well as a modified form of this function.

The next direction on research focused on new precise measurement method is the problem of ALS data filtering by using the modified Huber method.

### 2.2.1 Examples of practical analysis and research on methods of filtration

#### Huber Method

Fig. 6 shows a fragment of the cloud of points obtained from measurements from LSL. This collection contains about 15 000 points.

![Figure 6: The cloud points of measurement LSL [4].](image)

Practical analysis model was used functional Character

$$ z_i = \hat{a} + \hat{b}x_i + \hat{c}y_i + v_i \quad i=1,...,n $$

(1)

In the calculation of the weighting function used Huber predetermined Fig 7. For the numerical calculations assumed coefficient $k = 2.0$. Figure 4 presents the results of filtration using weighting factors Huber function. Red color indicating the points that in the filtration process have been removed.

![Figure 7: The results of filtration [4].](image)

By analyzing Fig.7, we see that not all the points that are situational details have been removed in the filtration process. This disadvantage can be eliminated by using a modified method of unilateral Huber buffer zone.
2.2.2 Examples of works using laser scanning

Terrestrial laser scanning (TLS)

In the current research work and education of engineers it is important to indicate the actual utility TLS solved. Of particular importance is the participation of students in group projects and works important for the economy or national culture.

Among many realizations noteworthy works are the following: on the reconstruction of the historic forge Orunia in Gdansk [2], scanning combined with monitoring of the Chapel Royal at the Old Town in Gdansk [31], monitoring the demolition of military structures on the cliff in Gdynia [and measurement and monitoring of the Forest Opera in Sopot [17].

![TLS example of the Royal Chapel in Gdansk](image)

**Fig. 8.** TLS example of the Royal Chapel in Gdansk [31].

![Example of the strength analysis with the use of reinforced concrete beam](image)

**Fig. 9.** Example of the strength analysis with the use of reinforced concrete beam [33].

Maritime laser scanning (MarLS)

Recent, research are also associated with the use of laser scanning in marine solutions. It resulted in the port scanning in Wladyslawowo and sea cliffs.
Fig. 10. Examples of the MarLS for the Władysławowo Harbor [12].

2.2.3 Other examples of the use of modern methods of remote sensing and photogrammetry

Examples beyond the using of laser scanning and photogrammetry are described in publications [7-10,36-38]. Of importance are working on light pollution together with methods of measurement of the propagation of such pollution, navigation based on image analysis and satellite positioning, analysis for spatial information systems, and extensive research on the analysis of human emotions.

3 CONCLUSION

The very broad spectrum of scientific research carried out in our universities give us the possibility to engaged students in the process of let’s say “creation of science”. According to the basic assumption about balance between applied and basic science we have shown in this paper that there is a possibility to coexists both types of research in the academic life, and that coexistence brings lots of advantages to the process of student’s education.

The main goal of engaging students in different research programs is the acquiring the ability to work in a team of researchers, ability to solve different problem and to draw proper conclusions, and to do some first steps in the process of preparing scientific publication. This skills seems to be very important in the present world and they represent the fundamental engineering knowledge.

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