On redefinition of image analysis and stereology

Wojnar, Leszek and Kosecka-Żurek, Sylwia

Cracow University of Technology, Institute of Applied Informatics, Cracow, Poland

Leszek.wojnar@gmail.com

Keywords

Image analysis, stereology, image processing, mathematical morphology, morphometry, tomography.

Introduction

Nearly 30 years ago Ewald R. Weiibel (1987) has noticed that "stereology cannot yet be found in any modern dictionary, nor is it an entry in any of the major listings of scientific literature. Unfortunately, the current state of art is very similar.

Image analysis and stereology is a name of an official journal of the International Society for Stereology. The title of the journal should be clear and informative for the scientific society as it assures both papers and (sign of present times) impact factor. If one asks people met at any university campus what *image analysis* means, almost nobody will give correct answer. However, people will try to guess what this term means. Probably, this is due to the fact that they understand the words: *image* and *analysis*. In the case of *stereology* situation is significantly worse. More than 99% of people have not heard anything about *stereology* and this is almost impossible for them to guess what this strange word describes.

Simultaneously, almost everybody will describe roughly but correctly what can be obtained from *tomography*. A significant number of people has undergone tomographic examination and understand the very basic principles of this technique. Some people know that their tissues have been analysed by pathologist but they are surprised when told that stereological methods have been applied for this examination. This is a kind of paradox, as simple analysis of basic definitions will demonstrate that *tomography* is just one of the methods of *stereology*. The aim of this work is to demonstrate that *image analysis* and *stereology* should be better promoted within the scientific society. One of the steps in this process should be redefinition of these terms. The final goals of this action would be, among others, minimizing the number of serious errors in interpretation of microstructural data and wider access to various funds for research.

Materials and Methods

No classical experiments known from biomedicine or technical sciences can be applied to prove that stereology and image analysis should be redefined and better promoted. We should rather apply methods related to social sciences. Fortunately, in the era of internet we have access to large data bases like, for example, Web of Science or Scopus. However, probably one of the best tools for such analysis is a browser developed by Google.

In Figure 1 one can find the results of simple Google search that illustrates how frequently the selected terms can be found in the cloud of electronically available information. If we compare the numbers for stereology and tomography, we will notice that there is only 0.5% probability to find information about stereology instead of tomography.
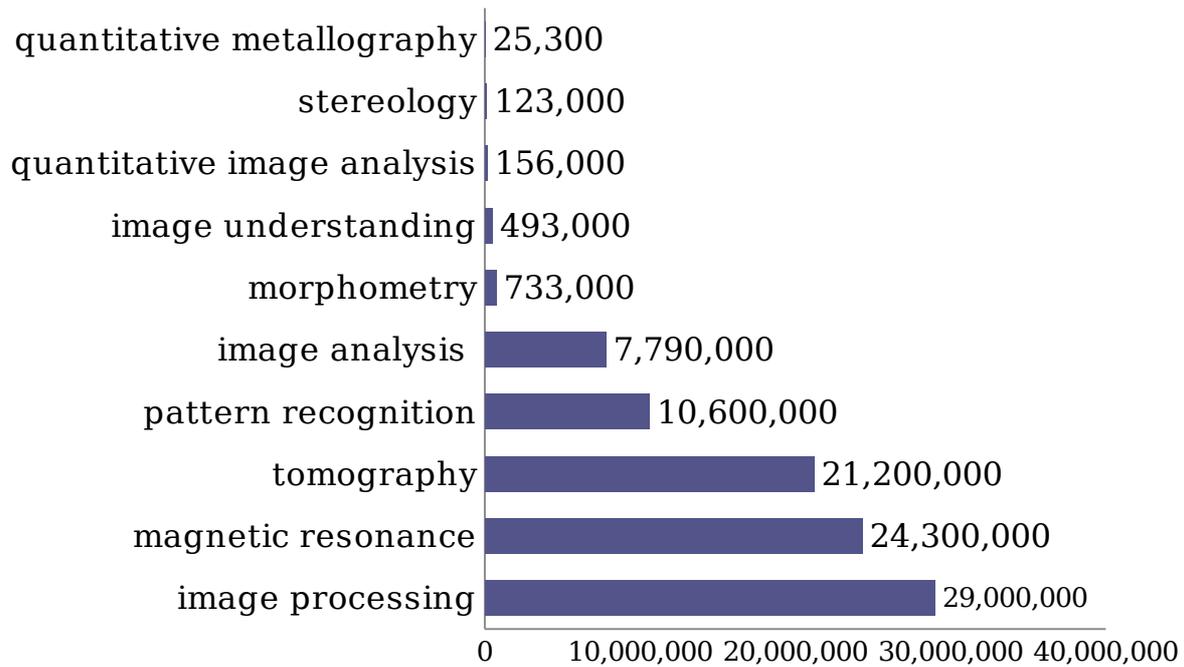
0

quantitative metallography	25,300
stereology	123,000
quantitative image analysis	156,000
image understanding	493,000
morphometry	733,000
image analysis	7,790,000
pattern recognition	10,600,000
tomography	21,200,000
magnetic resonance	24,300,000
image processing	29,000,000

0   10,000,000 20,000,000 30,000,000 40,000,000

Figure 1. Results of Google search on April 16, 2015

Results and Discussion

Let us analyse some definitions. Nowadays probably the first attempt to learn something about anything is looking for it in the internet sources. For stereology we will find the following (en.wikipedia.org/wiki/Stereology):

"Stereology is the three-dimensional interpretation of two-dimensional cross sections of materials or tissues". Next we can read that: "It provides practical techniques for extracting quantitative information about a three-dimensional material from measurements made on two-dimensional planar sections of the material". It sounds perfect, but further we find a notice that: "It is a completely different approach from computed tomography". It is difficult to find who has put such information but it reflects probably a really frequent opinion.

In the same source (en.wikipedia/wiki/Tomography) we can read that: "Tomography refers to imaging by sections or sectioning, through the use of any kind of penetrating wave". So, both methods use sections that are essential tool for examination. Moreover, in stereology we have no restrictions how the sections should be obtained. In addition, stereology involves three-dimensional interpretation of the data form sections and 3D reconstruction often applied on the basis of tomographic data fits perfectly this basic stereological principle. In that way we come to conclusion that **tomography is one of the methods of stereology**. Surprisingly, this method is 200 times more frequently noticed than stereology!

A very similar discussion can be performed with image analysis. In some works image analysis is treated as a step in the following sequence: image acquisition – image processing (filtering, noise reduction, etc.) – detection (extraction of some objects) – **image analysis** – application of the results (Tadeusiewicz and Korohoda, 1997). In the majority of sources, however, image analysis is interpreted as a sequence similar to that suggested by Grande (2000): image acquisition – **image processing** (digitization, thresholding) – image editing (binary image processing, segmentation) – feature

1 🔖

selection and measurement – statistical analysis and interpretation. So, image processing is a step of image analysis that seems to be more adequate to real solutions. In other words, image analysis contains image processing as one step of the process. Surprisingly, Google search (see Figure 1) shows that the term image processing is four times more frequently met than image analysis.

Conclusion

We should force redefinition and reinterpretation of image analysis and stereology. The current state, where these terms are misinterpreted and even unknown is for sure not satisfactory. As the first step the following definitions are proposed that can be a starting point for a wider discussion:

Stereology – a set of methods and techniques devoted to (usually quantitative) analysis and interpretation of data available from images. Note that both sections and projections are in principle images. So, this definition is in agreement with the most traditional one: a set of methods for analysis of three-dimensional geometrical features based on two-dimensional sections or projections. The proposed new definition is just wider and reflects contemporary state-of-art.

Image analysis – a process of data acquisition and interpretation in which the initial data set is an image or series of images and the final step is not an image (it can be number or a set of numbers, text, decision, movement etc.).

Possibly these new definitions would be helpful in better understanding and promotion of the achievements in stereology and image analysis.

References

Grande J.C. (2000) 'Principles of image analysis', in: Practical guide to image analysis, ASM International, Materials Park, OH, pp.75-100.

Tadeusiewicz R., Korohoda P. (1997) 'Komputerowa analiza obrazu', Wydawnictwo fundacji postępu telekomunikacji, Cracow, Poland.

Weibel E.R. (1987) 'Ideas and tools: the invention and development of stereology', Acta Stereologica, V.6 Suppl II pp.23-33.