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The cognitive process in metrology

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ABSTRACT

Human aspiration for deeper and fuller understanding of reality results from the philosophical meaning of the science developed by the man. The way that leads him to the utter recognition is made by more and more perfect systems of thinking. They enable the man to create infinitely complicated models of various phenomena from simple yet subtle laws of the nature.

This work shows the philosophical threads of metrology as a set of theoretical and empirical facts verifying human hypotheses as well as the metrology intellectual superstructure.

1. Introduction

Practical measurements have been used for thousands of years. Their purpose is to determine the values of properties of real objects, which are to be compared and exchanged. To this very end, these properties are compared with those of the assumed benchmarks, and the limits within which these properties are located – due to measurement errors – are then delineated. Thus, practical measurements include pattern adoption, comparing the patterns' properties with those of the objects studied, as well as determining the probable margins of errors made in the process and their calculation method.

Measurements have always formed a basis of interpersonal dealings, and since they permeate our practical life to such a remarkable extent, we have never recognised the need to create an overall theoretical measurement superstructure, which would, in turn, engender a solution to some basic metrological problems. For we cannot possibly dismiss the empirical knowledge of surveying methods accumulated over the centuries.

The science of measurement – metrology – is designed to fulfill a slightly different task. Like any other science, metrology is concerned not with material objects, but with abstract notions encompassing all classes of object properties. Metrology is still a relatively young science, emerging before our eyes. Its essence consists in theoretical, primarily mathematical, determination of surveying rules – on a global basis – without limitation to the description of its specific parts [3–6,31].

We live in the 21st century, when technology is based on the flow of information, and not, as previously, solely on the flow of energy. This qualitative change entails substantive and methodological alterations in many disciplines. Qualitative and quantitative change of the information flowing in from the surrounding world sheds a new light on the hitherto-existing problems and forces the coining of new concepts. These new circumstances require the development of interdisciplinary research. Metrology is one of these.

Everyday life makes us aware of the fact that we are surrounded by the real, material, tangible world, which is fully independent of us and which is our object of cognition. Our consciousness maps this world out in the form of words and phrases, images, numbers, and similar abstractions created by ourselves, as recipients of the cognitive process. This fact reminds us that there must be a link projecting the material reality into the abstract imagery of our consciousness.

Cognitive methods may include observations of everyday life, in which the senses are exploited as cognitive

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means. We are the set of cognitive tools, as well as the recipient of these tools' result of operation. This duality shows us the weakness of direct observation as a cognitive method, because its results depend significantly on the individual characteristics of the observer.

Metrology is a cognitive science, developed by man in order to imprint an image of the surrounding environment in human consciousness. As in any other branch of science, cognitive process involves at least two links: the object of cognition and the recipient of the results of the cognitive process. The cognitive subject is the world around us, and as such it is made up of inanimate objects, and filled with living creatures. Based on the experience of everyday life, we assume that this world is indeed real and independent of us. Instantaneous states of things and beings correspond to specific energy states of the surrounding electrical, thermal, optical and other fields. In the cognitive process, we derive information about the objects of this world by means of signals arising from changes in these fields [7,9,11,12].

A certain question often arises in the course of the discussion, namely: what methods and means can be used to create a scientific view of the world and when should they be applied? Science is a set of true theorems or the ones that are currently widely regarded to be true, which have been experimentally proven. So do the results of direct observations meet the condition of universality, or experimental verifiability? We cannot prove the truth of our views on the world – we can only assume the currently most likely state of their interpretation.

In the process of its continuous development, metrology keeps on discovering new measurement problems, and even hitherto unknown cognitive problems. Any such discovery leads to the formation of a new branch. In addition to traditional branches of metrology, such as the basis of metrology, standards and patterns, measurement methods, measurement data processing for error-tracing, there are new sections emerging, such as stochastic surveying, image recognition, the technique of measurement systems and many others.

This process of internal differentiation of metrology gives off the erroneous impression that metrology as a whole does not exist. Such a perception is superficial. Metrology is not only in the process of differentiation and specialisation, but also keeps integrating its various narrowly specialised departments within more general concepts. This is a consequence of the fact that a more detailed reality analysis entails a more comprehensive conceptual synthesis. This fact reinforces the cognitive nature of metrology.

An important issue in metrology is that the physical and mathematical models are only hypotheses, until they are verified experimentally, which is ultimately effectuated by means of measurements. It is only then that they become theorems and rights. In its cognitive process, metrology applies analysis and synthesis in the field of abstraction in reality imagery expressed by physical and mathematical models. It is in relation to these models that we find examples of "formal" analogies between notions which differ with respect to their phenomenal nature, while showing great similarities with respect to their conceptual upkeep.

This way of thinking underlies metrological activities, in which the issues of physical modelling of the real phenomena can be described using the concepts of matter, energy (entropy), time and information (negentropy). The main objective of metrology is to convert physical models built with the concepts of matter, energy and time into metrological models along with an experimental verification of their correctness, in the process of which physical models are complemented with information concepts, so as to provide qualitative (observation) and quantitative (measurement) information. The basic operating scheme of metrology corresponds to the schematic diagram of the cognitive process which constitutes the connection of the object studied, being the target of cognition, with its physical model and the mathematical and metrological models, which are interconnected, reflecting the verification processes of the individual models [13,20].

The creation process of a physical and mathematical model of the phenomenon under investigation may be either:

- deductive, facilitating the determination of the logical cause-and-result links of the object's properties;
- inductive, where the experiment may be the basis of a generalised hypothesis analogical to deductive reasoning which serves to distinguish the given phenomenon.

Model verification in physics is always of an experimental nature; however, experimental verification in a particular case does not constitute a corroboration of the truth, whereas a negative result of experimental verification, even in a single case, falsifies the hypothesis.

Metrology, as any independent discipline of science, has its basic problems, i.e. such issues without the resolution of which it could not be deemed a science and keep on evolving. These problems include, first and foremost, the creation of alternative reality patterns, its formal models, which reproduce reality with a known and sufficient approximation. These models should be characterised by clarity and accessibility, thus allowing for experimental validation of the reality reproduction, as well as a measure-based determination of the specific values of the models' elements.

Metrology is a result of transformations which combine scientific threads of many existing theoretical disciplines and engineering sciences. The evidence for metrology being a distinct and independent discipline is provided by:

- institutions which are programme-oriented to practice this discipline,
- newly-emerging journals, publishers, scientific and academic societies associated with surveying and measurements,
- an already-existing community of people practicing this specific discipline of science,
- specific set of issues and themes based on the cognitive theory, with the inclusion of the research methods and techniques consequent to it,