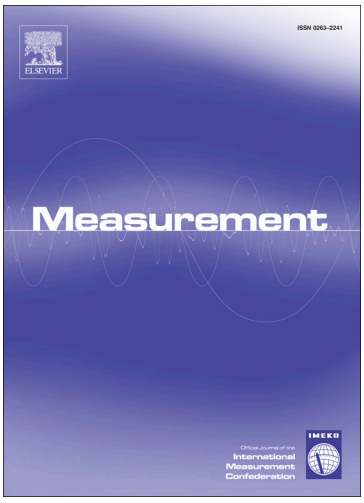

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A FORMAL THEORY OF THE MEASUREMENT SYSTEM

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Abstract

Measurement aims at obtaining a numerical description of objects/events/persons in the real world by means of a measuring system. Measurement is widely used as a key way for obtaining high quality information from the real world, across disciplines. In the present day, there is growing consensus in holding that measurement is characterized by the use of something that qualifies as a "measuring system". Therefore, we discuss sufficient conditions for an empirical system to qualify as a measuring system and we present a formal model of the measuring system, in terms of empirical relations among objects to be measured and the measuring device. The theory applies to all the main structures of metrological interest – order, difference, intensive and extensive, and we hope that this may help to fill a gap in these studies. We also briefly address practical applications of the theory, including calibration, modelling of measuring devices and performance statement.

Keywords: measurement science, measurement system, modelling in measurement

1. Introduction

The notion of measurement (or measuring) system has been only recently considered as an important object of investigation in measurement science [13-16, 18-19, 21-23, 27][1]. This apparently inexplicable delay, may be probably imputed, to some extent, to the influent position of Campbell[2], who, at the dawn of measurement theory, stated that the way measurement is actually performed is of no foundational interest [2], which probably contributed to often identify the theory of measurement with the representational approach [8]. A somewhat different approach was implied in the development of psychometrics, with the notion of latent variable, somewhat traceable to Galton and expressed as a hidden underlying cause of the variations", as properly noted by Spearman [1][3]. The methods of psychometrics, based on administering properly designed questionnaires, constitutes the implementation of (some kind of) a soft measuring device. Yet this interpretation, which is no more surprising at the present day, was far from being envisaged, at that time.

On the other hand others recognised the centrality of this issue in measurement. One of the earliest contributions in this direction was an important communication by the late Gonella, at the IMEKO World Congress in Huston [5], which unfortunately had much less resonance than it deserved. Sobolev and Aumala investigated the notion to some extent, making explicit the distinction between the transduction phase, and what they called the gauging phase [7].

[1] References are listed in a chronological order, to provide an immediate feeling of the historical development of the subject.
[2] Norman Campbell is the author of the first (and one of the few) systematic treatise on measurement theory, published in 1920. He strongly influenced, for better or for worse, the successive development of measurement science, especially in regards of the development of a coherent, and autonomous, measurement theory.
[3] The notion of *latent variable* is somewhat alternative to the notion of *quantity*, or "measurable property", of physical sciences.