Metrology and Quantitative Analysis in ISO 15939

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Abstract – *Measurement based on international standards for measurement (i.e. metrology) is not the same as the judgment-based quantification of implicit relationships across a mix of entities and attributes without due consideration of admissible mathematical operations on numbers of different scale types. This paper analyzes the Measurement Information Model in ISO 15939 and clarifies what in it refers to the classical metrology field, and what refers to the quantitative analysis of relationships.*

Keywords: Measurement, Metrology, ISO 15939, ISO VIM

1 Introduction: Numbers are not all created equal

Software practitioners and researchers alike often forget that numbers are not all created equal. For instance, a number derived from the result of a measurement process which meets the metrology requirements is a quantity expressed with a measurement unit. By contrast, a number derived from a mix of mathematical operations without consideration of measurement units and scale types will still be a number, but it could be a meaningless one (some of the Halstead's software metrics, for example [1]). Practitioners may feel good about such a potpourri of numbers from models which appear to take into account a large number of factors (i.e. as in many estimation and quality models) – see, for example, Use Case Points [2]. However, feeling good does not add validity to mathematical operations that are inadmissible in measurement.

In practice, various types of quantitative models produce numbers in outputs (i.e. the outcomes of the models), but they do not have the same qualities as the numbers that meet the requirements of metrology:

- An estimation model will provide a number as an estimate. However, with every such estimated number is associated a (potentially large) range of variations, depending on the number of input parameters and their corresponding uncertainties, as well as on the uncertainties about the relationships across all such parameters. The estimated numbers are not meaningful without a knowledge (and understanding) of the corresponding uncertainties.
- A quality model will provide a number which typically depends on: a specific selection among a (potentially large) number of alternatives; the assignment of a percentage to each contributing alternative, based on the opinion of one person (or a group of persons); and comparison of the contributing alternatives, with their distinct threshold values that are often defined by opinion as well.

In many instances, in these analysis models,

- some, if not all, of the numbers used as inputs to them are obtained by opinion, rather than from precise measurements (i.e. with measurement instruments or from the application of detailed measurement procedures);
- the input numbers are combined without explicitly describing the admissible mathematical operations and the treatment of the corresponding measurement units; and
- while the outputs of such models are indeed numbers, they do not have metrological properties, and should be handled very cautiously.

Analysis models like these are quantitative models, but they are not measurement models in the metrological sense. Such differences between quantitative analysis and measurement are not generally discussed in the software engineering literature. In this paper, we discuss these differences, using in particular the ISO 15939 Measurement Information Model which contains a metrology-related perspective as well as an analysis perspective. These concepts are illustrated with a productivity model as a Measurement Information Model.

2 ISO 15939 Measurement Information Model

The Measurement Information Model from ISO 19539 [3] (Figure 1) sets out the various steps necessary for the design of an *information product* when a measurable concept has to be designed and used in practice. In the illustration of this model in the figure, ovals represent activities and rectangles represent the

- the specific outcome of the regression model would be the Indicator, and
- the set of information from the specific productivity model built by this organization would correspond to the Interpretation context, while the standard statistical technique of linear regression, which forms the basis for the *organizational* reference context, would also be part of the Interpretation context.

7 Summary

Practitioners and managers can have much more confidence in measurement results based on international standards of measurement (i.e. metrology) than on the judgment-based quantification of implicit relationships across a mix of entities and attributes without due consideration of admissible mathematical operations on numbers of different scale types. This paper has analyzed the Measurement Information Model in ISO 15939 and clarified what in it refers to the classical metrology field, and what refers to quantitative analysis of relationships. The example presented has illustrated the quantification of relationships modeled by a productivity model built from a well-known and well-mastered statistical analysis technique such as regression. However, some of the quantitative models, such as the quality models built using ISO 9126, will provide numbers which typically depend on a specific selection among a (potentially large) number of alternatives, the assignment of a percentage to each contributing alternative, based on the opinion of one person (or a group of people), and comparison of the contributing alternatives with their distinct threshold values that are often defined by opinion as well. Future work is required to investigate, for instance, if these numbers, when combined adequately, consider the admissible mathematical operations and treatment of the corresponding measurement units, and whether or not the outcomes of such models are indeed meaningful numbers.

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