ISO/IEC Guide 98-6:2021-02 (E)

Uncertainty of measurement - Part 6: Developing and using measurement models

Contents

Page

Foreword v
Introduction vi
1 Scope 1
2 Normative references 2
3 Terms and definitions 2
4 Conventions and notation 2
5 Basic principles 3
6 Specifying the measurand 5
7 Modelling the measurement principle 9
7.1 General . . . 9
7.2 Theoretical, empirical and hybrid measurement models . . . 9
7.3 Differential equation models . . . 11
8 Choosing the form of the measurement model 13
8.1 General . . . 13
8.2 Fitness for purpose and approximations . . . 16
8.3 Representation and transformation of models . . . 16
8.3.1 Parametrization . . . 16
8.3.2 Re-parametrization . . . 17
8.3.3 Use in regression . . . 17
8.3.4 Simple transformations . . . 19
8.3.5 Non-linear relationships . . . 20
8.3.6 Impact on uncertainties . . . 20
8.3.7 Explicit and implicit forms of measurement model . . . 22
8.4 Multi-stage measurement models . . . 22
8.5 Uncertainty associated with choice of model . . . 24
8.6 Loss of numerical accuracy and its compensation . . . 24
9 Identifying effects arising from the measurement 28
10 Extending the basic model 29
10.1 General . . . 29
10.2 Adding effects to the basic model . . . 30
10.3 Modelling well-understood effects . . . 31
10.4 Modelling poorly understood effects . . . 33
10.5 Shared effects . . . 35
10.6 Drift and other time-dependent effects . . . 37
11 Statistical models used in metrology 39
11.1 General . . . 39
11.2 Observation equations . . . 40
11.3 Specification of statistical models . . . 41
11.4 Models for calibration and analysis . . . 42
11.5 Models for homogeneity studies . . . 43
11.6 Models for the adjustment of observations . . . 45
11.7 Models for time series . . . 47
11.8 Bayesian statistical models . . . 48
11.9 Estimation and uncertainty evaluation for statistical models . . . 50
11.10 Model selection and model uncertainty . . . 56
12 Assessing the adequacy of the measurement model 57
13 Using the measurement model 59
13.1 General . . . 59
13.2 Use of a model beyond the range for which it has been validated . . . 61
13.3 Explicit univariate measurement model . . . 62
13.4 Explicit multivariate measurement model . . . 63
13.5 Implicit univariate measurement model . . . 63
13.6 Implicit multivariate measurement model . . . 64
13.7 Measurement models involving complex-valued quantities . . . 64
A Glossary of principal symbols 66

B Modelling of dynamic measurements by linear time-invariant systems **67**
B.1 General . . . 67
B.2 Continuous-time models . . . 67
B.3 Discrete-time models . . . 68
C Modelling random variation **71**
C.1 General . . . 71
C.1.1 Random variation . . . 71
C.1.2 Considerations in modelling random variation . . . 71
C.2 Including random variation in a measurement model . . . 71
C.2.1 Options for including random variation . . . 71
C.2.2 Random variation associated with an existing input quantity . . . 72
C.2.3 Random variation as an effect associated with the measurand . . . 73
C.3 Multiple sources of random variation . . . 74
C.4 Asymmetrically distributed effects . . . 75
C.5 Use of reproducibility studies . . . 75
D Representing polynomials **78**
E Cause-and-effect analysis **80**
E.1 General . . . 80
E.2 5M method . . . 81
E.3 Measurement System Analysis (MSA) . . . 82
F Linearizing a measurement model and checking its adequacy **84**
Bibliography **86**
Alphabetical index **94**