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BSI Standards Publication

Road vehicles — Objective rating metrics for dynamic systems

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National foreword

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Road vehicles — Objective rating metrics for dynamic systems

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Foreword

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The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 10, *Impact test procedures*, and SC 12, *Passive safety crash protection systems*.

Introduction

Computer-Aided Engineering (CAE) has become a vital tool for product development in the automobile industry. Various computer programs and models are developed to simulate dynamic systems. To maximize the use of these models, their validity and predictive capabilities need to be assessed quantitatively. Model validation is the process of comparing CAE model outputs with test measurements in order to assess the validity or predictive capabilities of the CAE model for its intended usage. The fundamental concepts and terminology of model validation have been established mainly by standard committees including the United States Department of Energy (DOE),[6] the American Institute of Aeronautics and Astronautics (AIAA),[1] the Defense Modeling and Simulation Office (DMSO) of the US Department of Defense (DOD),[5] the American Society of Mechanical Engineers Standards Committee (ASME) on verification and validation of Computational Solid Mechanics,[2] Computational Fluid Dynamics and Heat Transfer,[3] and various other professional societies.[4][22][23]

One of the critical tasks to achieve quantitative assessment of models is to develop a validation metric that has the desirable metric properties to quantify the discrepancy between functional or time history responses from both physical test and simulation result of a dynamic system.[7][19][20] Developing quantitative model validation methods has attracted considerable researchers' interest in recent years.[12][13][14][18][20][21][26][28][29][32] However, the primary consideration in the selection of an effective metric should be based on the application requirements. In general, the validation metric is a quantitative measurement of the degree of agreement between the physical test and simulation result.

In this Technical Report, four state-of-the-art objective rating metrics are investigated and they are: CORrelation and Analysis (CORA) metric,[10][30][31] Error Assessment of Response Time Histories (EARTH) metric,[28][34] model reliability metric,[18][27][35] and Bayesian confidence metric.[14][16][36] Multiple dynamic system examples for both tests and CAE models are used to show their advantages and limitations. Further enhancements of the CORA corridor rating and the development of an Enhanced Error Assessment of Response Time Histories (EEARTH) metric are proposed to improve the robustness of these metrics. A new combined objective rating metric is developed to standardize the calculation of the correlation between two time history signals of dynamic systems. Multiple vehicle safety case studies are used to demonstrate the effectiveness and usefulness of the proposed metric for an ISO Technical Report.

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1 Scope

This Technical Report specifies a method to calculate the level of correlation between two non-ambiguous signals. The focus of the methods described in this Technical Report is on the comparison of time-history signals or functional responses obtained in all kinds of tests of the passive safety of vehicles and the corresponding numerical simulations. It is validated with signals of various kinds of physical loads such as forces, moments, accelerations, velocities, and displacements. However, other applications might be possible too, but are not in the scope of this Technical Report.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
filtering
smoothing of signals by using standardized algorithms

2.2
goodness or level of correlation
similarity of two signals

2.3
interval of evaluation
time domain that is used to calculate the correlation between two signals

2.4
rating
rating score
calculated value that represents a certain level of correlation (objective rating)

2.5
sampling rate
recording frequency of a signal

2.6
time sample
pair values (e.g. time and amplitude) of a recorded signal

2.7
time-history signal
physical value recorded in a time domain; those signals are non-ambiguous

3 Symbols and abbreviated terms

3.1 General abbreviated terms

CAE	Computer-Aided Engineering
CORA	CORrelation and Analysis
DTW	Dynamic Time Warping