2007 IEEE International Workshop on Advanced Methods for Uncertainty Estimation in Measurement

16 - 18 July 2007

Sardagna, Italy

AMUEM 2007 Technical Program Tracks & Sessions

Tuesday, July 17

9:00 AM - 10:15 AM

Opening session

Room: Conference room
Chair: Alessandro Ferrero (Politecnico di Milano, Italy)
Chair: Dario Petri (University of Trento, Italy)

10:45 AM - 12:00 PM

Uncertainty expression I

Room: Conference room
Chair: Alessandro Ferrero (Politecnico di Milano, Italy)

Quantifying the Measurement Uncertainty Using Bayesian Inference **1**
Andrea Zanobini (Università di Firenze, Italy)
Lorenzo Ciani (Università di Firenze, Italy)
Gabriella Pellegrini (Università di Firenze, Italy)

Abstract - In this paper we describe the use of Bayesian inference for the evaluation of measurement uncertainty. The performance of the proposed approach is tested in a multivariate non linear measurement model in which the measurand is the ratio between two quantities: the first one being the sum of constant systematic effects and experimental indications, while the second one is referred to a measurement standard. By assuming that the information about the input quantities are in form of prior joint probability density functions and a series of direct measurement data are available by experiment, the Bayes' theorem is applied to evaluate the posterior expectation (estimate), the posterior standard uncertainty and the posterior coverage probability concerning the measurand. Numerical results are reported to assess the validity of the proposed analysis.

Approximating Coverage Intervals of Well-Known Continuous Probability Distributions by Possibility Distributions **5**
Gilles Mauris (Université de Savoie, France)

Abstract - At the application level, it is important to be able to define around the measurement result an interval which will contain an important part of the distribution of the measured values, that is, a coverage interval. This practice acknowledged by the ISO Guide is a major shift from the probabilistic representation. It can be viewed as a probability-possibility transformations by viewing possibility distribution as encoding coverage intervals. In this paper, we extend previous works by proposing approximate closed form possibility expressions of optimum coverage intervals associated to well known underlying continuous symmetrical unimodal probability densities

On a generalized T-norm for the representation of uncertainty propagation in statistically correlated measurements by means of fuzzy variables 10
Arianna Mencattini (University of Rome Tor Vergata, Italy)
Marcello Salmeri (University of Rome Tor Vergata, Italy)
Roberto Lojacono (University of Rome Tor Vergata, Italy)

Abstract - The problem of uncertainty representation and propagation in the context of statistically correlated variables is commonly addressed by means of Montecarlo simulation as recommended in IEC-ISO Guide. Moreover, in a recent literature, fuzzy sets have proved to be a valid alternative in the case of independent variables. Unfortunately, the problem of modelling statistically correlated variables, by means of fuzzy sets, is still an open problem. Since it is well known that T-norms are the natural way of combining fuzzy variables into a nonfuzzy function f, in this paper, we investigate how to generalize the class of T-norms, making it dependent from correlation coefficient in order to emulate different statistical correlation degree among variables. A practical example will be provided in order to compare the proposed method with Montecarlo simulation and with that obtained by uncertainty propagation described in IEC-ISO Guide.

Poster session I

Room: Poster room
Chair: Alessandro Ferrero (Politecnico di Milano, Italy)

Air Gauge Adjustment Uncertainty Reduction 16
Miroslaw Rucki (Poznan University of Technology, Poland)

Abstract - Investigations on air gauging have long tradition. Nowadays, various methods of air gauging are in use: flow gauge with rotameter, velocity type air gauge with Venturi chamber, Bourdon tube pressure gauge, air gauge with variable amplification, differential type devices and other back-pressure air gauges. The advantages of pneumatic gauging are widely known, among others they are: non-contact measurement, no sliding members, self-cleaning of the target area on the object surface, self-aligning and centering inside bores, wide range of amplifications, adaptability to multiple dimension gauging, economic advantages and so on. Nowadays, the piezoresistive measurement of back-pressure gives high resolution and digital output which increases the merits of pneumatic gauging. To estimate properly uncertainty of the measurement, the engineers have to have some “experience” with the system components. In fact, the static characteristic represents not a line, but the area where the signal might appear with certain probability. Usually the confidence area corresponds with six-sigma area around the expected value of static characteristics. In practice, however, the air gauge is being adjusted basing on two points, usually set by setting masters. After the adjustment, the theoretical, linear static characteristics would be established, but it may differ from the true static characteristics, because the set points may appear somewhere in six-sigma area. It is obvious that further distribution of the measuring signals will depend on the set characteristics. Thus, the final uncertainty of air gauge is affected by both adjustment and measurement. It should be considered as 12? area, where ? is standard deviation of pneumatic measuring signal. To avoid such propagation of measurement uncertainty, the thorough analysis of measuring signal should be performed, and some steps undertaken. The investigations of the dispersion of measurement results showed its correlation with pressure pk fluctuations in the measuring chamber. The very fluctuations of the measuring pressure pk during adjustment are the main source of uncertainty and may affect the whole measurement. Therefore, they should be examined, measured and processed in order to minimize the effect of error propagation. The paper presents the analysis, experimental results and proposals which enable to reduce the adjustment uncertainty of pneumatic gauge.

Uncertainty in CMM Measurement of Roundness **20**
Bartosz Gapinski (Poznan University of Technology, Poland)
Miroslaw Rucki (Poznan University of Technology, Poland)

Abstract - In the paper, the roundness has been chosen as an object of measurement uncertainty analysis because of wide application of bore-shaft connection. Obviously, the form deviations of those elements (roundness and cylindricity) will affect substantially the way of their work. The measurement of those deviations may be performed using both universal and specialized measuring devices, dependent on the assumed uncertainty, price and time of the measurement. Specialized devices are most accurate and fast, but in most cases only one kind of deviations may be measured with one device. The basic procedure in the Coordinate Measuring Technique is the definition of coordinate system of measured object. There are many possibilities for such definition, therefore its accuracy and influence on further measurement would depend highly on the knowledge and skill of operator. In order to reduce the uncertainty of coordinate system, some recommendations have been worked out. If the axis of measured cylinder is declined to the measurement base (and, hence, to the coordinate system axis), the measurement of roundness will be performed in elliptic cross-section. As a result, the untrue form deviation will be calculated (ovality), and decrease or increase of the harmonic characteristics will be seen. the results of measurement are affected by the angle between the cylinder axis and the axis of the coordinate system. The fitting element affects it, too. When the diameter is measured, the result is almost independent for the MIC fitting method, while the MCC method is dependent in highest degree on the angle "alfa" value. The investigations enabled to point out the general trend for all fitting methods. In the experimental researches, the master with roundness deviation below 1.8 μm was applied. Based on the performed simulations and measurements, the algorithm and program has been worked out to support the operator's decision on the appropriate number of points. The following two criteria may be applied: Criterion "MPEE" – bounded with the inaccuracy of the Coordinate Measuring Machine. If this criterion is chosen, the recommended number of points will ensure the uncertainty of final result below the inaccuracy of CMM. Here, the inaccuracy of the CMM is considered to be a parameter MPEE defined by standard ISO 10360. Criterion "0.1T" – bounded with the tolerance of measured detail. The condition of the metrologically correct measurement is the uncertainty below 10% of tolerance (in some cases 20% are allowed). Here, the recommended number of points ensure uncertainty on the level of 10% of assumed dimensional tolerance of measured detail. The measurement results fully confirmed the values obtained by the digital simulations.

Estimation of Uncertainty in Complex Biomeasurements **24**
Anna Cysewska-Sobusiak (Poznan University of Technology, Poland)

Abstract - Optoelectronic processing is of especial importance in present-day biomedical engineering. The paper covers the new practical application of advanced methods for uncertainty estimation in very complex noninvasive measurements based on the pulse oximetry method. One of most important limitations is that measuring devices usually demand to be standardized on human subjects. The role of knowledge of uncertainty of the reading to be obtained with monitoring equipment has fundamental relevance in clinical practice. A representative series of noninvasive optoelectronic measurements of the arterial blood oxygenation has been selected to describe in detail and to summarize results with graphical illustration. The author has made a broad set of experiments made under laboratory and clinical conditions, monitoring a lot of different human subjects. In comparative studies, two methods and three measuring devices were used to measure the same variable. The proposed procedure may aid improving the evaluation of uncertainty based on an analysis of the processing function. As was counted in numerous situations, the covariances can significantly contribute to a decrease in the combined standard uncertainty, weighted according to how the result varies with changes in these quantities.

Uncertainty Propagation In Diagnostic Systems Based On Soft Computing Techniques **30**
Loredana Cristaldi (Politecnico di Milano, Italy)
Marco Faifer (Politecnico di Milano, Italy)
Ferdinanda Ponci (University of South Carolina, USA)

Abstract - Currently, in industrial application, the timely detection of performance degradation is critical in sparing faults, service interruptions and consequent costs. When maximum availability is required, the maintainability of the system is a focal point: in this way a effective diagnosis may also allow for convenient maintenance scheduling. The exploitation of soft-computing techniques supports methodologies that may allow for early fault detection also in presence of limited sensing capabilities, thus limiting the intrusion in the physical system and the costs of additional sensing units. In this scenario the idea of "dedicated diagnosis" can be modified by the point of view of "diagnosis activity" linked to the monitoring one. Soft-computing techniques have been proposed in literature and have been proven capable of providing meaningful qualitative diagnostics in some cases. Still, further investigation is required to verify the impact in the decision-making process of measurement uncertainty and uncertainty propagation in the diagnostic algorithms . This issue is the focus of the present work, which analyses in this perspective the wavelet-based neuro-fuzzy algorithms for diagnostics. This approach involves feeding a neuro-fuzzy fault risk index with the wavelet decomposition of a measured signal. The impact of the wavelet decomposition and the sensitivity of the risk index to changes in the membership functions, is investigated The physical benchmark of this work are small electrical motor-drives.

2:00 PM - 3:40 PM

Uncertainty expression II

Room: Conference room
Chair: Gilles Mauris (Université de Savoie, France)

Different possible approaches to RFV construction based on the available metrological information **35**
Alessandro Ferrero (Politecnico di Milano, Italy)
Simona Salicone (Politecnico di Milano, Italy)

Abstract - Different approaches than those framed strictly within the theory of probability and recommended by the GUM have been proposed during the last recent years for uncertainty expression and estimation. The one based on Random-Fuzzy Variables (RFV) appears to be the most promising one, since it is based on the theory of evidence, that encompasses both the probability and possibility theories as particular cases. The correctness of the final uncertainty estimation depends, quite directly, on the way the RFVs are built, which depends on the available metrological information. After briefly recalling the fundamentals of the RFV approach, this paper discusses how the available information should be exploited to attain correct results.

An Adaptive Model of the Fuzzy Variable - Quality Index **41**
Jenny Wirandi (University of Kalmar, Sweden)
Jiandan Chen (University of Kalmar, Sweden)
Wlodek Kulesza (University of Kalmar, Sweden)

Abstract - In this article we discuss a model of the quality as the fuzzy variable in order to gain understanding and enable their development. We propose a general method to estimate the quality index which can handle both qualitative and quantitative issues. The method uses a fuzzy neural network since the system learns how to integrate the human judgement of quality into a quantitative index. As a case study we have used the measurement of pulp quality and image quality.

Image Quality Assessment: an Overview and some Metrological Considerations **47**
Alessio De Angelis (University of Perugia, Italy)
Antonio Moschitta (University of Perugia, Italy)
Fabrizio Russo (University of Trieste, Italy)
Paolo Carbone (University of Perugia, Italy)

Abstract - This paper presents the state of the art in the field of Image Quality Assessment (IQA), providing a classification of some of the most important objective and subjective IQA methods. Furthermore, some aspects of the field are analysed from a metrological point of view, also through comparison with the software quality measurement area. In particular, a statistical approach to the evaluation of the uncertainty for IQA objective methods is presented and an example is provided. The topic of measurement modelling for subjective IQA methods is also analysed. Finally, a case study of images corrupted by impulse noise is discussed.

Expectation – A Fuzzy Term in Metrology? **53**
Karl Ruhm (Federal Institute of Technology (ETH), Zürich, Switzerland, Switzerland)

Abstract - Within the metrology community we find several ideas concerning the importance and definition of the term "expectation". Sometimes it is used inadequately. Here we quote the most popular ones and derive, from the point of view of signal and system theory as well as of stochastics and statistics, one pair of definitions as being the most reasonable. Several familiar examples will support this systematic approach. In the surroundings of the ISO Guide to the Expression of Uncertainty in Measurement (GUM) [1] at least the use of the term expectation is not always clear.

4:00 PM - 5:15 PM

Uncertainty estimation - Case study I

Room: Conference room
Chair: Simona Salicone (Politecnico di Milano, Italy)

Uncertainty and Worst Case Analysis for a Low-Pass Filter Using Polynomial Chaos Theory **59**
Anton Smith (University of South Carolina, USA)
Antonello Monti (University of South Carolina, USA)
Ferdinanda Ponci (University of South Carolina, USA)

Abstract - Power measurement is very important for accessing power quality and efficiency. However, this measurand can be affected by the presence of low pass filters used for anti-aliasing or high frequency noise reduction. In AC power measurement the low pass filter affects two important properties of the AC signals magnitude and phase. The low pass filter can be made of discrete components, which inherently have some sort of uncertainty. The effect of this parameter uncertainty must be quantified to determine the effect of the low pass filter on the quality of the power measurement. This paper describes the use of Polynomial Chaos Theory (PCT) to quantify the effect of parameter uncertainty of a second order low pass filter such as the Sallen-Key filter. The paper demonstrates the use of PCT to obtain the probability distribution function (PDF) of the Sallen-Key filter given a certain parameters uncertainty, it also demonstrates that it is possible to obtain the worst-case, expected and best-case output of the Sallen-Key filter without actually reconstructing the PDF.

Prediction of the Lifetime of a Battery-Operated Video Node Using Offline and Online Measurements **64**
Gefan Zhang (University of California Santa Cruz, USA)
Roberto Manduchi (University of California Santa Cruz, USA)

Abstract - This paper presents a model for determining the first and second order statistics of the lifetime of a battery-operated node. This model assumes knowledge of the statistics of duration and consumption of the tasks that can be performed by the system, as well as of the statistics of the task occurrences and of the remaining charge in the battery. The latter may be monitored by an onboard sensor. Knowledge of the remaining lifetime is very important in order to devise an online control strategy assuring that specific requirements are met.

An effective Method to Handle Measurement Uncertainty in Conformance Testing Procedures **69**
David Macii (University of Trento, Italy)
Dario Petri (University of Trento, Italy)

Abstract - This paper deals with a new design criterion aimed at keeping the decisional risks associated to conformance testing procedures below given target values. The proposed approach is based on two closed--form analytical expressions describing the dependence of both the Consumer's Risk (CR) and the Producer's Risk (PR) on three essential parameters for conformance testing, i.e. the process capability index (C_p), the Test Uncertainty Ratio (TUR) and the Gauging to Tolerance interval Ratio (GTR). Such approximate expressions are not only very accurate, but also much less computationally demanding than the implicit, integration-based expressions of CR and PR. This assures faster results and less numerical problems when the values of TUR and GTR meeting the wanted CR and PR requirements are determined.

5:15 PM - 5:45 PM

General discussion I

Room: Conference room
Chair: Alessandro Ferrero (Politecnico di Milano, Italy)

Wednesday, July 18

9:00 AM - 5:15 PM

Poster session II

Room: Poster room
Chair: Dario Petri (University of Trento, Italy)

Accounting Measurement Uncertainty in Fuzzy Inference **74**
Alessandro Ferrero (Politecnico di Milano, Italy)
Simona Salicone (Politecnico di Milano, Italy)
Grazia Todeschini (Politecnico di Milano, Italy)

Abstract - Fuzzy inference systems are presently employed in the presence of uncertain models, or when deterministic models are too complex to be implemented. Up to now, all input data to fuzzy inference systems are represented by crisp variables also when they represent experimental measurement results, thus disregarding measurement uncertainty. Since recent works have shown that measurement results can be effectively represented, together with their associated uncertainty, by fuzzy variables, this paper proposes a modified fuzzy inference system characterized by considering fuzzy variables as input data.

Analysis of the Maximum Entropy pdf Reconstruction Based on Uncertain Higher Order Moment Estimates 80
Gabriele D'Antona (Politecnico di Milano, Italy)

Abstract - The ISO guide for the expression of uncertainty requires the statement of the measurement uncertainty in terms of expanded uncertainty associate to a defined level of confidence. This analysis requires implicitly the knowledge of the probability density function (pdf) of the measurement results. Unfortunately even for a simple measurement models, as the ISO one, it is difficult to determine the pdf of the measurement result if the pdf of the uncertainty terms of type A and B are not Gaussian. As a consequence it is difficult to determine the coverage factor and the expanded uncertainty to associate to a given confidence level. When we are dealing with situations characterized by a large number of type B uncertainty sources we can count on the central limit theorem and consider the pdf of the measurement estimate Gaussian. Unfortunately usually we cannot count on this hypothesis since we deal with only a few type B uncertainty terms. A solution to this problem, suggested in a previous work by the author, was to approach the problem in terms of few higher order statistical moments analysis. As a matter of facts the pdf of the type B uncertainty sources are known, i.e. we have an a-priori knowledge of the moments of any order for these terms. The higher order moments of the type A uncertainty source can be estimated by repeated observations. It is thus possible to propagate the known estimates of the higher order moments through the measurement ISO model. On the basis of the resulting moments the author showed that adopting the maximum entropy principle the pdf of the measurement result could be reconstructed. When the moments considered are only the first and second, this approach is consistent with the ISO recommendations based on the classical law of propagation of uncertainty and a Normal pdf for the measurement uncertainty. Since the higher order moments results from an estimation process, are themselves affected by uncertainty. Consequently also the pdf reconstructed by the maximum entropy principle will be uncertain as well. This paper will mainly focus on the analysis of pdf reconstruction dispersion caused by the higher order moments estimate uncertainty and, in particular, the uncertainty of the estimate of the coverage factor associated to a given level of confidence. The results will generalize the concept of degrees of freedom adopted in the classical ISO uncertainty analysis based on the first two moments analysis and the hypothesis of Gaussian pdf.

A Digital Circuit for Jitter Reduction of GPS-disciplined 1-pps Synchronization Signals 84
Leonardo Gasparini (University of Trento, Italy)
Olga Zadedyurina (University of Trento, Italy)
Giorgio Fontana (University of Trento, Italy)
David Macii (University of Trento, Italy)
Andrea Boni (University of Trento, Italy)
Yoram Ofek (Università di Trento, Italy)

Abstract - The Global Positioning System (GPS) satellites are equipped with atomic clocks that are used not only for localization purposes, but also to enable the receivers to produce high-stability synchronization signals (i.e. trains of low-jitter pulses). Such signals can be used to synchronize the operation of multiple electronic systems or for fundamental metrological applications. Of course, the timing accuracy of the generated stream of pulses depends on the features as well as on the cost of the specific GPS receiver employed. This paper describes a fully digital synchronization circuit which is able to reduce the jitter associated to the 1 pulse per second (1-pps) signal generated by a typical low-cost receiver of moderate timing accuracy within a short settling time interval. The proposed circuit has been implemented using an FPGA and the jitter reduction has been estimated experimentally.

On the Use of Numeric Integration for Uncertainty Evaluation in Indirect Measurements **89**
Pasquale Memmolo (Università di Napoli Federico II, Italy)
Rosario Schiano Lo Moriello (Universitò degli Studi di Napoli Federico II, Italy)
Paolo Pinto (Università di Napoli Federico II, Italy)
Blandina De Iorio (Università di Napoli Federico II, Italy)

Abstract - The most meaningful issue of measurement practice is the estimation of uncertainty that must be associated with the result of a measurement so that it can usefully be employed in any technical, commercial, or legal activity. Rules for correctly estimating measurement uncertainty were formalized by the IEC-ISO recommendation “Guide to the expression of uncertainty in measurement” (GUM). In recent years, several authors highlighted some limitations the GUM suffers from; to overcome these limitations, Workgroup 1 (WG 1) of the Joint Committee for Guides in Metrology (JCGM) proposed to move from variances propagation (the approach peculiar to the GUM) to distributions propagation in order to evaluate measurement results. To this aim, numeric methods based on MonteCarlo simulations are, in particular, suggested to be adopted. To suitably overcome the limitations affecting the LPU and simultaneously assure results similar to those granted by MonteCarlo simulations, the authors propose hereinafter a numeric method based on direct integration of the measurement model for the estimation of output quantity and standard uncertainty in indirect measurement. More specifically, the method applies the definition of mathematical expectation and variance to the measurement model f for numeric evaluation of the desired estimates. Preliminary results on simulated measurement data have highlighted the promising performance of the methods in terms both of estimates reliability and computational. In particular, conducted tests have shown remarkable concurrence between the estimates of output quantity and standard uncertainty provided by the proposed method and those granted by 1 million MonteCarlo simulations. Computational times required by the porposed method have, however, been 50 times lower than those exhibited by MonteCarlo simulations.

Uncertainty estimation I

Room: Conference room
Chair: Alessandro Ferrero (Politecnico di Milano, Italy)

Combining inconsistent data **93**
Ignacio Lira (Pontificia Universidad Catolica de Chile, Chile)

Abstract - At present, the most widely used procedure for finding the value of a quantity from data obtained by different observers involves calculating the inverse-variance weighted mean of the observers' estimates. This method produces reasonable results if the data are consistent. However, in many cases a consistency test reveals the possible existence of outliers that nevertheless have to be included in the evaluation task. In this paper the Bayesian understanding of probability is used to treat this problem. It is first shown that the weighted mean method results from the assumption that the observers’ biases are identically zero. If the data do not support this assumption, other evaluation methods are needed. Three such methods are then derived, application of which is discussed through a simulated example.

Modeling Time Synchronization Uncertainty Sources in Wireless Sensor Networks **98**
David Macii (University of Trento, Italy)
Anton Ageev (University of Trento, Italy)
Dario Petri (University of Trento, Italy)

Abstract - This paper deals with a thorough analysis of the uncertainty sources affecting the inter-node time synchronization in Wireless Sensor Networks (WSNs). Such an analysis relies on a stochastic model describing the various uncertainty contributions as well as on the abstraction of the main features of real WSN node architectures. Some simulations and experimental results confirm the correctness of the theoretical approach.The achieved results will enable a fast and trustworthy comparison about the accuracy performances of various synchronization protocols running on different node models.

Uncertainty evaluation of speech quality measurement in VoIP systems **104**
Pietro Paglierani (Italtel S.p.A., Italy)
Dario Petri (University of Trento, Italy)

Abstract - The paper analyses the problem of testing the speech quality performance provided by a real VoIP telephony network. To this aim, the objective measurement of end-to-end speech quality by means of the PESQ algorithm is discussed, and its accuracy as an estimator of the subjective Mean Opinion Score is summarised. Then, the application of the PESQ algorithm in the analysis of the performance of real life VoIP systems is presented. A characterization of the PESQ algorithm uncertainty under different measurement conditions and network scenarios is provided. This particular problem, in fact, has received little attention in the literature, even though many results on the use of the PESQ algorithm in other types of applications have been presented by researchers. Experimental data obtained in the speech quality characterization of a real-life VoIP equipment (Media Gateway) are reported and discussed.

Optimized uncertainty estimation in the calibration of two port networks transmission coefficient **109**
Bruno Audone (Sinal, Italy, Italy)
Ludovico Azzolin (University of Padova, Italy)
Alessandro Sona (University of Padova, Italy)

Abstract - The uncertainty evaluation in the calibration of two-port networks transmission coefficient is here dealt with. Attention is focused on the covariance contribution of the uncertainty expression and on the effect of mismatch terms. To this aim, the approach suggested by the Guide for the expression of uncertainty in measurement (GUM) is discussed, and solutions are proposed aimed at optimally combining all the uncertainty terms to be considered. To confer reliability and generality to the research activity, a number of experiments are conducted through a proper test bench. The ultimate goal is to provide practical hints for improving the calibration accuracy of two-port networks transmission coefficient, and simplifying the derivation of the standard uncertainty.

11:00 AM - 12:15 PM

Uncertainty estimation II

Room: Conference room
Chair: Dario Petri (University of Trento, Italy)

Virtual Instruments: Uncertainty Evaluation in the Presence of Electromagnetic Interferences **115**
Salvatore Nuccio (University of Palermo, Italy)
Ciro Spataro (Università di Palermo, Italy)
Giovanni Tinè (National Research Council, Italy)

Abstract - The electromagnetic interferences can influence the performances of a generic virtual instrument and alter the related uncertainty sources. In the paper, we report the results of various experimental tests performed with the aim to check if and how the radiated and/or conducted emissions affect the instruments' characteristics and, in particular, the single uncertainty sources. In order to apply standard requirements and criteria, we consider the disturbance limits suggested by the product EMC standard and we follow the test procedures prescribed by the basic EMC standards. The results show that, in some cases, the electromagnetic disturbances boost the uncertainty sources and, consequently, increase the uncertainty values, worsening the measurement quality.

Metrological Characterization of a Vision-Based Measurement System for the Online Inspection of Automotive Rubber Profiles 121
Rosario Anchini (University of Salerno, Italy)
Giuseppe Di Leo (University of Salerno, Italy)
Consolatina Liguori (University of Salerno, Italy)
Alfredo Paolillo (University of Salerno, Italy)

Abstract - The paper deals with the metrological characterization of a stereo-vision based measurement system for the inspection of automotive rubber profiles in an industrial plant. The characterization of the class of such measurement systems introduces new challenges, both for the unavailability of reference measurement instruments and for the complexity of the measurement system itself that does not allow a straightforward application of the standard procedures for the uncertainty evaluation. After a description of the measurement system, the characterization is presented in terms of evaluation of the dependencies of systematic effects and uncertainties on known and expected influence quantities. With this aim, several experimental results are reported and commented.

Uncertainty-Complexity Trade-Offs for Sensor Compensation Design 127
Michele Gubian (University of Trento, Italy)
Anna Marconato (University of Trento, Italy)
Andrea Boni (University of Trento, Italy)
Dario Petri (University of Trento, Italy)

Abstract - In this work we focus on the design of reduced-complexity sensor compensation modules based on learning-from-examples techniques. A Multi-Objective Optimization design framework is proposed, where system complexity and compensation uncertainty are considered as two conflicting costs to be jointly minimized. In addition, suitable statistical techniques are applied to cope with the variability in the uncertainty estimation arising from the limited availability of data at design time. Experimental results on a synthetic benchmark are provided to show the validity of the proposed methodology.

2:00 PM - 3:15 PM

Uncertainty estimation - Case study II

Room: Conference room
Chair: Simona Salicone (Politecnico di Milano, Italy)

The role of Uncertainty in the Design of a Control System for Magneto Hydro Dynamic Instabilities in a Tokamak 133
Gabriele D'Antona (Politecnico di Milano, Italy)
Sante Cirant (Politecnico di Milano, Italy)
Daniela Farina (Politecnico di Milano, Italy)
Franco Gandini (Politecnico di Milano, Italy)
Adriano Manini (Politecnico di Milano, Italy)
Hartmut Zohm (Politecnico di Milano, Italy)

Abstract - A tokamak is a toroidal plasma confinement system designed for achieving the conditions for nuclear fusion reactions. The regime of stable operation in current and density in a tokamak is limited by disruptions which involve sudden loss of confinement and plasma current. Density limit disruptions are connected with the non-linear evolution, in amplitude and phase, of Magneto Hydro Dynamics (MHD) instabilities associated to magnetic islands (tearing modes). Active control of MHD instabilities is important in order to improve tokamak performance. Such instabilities are associated with local distortions of the temperature and current density profile. In order to restore locally the perturbed current profile, localized heating by electron cyclotron heating systems (ECH) is a crucial tool for an active control of the MHD behaviour of the discharge. The ECH heating system, composed by several high power (1 MW) ECH line sources that can be steered independently, must be controlled in order to deposit the heating power in a thin plasma layer close to the magnetic island position. In order to assure the fastest stabilization action of the feedback control system a new scheme has been proposed for the International Thermonuclear Reactor (ITER) that will be experimented in the next two years on the German tokamak ASDEX Upgrade. The novelty of the proposed control scheme is that the control action will be based not only on the estimate of the magnetic island and ECH heating lines positions, but also on the uncertainties of these estimates. This paper will describe the diagnostic tools adopted for the estimation process and the control strategy based on the uncertainty estimation. In particular two Bayesian filters will assimilate (fuse) the estimate of the magnetic islands position and ECH deposition radius obtained by complex numerical models with the respective position observed with proper plasma temperature distribution measurements.

Uncertainty Propagation in a Non-linear Regression Analysis: Application to a Ballistic Absolute Gravimeter (IMGC-02) 137
Walter Bich (Istituto nazione di ricerca metrologica, INRIM, Italy)
Giancarlo D'Agostino (Istituto Nazionale di Ricerca Metrologica (INRIM), Italy)
Alessandro Germak (Istituto Nazionale di Ricerca Metrologica (INRIM), Italy)
Francesca Romana Pennecchi (Istituto Nazionale di Ricerca Metrologica - INRIM, Italy)

Abstract - Today's most accurate measurements of the gravitational acceleration are based on interferometric reconstruction of the vertical trajectory followed by a test body launched in a vacuum chamber. The gravity value g is one of the parameters of a model function derived from the law of motion of the body, and is estimated by a least squares adjustment. In this paper we present the regression analysis applied to the IMGC-02 absolute gravimeter and the associated uncertainty propagation. We also show how a suitable choice of the reference height z, at which g is calculated, can yield a minimum-variance estimate. This choice is based on the covariance matrix of the parameter estimates provided by the adjustment algorithm.

Evaluating Measurement Uncertainty of Traffic Monitoring Systems 143
Giuseppe Di Leo (University of Salerno, Italy)
Antonio Pietrosanto (University of Salerno, Italy)
Paolo Sommella (University of Salerno, Italy)

Abstract - All the more Advanced Traffic Management techniques base their efficiency on reliable traffic monitoring systems. In a so important and emerging field, where the technical solutions proposed to measure and collect traffic primary data are not few, a unique methodology to evaluate and compare their performance still misses. In the paper the problem of the metrological characterization of traffic monitoring systems is widely treated, founding inspiration on the ISO Guide to Uncertainty in Measurement. Early experimental results are reported to demonstrate the applicability of the suggested procedure to some off the shelf instruments.