METTI5 Tutorial T7 on

“Experimental identification of low order model”

Author
Jean-Luc Battaglia, Laboratory I2M, Department TREFLE.

Duration
1 h 30

Type
Experimental/Numerical

Content

The goal of this tutorial is to apply the system identification technique in order to obtain an accurate direct model devoted to measurements inversion. This tutorial is closely related to Lecture L8. A simple experiment will be used in order to give the basic ideas of the optimal experiment in system identification approach. The choice of the excitation sequence will be particularly emphasized. Two methods will be used: the correlation method and the parametric method. A direct model will thus be obtained and it will be analyzed in terms of reliability and accuracy.
As a conclusion, the advantages of this approach will be pointed out with respect to the classical one based on the resolution of the heat diffusion equation.

METTI5 Tutorial T2 on

“Zero-order optimization algorithms”

Authors

Emmanuel RUFFIO, Didier SAURY, Daniel PETIT, Manuel GIRAULT

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Duration

1h30

Type

Methodological/numerical

Content

This workshop deals with local and global optimization algorithms and particularly with zero-order algorithms. The field of optimization has gained increasing attention in past decades. This led to the emergence of new optimization algorithms sometimes referred as “metaheuristics”. Most of them are nature-inspired: they mimic biological evolution, or the way biological entities communicate in nature. After a brief overview of the most traditional local search algorithms – simplex and gradient-based methods – the concept of heuristic and metaheuristic is presented. Some hints are pointed out in order to identify hard and simple optimization problems.
Two evolutionary algorithms are then presented: Evolution Strategies (ES) and Genetic algorithms (GA), but more details will be given on Particle Swarm Optimization (PSO), a swarm intelligence-based algorithm. An optimal experiment design problem is solved to illustrate benefits and drawbacks of metaheuristics over traditional local search algorithms. Common test functions like Rastrigin and Rosenbrock are finally used to assess the efficiency of each algorithm.

METTI5 Tutorial T3 on

"Thermal characterization of materials through the hot wire/hot plate techniques"

Authors:

Andrzej Kusiak, Jean-Luc Battaglia

Duration:

1h00

Type:

Experimental

Content:

The authors will present two very simple techniques for thermal characterization of bulk materials.
The first one, the hot wire method permits obtaining the thermal conductivity of solids and liquids. The second one, the hot plate, leads to the thermal effusivity of solids.
The common feature of the two techniques is the use of extremely simple devices for thermal excitation of the studied media. In the two cases, the heat source is based on electrical Joule dissipation in a wire or in a plane resistance.
The advantages and the drawbacks of the two methods will be discussed.

METTI5 Tutorial T4 on
"In situ realization/characterization of temperature /heat flux sensors "

Authors

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Duration

1h30

Type

Experimental/methodological

Content

One will expect from a temperature sensor to be 1) sensitive to temperature, 2) accurate and 3) with low inertia. The sensitivity is provided by the thermometric phenomena. The accuracy comes on one hand from the calibration and measurement of the thermometric phenomena and on the other hand, from the correct mounting of the sensors. The first one is rather well known, the latter being very often ignored. The inertia of thermocouple is usually characterized by its time constant which depend also on the medium in which it is mounted.

This tutorial is about temperature and heat flux measurement with thermocouples and can be seen as a complementary information to lecture L5. Time constants, errors due to heat leakage through the connection wires of the thermocouples will be illustrated with experiments. Some rules will be explained to implement thermocouples in metallic sample in order to realize accurate and sensitive 1D heat flux sensors. Thin film heat flux sensors will also be discussed.

METTI5 Tutorial T5 on

"Characterization of transient distributed surface sources through infrared thermography"

Authors: S. Vintrou[1,2], N. Laraqi[1], J.-G. Bauzin[1], A. Baïri[1]

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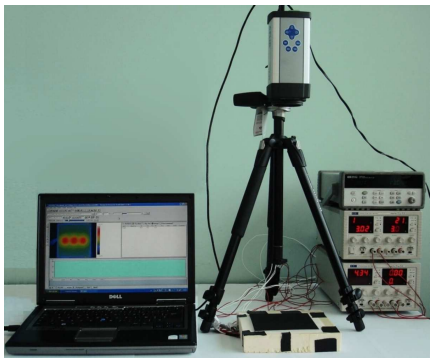
Duration: 1h30

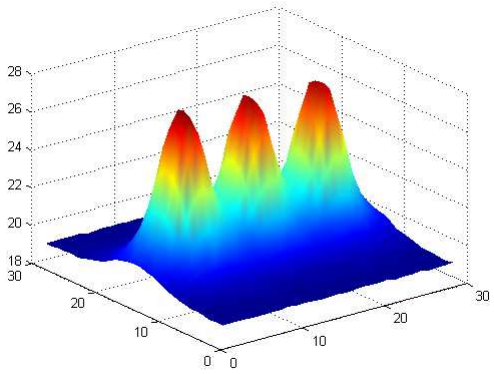
Type: experimental and numerical

Content

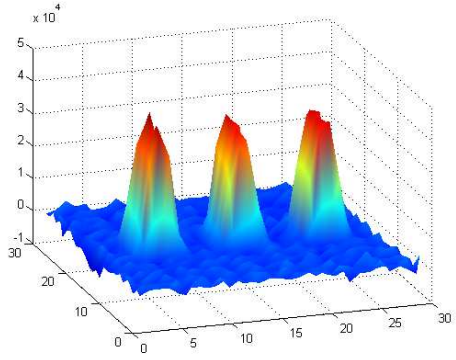
During this workshop, we invite the participants to put into practice some of the fundamental notions seen during the courses dealing with the problem of spatio-temporal reconstruction of heat source. This course focuses on the estimation of spatial and temporal distributions of a given heat flux distribution received by the front face of a thin metallic plate from the temperature field collected on the back face of the sample by infrared thermal imaging. Measurements realized on the spot will allow to liven up the workshop. The collected data will be processed and then used in a code based on a sequential estimation method: the state representation "pseudo-inversion" of the 3D parabolic model of heat conduction phenomenon in the material. The heat flux density is made discrete in space (2D) and time. A good spatial and temporal resolution involves a high number of unknown values. The method not being iterative, the solutions are not auto-regularized by a stopping criterion. The high number of unknowns to be estimated simultaneously and the measurement noise increase the ill-posed character of this multi-dimensional inverse problem and regularisation tools are highly recommended in such situations. The optimization under constraints allows shading off these inherent instabilities. We suggest testing two regularizing techniques: (i) the stabilization by function specification proposed by Beck and (ii) the regularization by penalization developed by Tikhonov with three orders: 0, 1 and 2.



Experimental test bench (transportable)



Measured temperature (back)



Estimated heat flux (front)

METTI 5 Advanced Summer School - Tutorial T6

Inverse problems in a microchannel (experimental)

Christophe RAVEY – Christophe PRADERE

I2M Departement TREFLE, CNRS UB1 Arts et Metiers ParisTech,
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Abstract:

The aim of this work is to present new techniques for the estimation of thermophysical properties in microfluidics devices. The estimations are performed from the experimental measurements of the front face temperature fields of microfluidics chips, using InfraRed (IR) thermography. The inverse methods developed are based on a correlation coefficient. It allows to estimate parameters like the thermal diffusivity, the velocity, and also the source term. Different applications will be shown. In the first experiment, we demonstrate how to use our methods for the estimation of Fourier and Peclet numbers in the case of transient flows in microchannels. Then, we will apply those methods for the kinetics characterization of an acid/base chemical reaction. This experiment is realized in co-flow configuration in microchannels and is used to quantify the enthalpy of reaction. Finally, phase change is studied, from freezing of single droplets on free surfaces to crystallization in microchannels. This part of the work focuses on the estimation of source term and its location. All experiments are realized with an IR Camera and rapid image processing using MATLAB software.

METTI5 Tutorial T7 on

"Real data identification of an actual radiator-room system aimed to virtual sensor design"

Authors

Stefano Malan, Cosimo Greco

Dip. di Automatica e Informatica, Politecnico di Torino, Torino, Italy

Duration

1 h 30

Type

Numerical / (Experimental, in the sense that actual acquired data are made available to students)

Content

The tutorial deals with both theoretical issues and practical hints on data analysis and processing, in order to identify linear and affine mathematical models, using standard techniques implemented by Matlab/Scilab tools. Actual acquired thermal and hydraulic data are made available to students to work out the proposed identification problem and to test the algorithms. Tutorial details are as follows. Firstly, the radiator-room system is described and the thermal model identification problem is stated, aimed to design a Virtual Sensor. Then, inputs (commands/disturbances) and outputs (measured/estimated) are defined together with the model typologies (transfer matrix/state space equations; linear/affine). Some practical suggestions on data preprocessing (detrend, scaling, etc.) are also pointed out. To conclude, the obtained models are shown and compared to evaluate their suitability in describing the plant behavior. Eventually, some notes on Virtual Sensor design are also given.

METTI5 Tutorial on Analysis of Error Factors for Measurement Data and Inverse Techniques, Application to Temperature Measurements and Heat Flux Estimations

Authors

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Duration

1h

Type

Methodological, Experimental

Content

I Methodology

The present document provides a complete methodology for the determination of inverse techniques uncertainties. The methodology is based on the Monte Carlo Method. It includes two steps:

- The first step is the **characterization of measurement errors**. The measurement errors can be described as t-distribution random variables. The document provides some details about the different calculation steps which, from a set of raw data measurements, lead to the determination of the total error random variable and the uncertainty on the measurement.

  The measurement total error is caused by various physical phenomena which may be identified. Those phenomena are called **error factors**. The document shows how to decompose the total error into a sum of errors associated to the error factors, and how to obtain the t-distribution random variables which describe those associated errors. The decomposition of the total error allows a better characterization of measurement errors.

- The second step is the **generation of noised input populations**, which is then used for the Monte Carlo method. Special input populations can be generated in order to evaluated the principal error factors which are responsible to the inverse techniques uncertainty.

II Application

The methodology which is described in the document has been applied to an inverse technique, which is used to obtain **heat flux values** at the surface of a wall, from **temperature measurements**. The temperature uncertainties are calculated from the calibration measurement

data, by considering two error factors: the electromagnetic noise, and the calibration curve error.

Then, different input populations are generated for the evaluation of the heat flux uncertainty. The analysis of the results provides a detailed description of the effect of the different error factors on the final uncertainty.

METTI5 Tutorial T9 on

“Thermal characterization of an insulating material through a tri-layer transient method”

Authors

Vincent Félix, Yves Jannot, Alain Degiovanni
LEMTA, Nancy-Université, CNRS,
2, avenue de la Forêt de Haye, BP 160 - 54504 VANDOEUVRE France

Duration

1 h 30

Type

Experimental

Content

The three layers transient method is dedicated to the thermal properties measurement of small samples of insulating materials. The three layers experimental device (brass/sample/brass) and the principle of the measurement based on a pulsed method will be first presented. The three dimensional model of the system will be developed and used for a sensitivity analysis. The estimation method will be described and its application to simulated noisy measurements realized with COMSOL will be presented. During the workshop, several experiments will be carried out on different materials and the experimental temperature recording will be used to estimate the thermal properties of the tested samples.
Some improvements to the initial model such as taking into account a parallel or series thermal resistance will be discussed.

METTI5 Tutorial T10 on

“Kalman and partical filters”

Authors

Helcio R. B. Orlande[1], Marcelo J. Colaço[1], George S. Dulikravich[2], Flavio L. V. Vianna[3], Wellington B. da Silva[1,4], Henrique Massard da Fonseca[1,4], Olivier Fudym[4]

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Duration

1h30

Type

Methodological/numerical

Content

State estimation problems, also designated as nonstationary inverse problems, are of great interest in innumerable practical applications. In such kinds of problems, the available measured data is used together with prior knowledge about the physical phenomena and the measuring devices, in order to sequentially produce estimates of the desired dynamic variables. This is accomplished in such a manner that the error is minimized statistically.

The solution of state estimation problems can be obtained within the Bayesian framework of statistics. The most widely known Bayesian filter method is the Kalman filter. However, the application of the Kalman filter is limited to linear models with additive Gaussian noises. Extensions of the Kalman filter were developed in the past for less restrictive cases by using linearization techniques. Similarly, Monte Carlo methods have been developed in order to represent the posterior density in terms of random samples and associated weights. Such Monte Carlo methods, usually denoted as particle filters among other designations found in the literature, do not require the restrictive hypotheses of the Kalman filter. Hence, particle filters can be applied to non-linear models with non-Gaussian errors.

In this tutorial we present in a didactical manner the Kalman filter, as well the Sampling Importance Resampling (SIR) algorithm of the Particle Filter. Such filters are then applied to a simple heat transfer problem involving a lumped system, aiming at the student’s comprehension of the algorithms and of the computational coding with MATLAB. Applications to more involved heat transfer problems are also presented.

METTI5 Tutorial T11 on

“Inverse Heat Conduction Problem using thermocouples deconvolution and infrared measurements: application to heat flux estimation in a Tokamak”

Authors

Jean-Laurent GARDAREIN, Jonathan GASPAR
Universités d’Aix-Marseille, IUSTI Laboratory, Marseille.

Duration

1h30

Type

Methodological/Numerical programming

Content

This tutorial is especially designed for beginners in inverse techniques in heat conduction. Internal components of magnetic confinement fusion machines are subject to significant heat fluxes. In order to estimate the input heat flux on these plasma-facing components, some temperature measurements techniques are used: IR scanner, embedded thermocouples. Through this experimental example we propose to detail a heat flux estimation procedure associating deconvolution and regularization methods (SVD, Tikhonov). This tutorial will be organized as follow:

- Presentation of the experimental context and of the measurements data
- Presentation of the inverse problem
- Description of the inversion procedure used and validity domain of the method
- Application to experimental data

All the source codes are written with Matlab. The source code will be given to the participants at the end of the tutorial.

METTI5 Tutorial T12 on

“Analysis of errors in measurements and inversion”

Authors
Philippe LE MASSON, Morgan DAL
Laboratoire d’Ingénierie des MATériaux de Bretagne. Université Européenne de Bretagne/ Université de Bretagne Sud; Centre de recherche de l’Université de Bretagne Sud, Rue saint Maudé, 56321 LORIENT Cédex.

Duration
1h30

Type
Methodological/numerical

Content
In this workshop, we recall first of all the sources of errors found in the inverse problems. We focus then on the errors connected to the measurements by thermocouples. This approach allows to underline the phenomena involved, as well as the analytical models in permanent and in transitory regimes, that are developed in the literature. This analysis, although fundamental, remains limited in complex cases. So, numerical models are then set up, to show the errors committed during measurements with various types of thermocouples and with various modes of setting-up. They concern an application connected to the welding of metallic materials.