Conference Organization and Goals

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A Workshop of the INI Programme on the
Design and Analysis of Experiments

5 September 2011

Outline

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2. **Stochastic Computer Experiment**
3. **Deterministic Computer Experiments**

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  - **Blocking factors** allow the experimenter to broader the inference about the **primary treatment factors** to **multiple environments**.
  - **Randomization** is used to prevent factors that are not recognized by the experimenter from systematically affecting treatment comparisons.

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  among other goals

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1. Physical Experiments
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- **Applications in** Business Management; Manufacturing; Management; Military Applications; Network analysis; Risk Analysis

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- **Input Variables**
  - Environmental (modeled stochastically)
  - Model (Input uncertainty)
  - Controllable

Stochastic Computer Simulations

- **Typical Scientific Goals**
  - Model verification
  - Screening
  - Sensitivity Analysis, to quantify the effects of individual inputs and joint effects of sets of inputs
  - Determine robustness of model output to random environmental or uncertain model inputs (components)
  - Choice of control variables to optimize system performance

Stochastic Computer Simulations

- **Interface with Classical Statistical Methodology**

(Weighted) Regression analysis; Xvalidation and Bootstrap methodology; Design: orthogonality, resolution, aliasing patterns

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- **Numerical implementations** of a (or more) physics- or biology-based **mathematical model** relating input-output relationship.
- **Use Micro-modeling**: Often Coupled PDEs

Thus consider the linear biphasic equations in the form appropriate to these field variables:

$$\begin{aligned} &\left(v_i^s - \kappa p_{,i}\right)_{,i} = 0 \\ &\sigma^{Tot}_{ij,j} = \left(\sigma^s_{ij} + \sigma^f_{ij}\right)_{,j} = \left(C_{ijkl} u^s_{(k,l)} - \delta_{ij} p_{,i}\right)_{,j} = 0 \end{aligned} \qquad (1)$$

where κ is the permeability, ( ),i denotes the partial derivative, σ^{α}_{ij}, α = s and α = f are the respective solid and fluid phase stress tensors, p is the fluid phase pressure, $\varepsilon_{ij} = u^s_{(i,j)}$ is the solid phase strain tensor (the superscript s is omitted), defined in terms of solid phase displacements, u^s_i, C^s_{ijkl} is the material property tensor of the solid phase, δ_{ij} is the Kronecker delta, $v^s_i = \frac{du^s_i}{dt}$ is the solid phase velocity, and $\sigma^{Tot} = \sigma^s + \sigma^f$ is the total stress. The solid phase and fluid phase stress tensors are defined as:

$$\begin{aligned} &\sigma^s_{ij} = C_{ijkl} u^s_{(k,l)} - \phi^s p \delta_{ij} \\ &\sigma^f_{ij} = -\phi^f p \delta_{ij} \end{aligned} \qquad (2)$$

where ϕ^s, ϕ^f are the solid and fluid volume fractions, respectively, for the saturated ($\phi^s + \phi^f = 1$) mixture.

With these phase stress definitions, the total stress, σ^{Tot}_{ij} is

$$\begin{aligned} \sigma^{Tot}_{ij} &= \sigma^s_{ij} + \sigma^f_{ij} = C_{ijkl} u^s_{(k,l)} - \phi^s p \delta_{ij} - \phi^f p \delta_{ij} \\ &= C_{ijkl} u^s_{(k,l)} - \left(\phi^s + \phi^f\right) p \delta_{ij} \\ &= C_{ijkl} u^s_{(k,l)} - \delta_{ij} p = \sigma^E_{ij} - \delta_{ij} p \end{aligned} \qquad (3)$$

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- **Output** is **deterministic** (up to numerical noise): stresses and/or strains in materials; Pressures; Time for some event to occur

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- **Typical Scientific Goals**
  - Model verification (does the FE, CFD, or other numerical method solve the mathematical model)
  - Screening
  - Sensitivity Analysis, to quantify the effects of individual inputs and joint effects of sets of inputs

Deterministic Computer Simulations

- If data from an analogous physical experiment is available, assess bias in computer simulator; calibrate the computer simulator; predict the output from future physical experiments
- Choice of control variables to optimize system performance (mean performance for the proposed environment)

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1. Physical Experiments
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- Share perspectives for solving using and fusing our experimental methodologies

Goals and Workshop

- **Workshop**

Day 1

1. Substantive applications from members of the computer simulation communities
2. Validation and calibration methodology
3. In Session on Computer Simulators and Physical Experiments I, Grant Reinman will speak on “Design for Variation”
4. Poster Storm/Preview
5. RVP Lecture on Orthogonal Arrays (wine reception)

Goals and Workshop

Day 2

1. Design
2. Panel Discussion #1– Interfacing Physical and Computer Experiments
3. Screening

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Day 3

1. Large-scale SCS
2. Use of Kriging Methodology in SCS
3. Free time to Tour Cambridge

Goals and Workshop

Day 4

1. Input uncertainty, Robustness and UQ
2. Kriging and related methodology
3. Panel Discussion #2–Input uncertainty and experimental robustness

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Day 5

1. Prediction methodology: multiple models, UQ,
2. Panel Discussion #3: What have heard? What are the common challenges to our research communities? (Qua es nos iens?)

Caius Dining Hall