Mapping of Temperatures from Coarser to Finer Grid using Temporal Derivatives

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Corning

- High-tech materials company (www.corning.com)

- Display Technologies
  - Glass substrates for liquid crystal displays

- Environmental Technologies
  - Catalytic substrates and filters for emission controls

- Speciality Materials
  - Gorilla glass as cover glass for handheld devices

- Life Sciences
  - Scientific laboratory products (e.g. Pyrex®)

- Telecommunications
  - Optical fiber, cable (backbone of internet)

- In news “Diamond-turned mirrors by Corning are part of the imaging system of NASA’s New Horizons mission that recently made its historic pass by Pluto”
Outline

• Background
  – Ceramic Manufacturing Process

• Problem
  – Improving the spatial resolution of thermocouple data

• Objectives

• Tentative timelines
Background

Ceramic Manufacturing process

- This problem broadly falls in the realm of Environmental technologies
- Ceramics parts subject to prescribed temperature cycle in kilns
- Thermocouples are installed in parts to observe temperature evolution inside the part
- Temperature further post-processed to estimate internal stresses experienced in the parts
- Stress estimation used for estimating probability of upset for the process

Ceramic Substrates

Ceramic Particulate Filters

40 years of Corning Environmental Technologies
Problem Statement

• Industrial manufacturing process
  • incomplete knowledge of material properties, boundary conditions, and sources for a given material/manufacturing process.
  • Making it difficult for direct prediction of process parameters such as temperature

• Process monitors such as thermocouples are commonly used

• Thermocouples are deployed on coarse spatial grid. Measurements usually have very high temporal resolution

• Internal stresses $\rightarrow$ spatial temperature gradients $\rightarrow$ temperatures on a finer spatial grid

• Mapping temperatures from coarser grid to finer grid
  • Interpolation techniques
  • Error prone when exotherms and endotherms are present during the process

**Mapping temperatures from coarser grid to finer grid**
Objectives

1. Figure of Merit

Temperatures are measured at the locations specified by

Interested in knowing temperature at

We could use bilinear interpolation
  • How incorrect is it to use interpolations for a given set of temperature measurements

Objective 1

Establish a figure of merit to make an assessment on invalidity of using interpolation techniques for a given temperature data set
Objectives

2. Develop Algorithm and goodness of fit

- Temperatures are measured on a coarse grid (m x n)
- Need temperatures on a finer spatial grid (p x q)
- Measurements are done with a high temporal resolution

Objective 2

Develop an algorithm to map temperatures from a coarse spatial grid to finer spatial grid. Also formulate a goodness of fit estimation

Sample test data will be provided for procedure development
Objectives

3. Test the Algorithm on different data sets

Objective 3

Test the developed algorithm on different data sets

*Data sets (measured data and synthetic data) with different degrees of heat source/sink strengths will be provided to test figure of merit, mapping algorithm and goodness of fit*
Objectives

4. Extend the approach to 2D axi-symmetric problems

• Problem at hand is a 3D problem
  – 2d axi-symmetry could be a reasonable approximation
• If you as a team feel that it is easier
  – Start developing the figure of merit, mapping algorithm, goodness of fit using 1D data
  – Quickly transition to 2D axisymmetric
Approach

• Generate synthetic data with various degrees of source/sink strengths
  – I have setup a direct problem that is very close to real case
• Use this data to develop mapping algorithm and test it
Tentative Timelines

• Aug 5th – Go over problem statements once. Supply you with some test data. Team members would discuss the problems and come up with potential solutions approaches
  – I will be available for any clarifying questions
• Aug 10th – Try to completes objectives 1 and 2
• Aug 13th – Try out algorithm for different data sets and check how well your procedure works
• Writing and preparing presentation should be an ongoing task