Learning Objectives

1. Illustrate how the real-world responds to the development of and limitations of computer solutions

Topics

- Validating and verifying the model that was previously created

1. Introduction

One of the reasons models have become important is that traditional approaches to designing systems and products, building and testing prototypes, and arriving at a final product are no longer sufficient for firms to stay competitive in the global market. With a design in mind, the building of a prototype is a very expensive process and takes a long time. Those things result in an increase in the cost of product development, a delay in getting products to market, and a limitation on innovation as few companies can afford to build more than a few prototypes and test a few designs.

Thus, there are substantial benefits to industry for adopting computational modeling as a part of their design, product development, and management processes.

The danger in using models, however, is that when their results do not match the physical world, they can lead to expensive errors and misjudgments. Therefore, before a model can be used in industry or government, it needs to be verified and validated.

- Verification – determination that a program was properly constructed by the stated rules (i.e. are there implementation errors in the actual programming?)
  - Did we build the system right?
  - Software testing and/or mathematical proof
- Validation – determination that program correctly predicts the state of the system
  - Did we build the right system (leave out a significant effect)?
  - Do the results approximate the real world?

Models that have been verified and validated are often given a “seal of approval” by some governing agency (accreditation).

- Accreditation
In complex systems, it is acceptable to have adjustable parameters that are fit to data from the system before predicting future behavior. However, before such programs are accepted for use, they must be shown capable of correctly predicting results outside the “calibration” period. The main sign that a model is improperly constructed is divergence, i.e. the model begins to produce results farther and farther from the real system as one gets away from the validation period (or the calibration period if the model has been adjusted to fit). Signs of growing error should be taken very seriously.

2. Practical Aspects of Verification, Validation, and Accreditation

When making decisions based on models, you are generally concerned about risk analysis and risk mitigation. Complex systems always involve some uncertainty.

- With uncertainty, there are concerns about:
  - Safety
  - Quality assurance
  - Reliability

- There are a number of types of uncertainty:
  - Epistemic – uncertainty in knowledge
  - Aleatory – uncertainty relating to natural variability

Judgment needs to be used when there is no way to differentiate among many possible situations. Decision-making is always made in some context or frame. Related to models:

- There are often many different models that forecast aspects of the same phenomenon
- Must judge models by their intended use
- No single process can capture the range of circumstances we will be dealing with
- Requires a flexible process that allows reviewers to apply the appropriate frame
ENGR 1181 MATLAB 17: Verification and Validation
Preparation Material

**Verification Tips:**
- Compare the computed results to a few analytically solved problems
  - User should get acceptably near the same answer
- Check algorithms, if possible
- Compare with other models or methods

**Validation Tips:**
- Carefully define the model assumptions and what those mean for the circumstances where the model will be valid
- Make a statistical comparison with empirical data from laboratory or testing results
  - Outside any calibration period
- Define the range of the validity for which the model is tested
  - Implications of extreme, untested conditions
  - For example, fit the wrong curve