Construction Operation Simulation

Lecture #1

Introduction to construction operation simulation

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Outline

- Introduction
- Why simulation?
- Simulation types
- Why simulating construction operations?
- Construction simulation and visualization
- Main steps in simulation studies
- Is simulation a proper tool?

Introduction

- A simulation is the imitation of the operation of real-world process or system over time. (Banks 1998, p3)
- The set up or apparatus used for doing the imitation (or simulation) of the real-world process or system is called *simulator* or *simulation model*!
  - Examples:
    - Wooden, mechanical, horse simulator during World War I

Introduction

- Examples (cont'd):
  - Simulation of outer space condition for astronauts in pool of water prior to their actual mission!

Introduction

- Examples (cont'd):
  - Use of flight simulators for training pilots!

Introduction

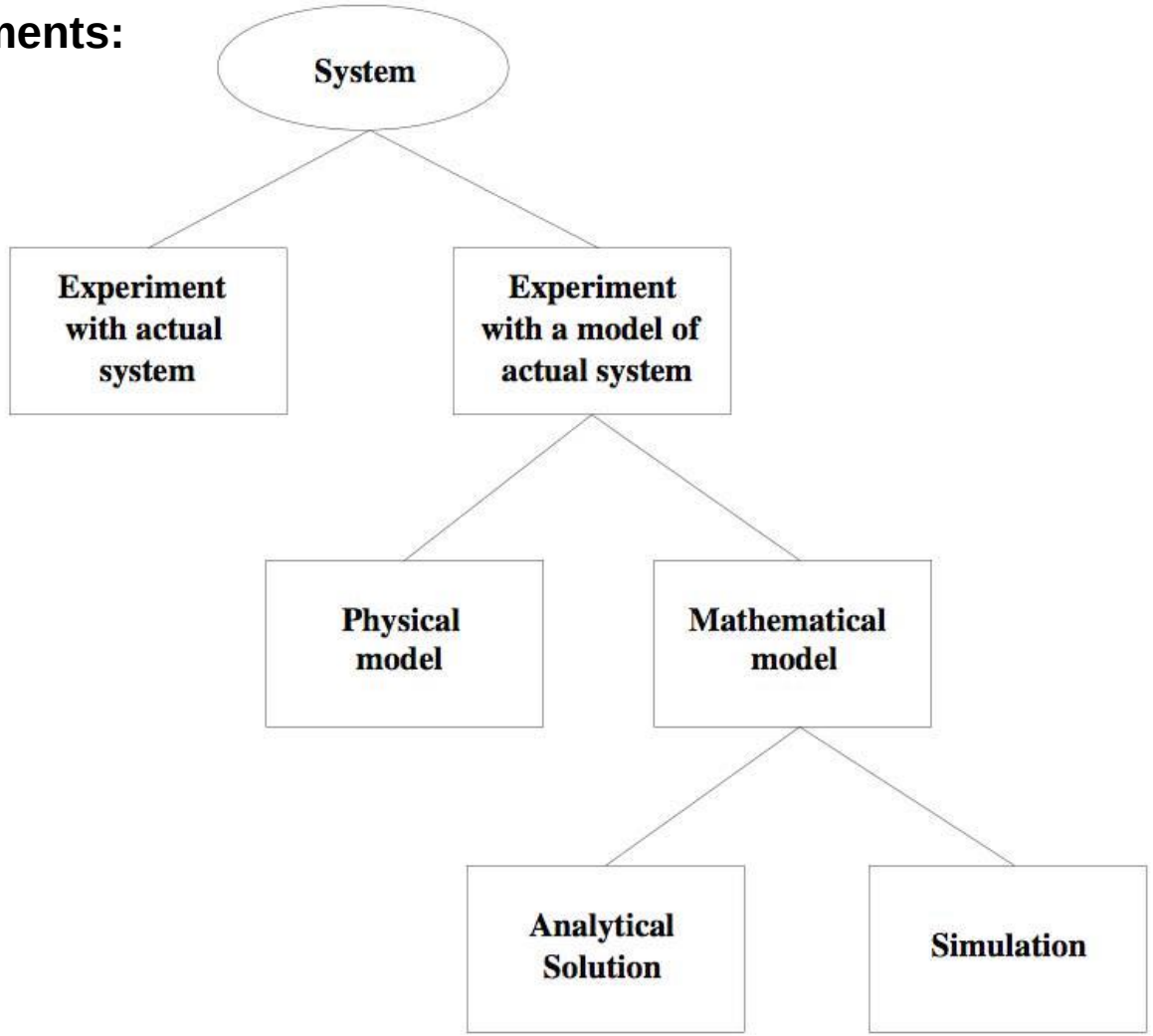
- Examples (cont'd):
  - Use of motorcycle simulator in a computer game!

Introduction

- Examples (cont'd):
  - Use of simulation model for planning crane lifts of building modules!

Introduction

Type of system experiments:



Why simulation?

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Why simulation?

- *Experiencing the real job or operation is expensive*. Use simulation to create similar condition to the real world's for training purposes!
  - Examples: Flight simulator. What if we use actual system, instead of a simulator, to train new pilots?
- *Condition of a prospective (to be built) process/ system is complex and difficult/ impossible to be captured by commonsense and/ or analytical methods* (e.g., numerical equations, mathematical programming and statistical analysis).

  Analysis and design with simulation: Use simulation to create different possible features/ specifications of a prospective process/ system, evaluate/ analyze the process/ system performance with different features in advance, select features which bring the best performance for the process/ system.

  In simulation you can compress the time and analyze different alternatives in a short period of time or expand the time and get more elaborated!

Why simulation?

Why simulation? (cont'd)

- Example: Simulation of crane lifts of complex building modules in congested site condition. Too many factors affecting the lift such as sequence of module installations, concurrent construction operations nearby, weather condition, size and shape of modules, crane location, etc. All these make our lift planning difficult/ inaccurate by just using analytical tools.

- *Simulation as a fancy presentation tool*. Simulation of prospective processes and systems, specially with supporting visual/ graphical interface, builds up the confidence of the system clients (government, investors, etc.) on how future process/ system will work.
  - Examples: 3D/ small scale house models; highway/ bridge animations 1, 2;
- *Simulation for fun.* Simulation is used for building virtual reality in computer and video gaming industry. Annually billions of dollars are spent in this industry to build new simulators from fantasy world of children!

Simulation types

- In regard to the simulation tool;
  - *Computer base simulation:* Main portion of the simulation model is developed by computer programming.
  - *Non-computer (physical) base simulation:* Computer programming is not used for developing the model. Example: Newton solar system model

- In regard to the time we have:
  - *Dynamic models:* To capture the changing nature of the system/ process over time.
  - *Static models:* To capture the system condition in a specific time section. Example: small-scale model of a house; Motne-Carlo Simulation.

Simulation types

- In regard to the uncertainty:
  - *Deterministic models:* All system component have pre-determined behaviours; e.g., durations, number of resources, number of clients, etc. are known and have pre-determined values!
  - *Stochastic models:* Some system components are stochastic and subject to uncertainty; e.g., durations, number of resources, number of clients, etc. are not known and their values are randomly set!

For modeling construction operations what types of simulation we need to develop?

Simulation types

- Simulation modeling type we use for construction operation analysis and design is a *Dynamic* (time dependent) and *Computer Base* Simulation.
- *There are two approaches in computer base simulation modeling:*
  - *Discrete event simulation (DES):* is a good approach for modeling operations with a set of repetitive activities which have start and finish events! In DES physical movements are simulated as batches of material.

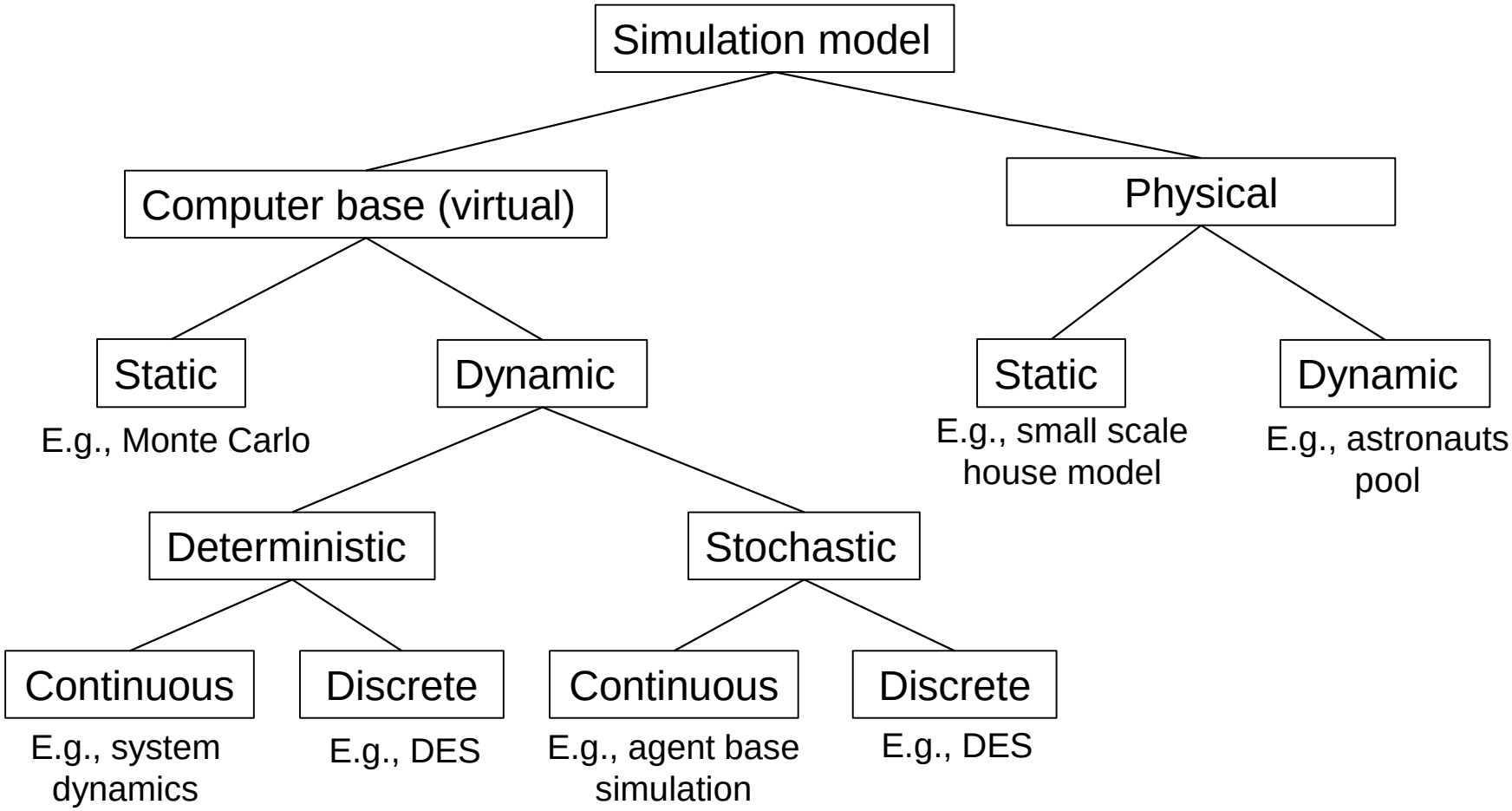
DES is our approach to simulate construction operations!

  - *Continuous simulation:* is a good approach for modeling complex inter-related systems in which single relations between system elements are known, usually in a form of mathematical functions with a time variable. In continuous simulation physical movements are simulated as flow of material.

    Example: Use of simulation for analysis and design of electronic circuits; Animated simulation (why?).

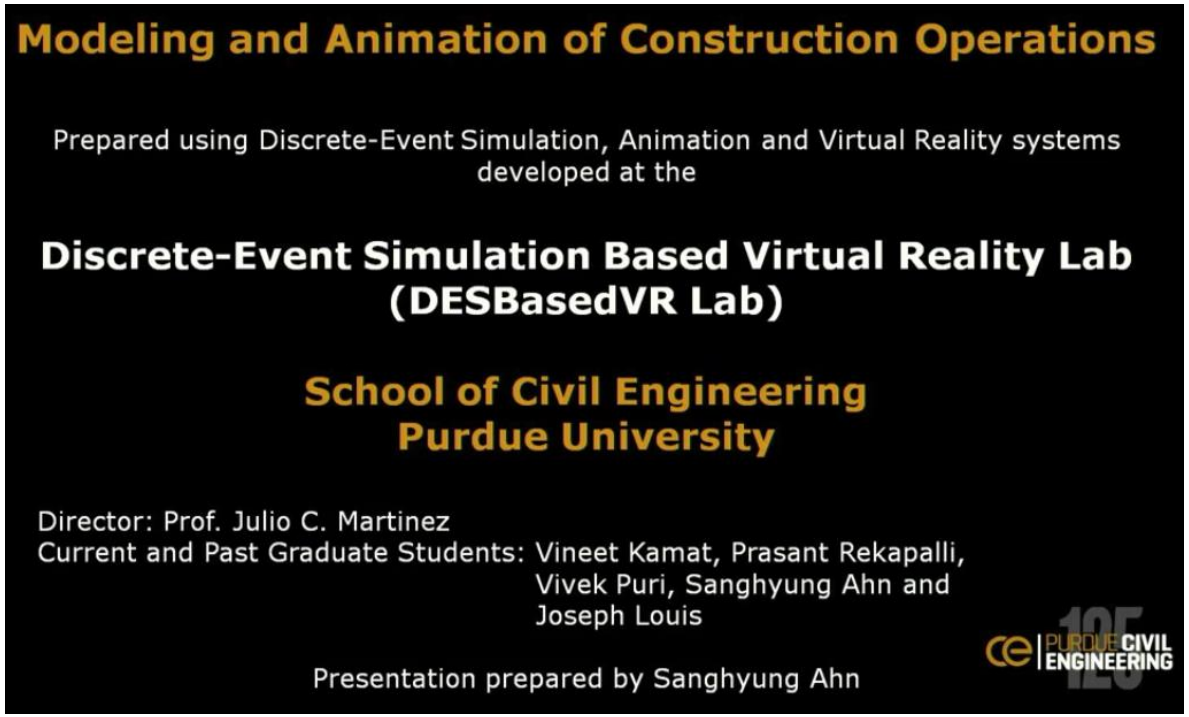
Simulation types

Simulation model taxonomy (classification):



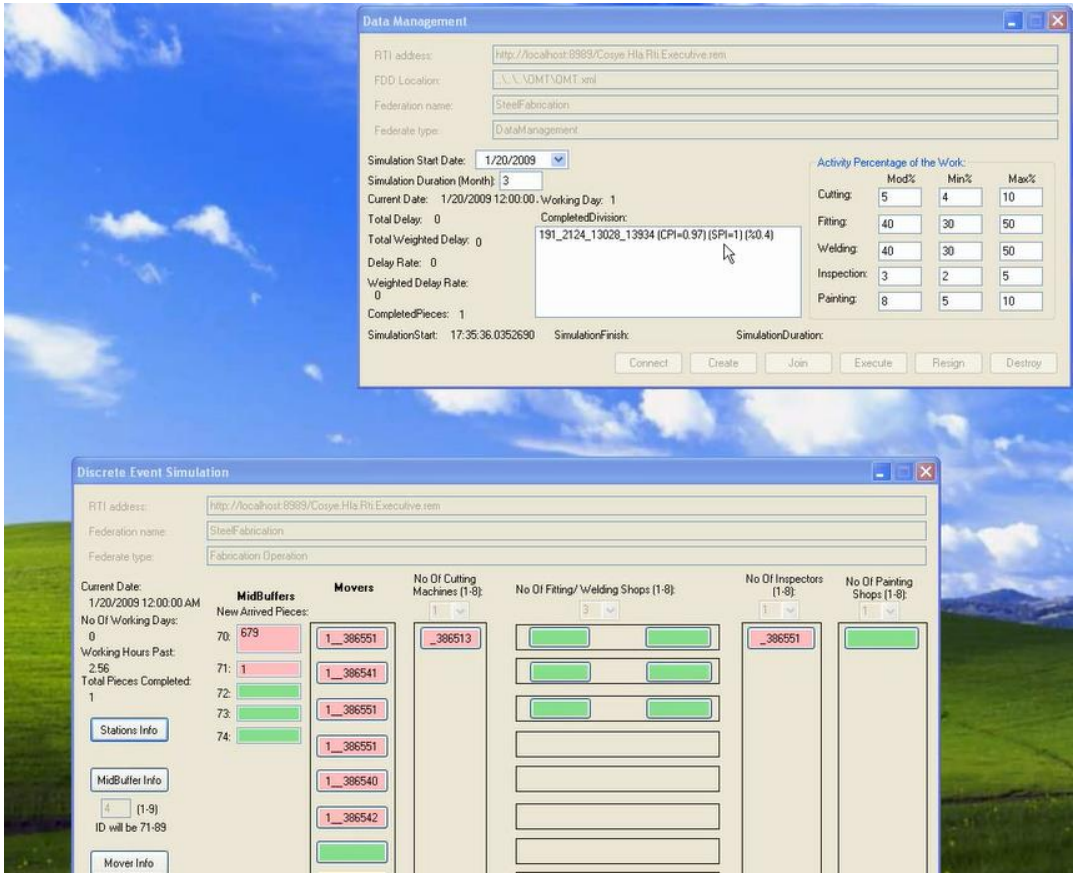
Why simulating construction operation?

- Construction projects include repetitive operations which their durations are difficult to estimate and plan as a result of uncertainty or randomness involved.
  - Example 1: Big earthmoving operations: How many trucks, loaders, dozers, shovels will gives the maximum productivity and minimum equipment idle time?



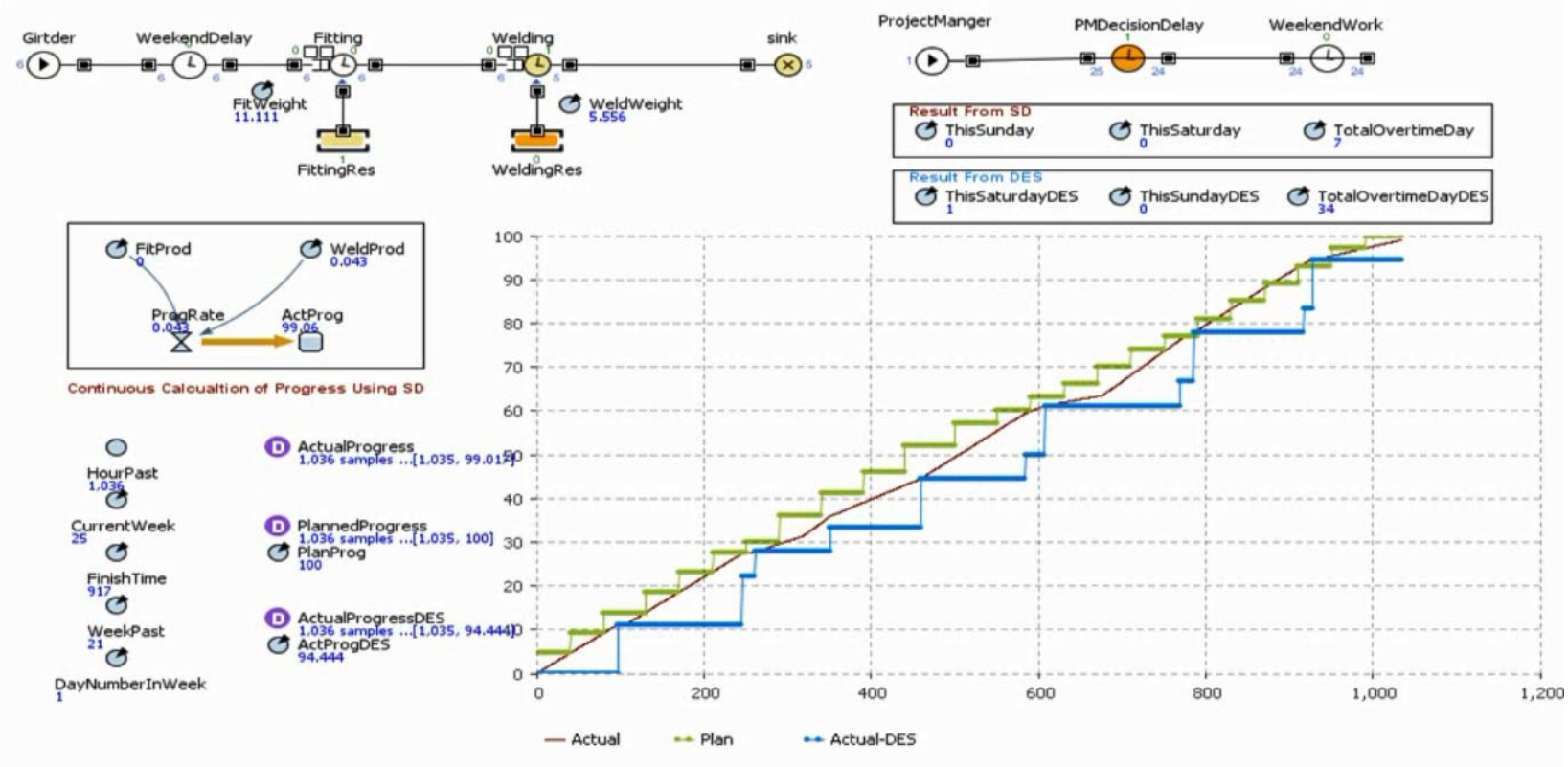
Why simulating construction operation?

- Example 2: Fabrication shop simulation: How much space do we need, how much a head or behind the schedule we are going to be, which stations needs more attention?



Why simulating construction operation?

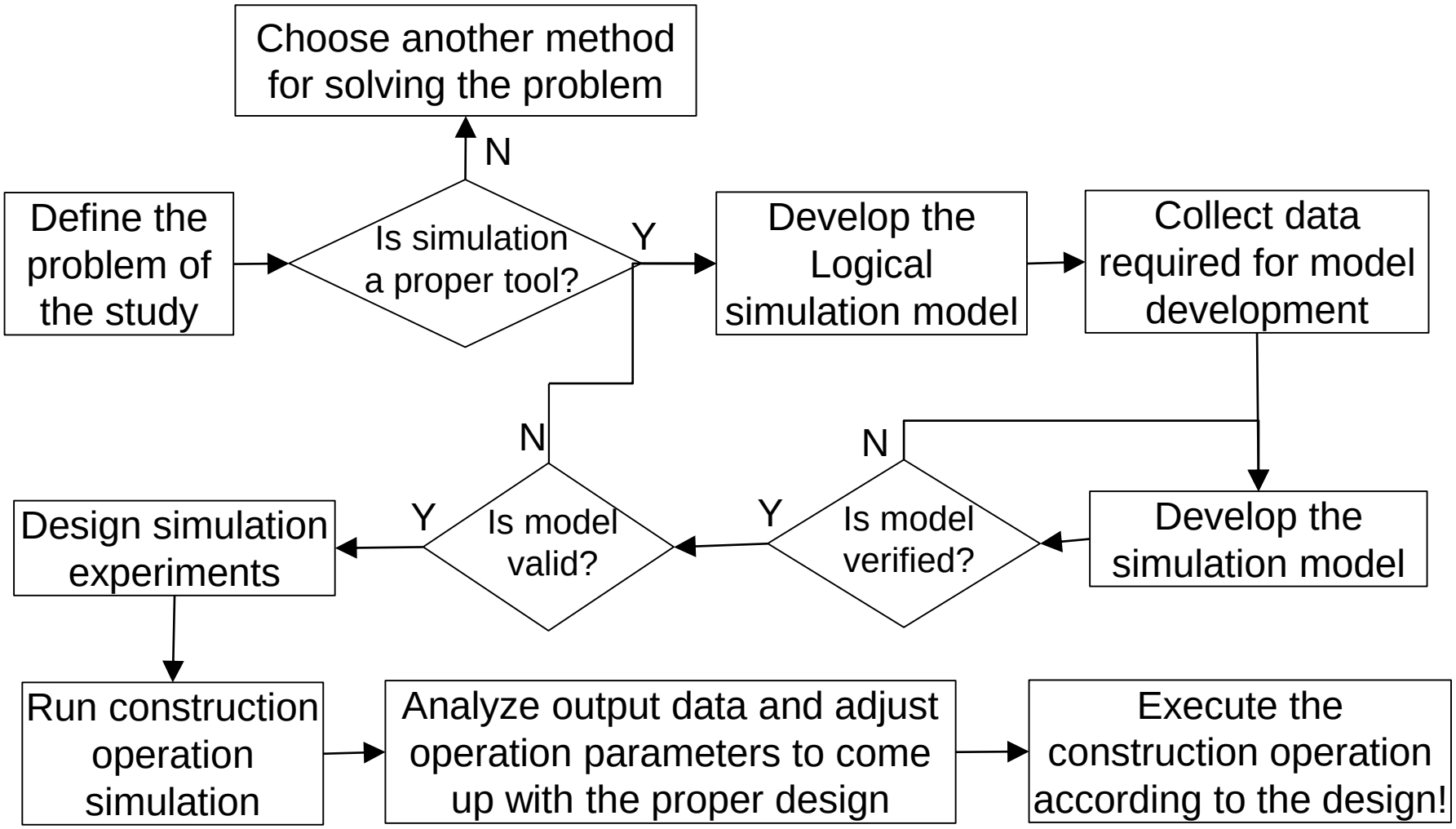
- Example 3: Fabrication Project hybrid DES-SD simulation: Forecasting project progress considering operational and non-operational (e.g., here fatigue and productivity) factors using Anylogic!



Construction simulation and visualization

- As we discussed before the simulation approach we are using for construction operation simulation is Discrete Event Simulation (DES). However, as you might have noticed in our construction operation simulation examples, there is an excessive interest on visualizing construction operation simulation and, in addition to its design and analysis application, using simulation as a presentation tool.
- Visualization in simulation has a completely different simulation method and calculation basis than what we use for DES. However, some commercial simulation programs such as AnyLogic have simple visualization features which can be linked to the DES simulation model. We are going to discuss more about this topic at the later sessions of the course!

Main steps in simulation studies



Is simulation a proper tool?

- Simulation application begins when analytical methods fall short in solving the problem. Compared to the analytical methods, simulation based method are usually more expensive, so we usually do not use simulation when analytical methods work!
- Construction operation simulation models are usually developed for finding improved sequences of tasks and number of resources required to do the construction operation.

  Simulation is a proper tool when you are to discover changes to the operation's productivity while changing the operation set up (sequences and resources).

  Example: Suppose that we have an earthmoving operation, for loading, we are to decide whether to rent 2 X 0.1 m3 bucket shovel or 1 X 0.23 m3 bucket shovel. For hauling we are about to decide among 3X10 m3 or 2x15 m3 trucks. Actual experience of all these operation set ups is impossible. The uncertainty involved in the loading time and the hauling trip makes it difficult to calculate the final productivity in an analytical method!

Is simulation a proper tool?

- Sometimes experiencing the real process/ system is way easier than developing a simulation model. This is specially true when designing many mechanical and electronic devices!

  Example: Accurately developing a simulation models for high pressure oil-valves which are used 1000s of meter under the sea level for controlling oil flow from the oil wells is very difficult and time consuming (creating an model of the valve with different alloys used in it and the under sea changing condition requires too much efforts). What is usually done is that you build a testing framework, build a real valve and expose it to the real condition. You are going to change the valve's specification until it passes all tests and works under the condition.

Home assignment 1

Name five simulation models (not necessarily computer based or dynamic models) that you have seen/ used in your day to day life. How do you classify their types? What are their main applications and what are their main outputs?

Reference

- Banks, J., Carson, J.S., Nelson, B.L. And Nicol D.M. (2004) “Discrete event simulation” Prentice Hall, ISBN: 0131446797.
- Banks, J. (1998) "HANDBOOK OF SIMULATION, Principles, Methodology, Advances, Applications, and Practice” John Wiley and Sons, Toronto, Canada. ISBN 0-471-13403-1.

Thank you!