SPM 9555: Experimental design

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Lecture goals

- Understand how to design an experiment with an ABM
  - Runs over time
  - Repeatability
  - Scenario (space) design
- Understand the computational requirements of parameter sweep experiments and how to reduce them
  - Full factorial experiments
  - Latin Hypercube sampling
  - Monte Carlo experiments
- Computing on a cluster

What is it that we want to measure and why ?

- Based on System Analysis
  - What is the observed macroscopic regularity that is of interest to us?
  - Specify how the the desired system regularity different from the observed one, if there is such a thing as a desired regularity.

Hypothesis

- Does (and under which conditions) the designed ABM emerge the macroscopic regularity that is of interest ?

  AND / OR

- Given the ABM, what is the range of behaviors that it is capable of?

Experiment

- First question:
  - We need to falsify a hypothesis !
  - Does the model do ***what*** we expect, and ***where*** (in the parameter space) does it do it.

- Second question
  - Oriented towards exploration, no "correct" or "false" answer.
  - Much more difficult to determine what are we looking for.
  - How do you determine that some behavior is emergent/relevant?
  - What is interesting behavior?

Experiment aspects -Time

- Time
  - Some cases dictated by the model
    - e.g. modeling 50 years, 4 ticks per year, => 200 ticks
  - When time is ill defined
    - we may not know how long the model takes before interesting emergent behavior can be observed.
    - Where no clear convergence to a stable attractor, we need to experiment with long runs
    - In extreme cases leaving the simulation over night/over a weekend might give some insights.

Experiment aspects - Repetitions

- ***Never trust a single run of an ABM!***
  - Even when agents are fully deterministic, their iteration order is randomized !
- How many repeats do we need to get a statistically reliable sample for a certain confidence level?
  - Assume that variability of outcomes is dependent on the location in the parameter space !

- Start with a small Latin Hypercube Sample across the parameter space
  - Do 100 repetitions at each point
  - Do descriptive statistics on them, see how they vary.

Scenario vs Scenario space

- Scenario - single or a group of time runs under certain parameter values.
  - narrative of what can/should happen in the system that is being modeled.
  - dynamic profiles for some parameter values over time.

- With scenarios we need to be careful
  - potentially be very limiting
  - wishful thinking can predetermine what is considered to be a likely scenario.

- Scenario space
  - identify the scope of the possible parameter space
  - aids the creation of a parameter sweep experiment,

Parameter sweeps

- Model is run repeatedly at different parameter settings
  - Repeat each parameter point x number of times (see previous slide)
- Each model run is an experiment

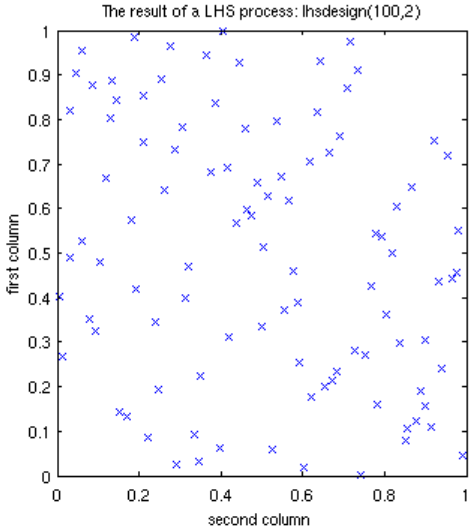
- If we are hunting for interesting regions / transitions
  - we should start coarse, then zoom in around outcomes that identify transitions

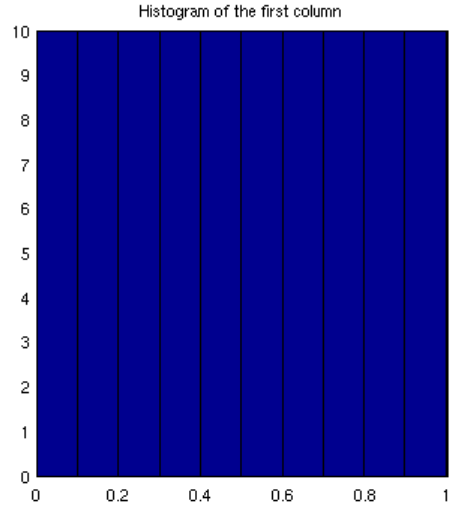
- How big is the scenario space?
- How granular does the analysis needs to be ?

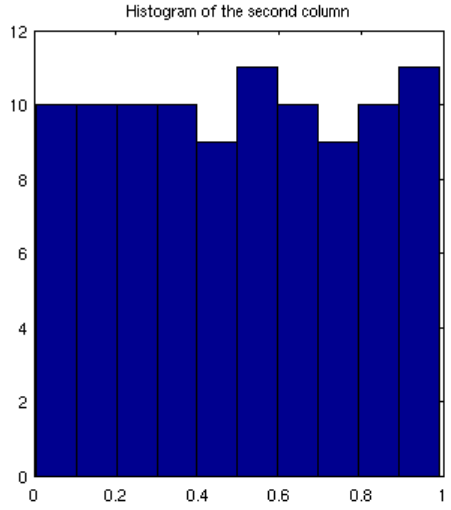
Full factorial vs LHS

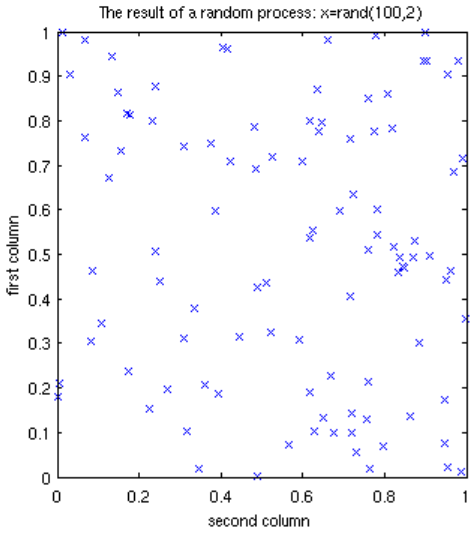
- Full factorial experiment
  - Try each combination of parameters
  - What is the granularity ?
  - 1-100 in steps of 0.1, 1, 10 ?
- Random sample
  - Take X random parameter combinations from the parameter space
- LHS
  - Statistical technique
  - If I can afford X experiments in a Y dimensional parameter space, where in the parameter space should I perform them so that I sampled the space uniformly

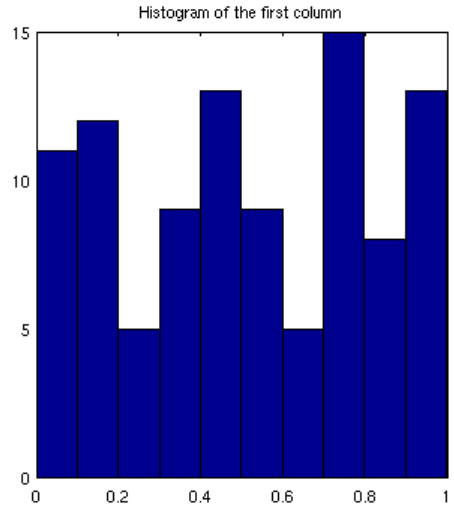
Random vs LHS

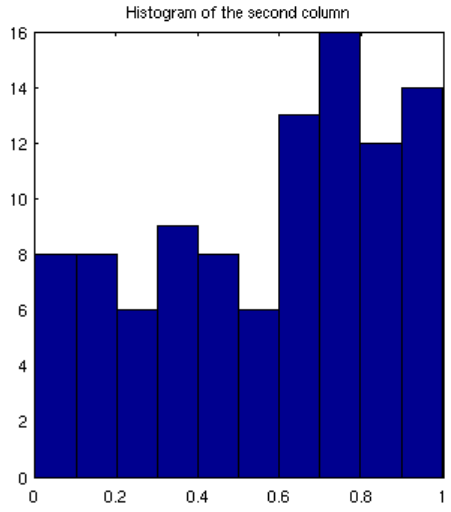












How to make a LHS sample

- Matlab – See example here : http://wiki.tudelft.nl/bin/view/Research/LatinHypercubeSamplin
- Gives you a vector of parameter settings per row.
- In Netlogo you can load that file ,
  - Set parameter values from data in that row,
    - Experiment number, ParVal1, ParVal2, etc.
    - Have behaviour space call experimentNumber 1 to n, steps 1
- In case of boolean switches, you can use -1 to 1 range, below 0 false, above true

Monte Carlo analysis

- Given a certain parameter setting, how sensitive is the model to random noise on these values
  - Choose a noise distribution
  - Add random noise to each parameter and run the model...

NetLogo on HPC

- Possible if necessary
- Extra work involved
  - Large amount of output data
  - Extra work combining split data files
  - Involves command line work