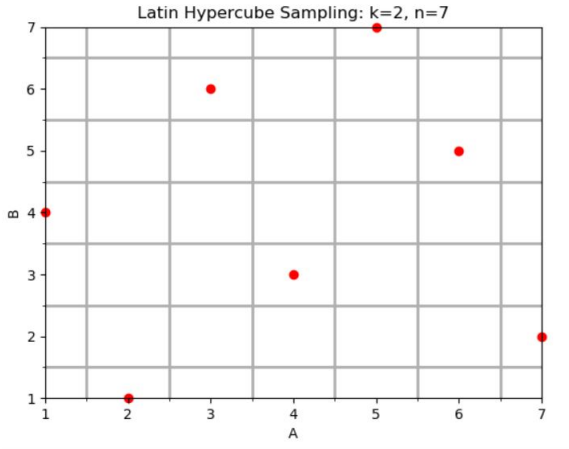
TTK31 - Design of Experiments (DoE), metamodelling and Quality by Design (QbD)
Autumn 2021

Big Data Cybernetics Gang

Latin hypercube designs

- Hypercube designs are model independent, space filling designs often used in computer experiments
- Each dimension space is cut into n sections where n is the number of sampling points → only one point is put in each section
- The number of experiments is n
- These designs are optimized by distance in order to fill out the factor space.
- Criteria for construction of the design:
  1. Center the points within the sampling intervals
  2. Maximize the minimum distance between points and place the point in a randomized location within its interval
  3. Maximize the minimum distance between points and center the point within its interval
  4. Preferably construct orthogonal designs, also among interaction terms

Latin hypercube design for 2 factors and 7 experiments



Paper on DoE and metamodelling

Syberfeldt, A., Grimm, H., Ng, A. (2008) Design of Experiments for Training Metamodels in Simulation-Based Optimisation of Manufacturing Systems.

- Applying metamodels in simulation-based optimisation of manufacturing systems
- Comparing results for two DoE designs and randomly sampled data
- Goal: Using Artificial Neural Networks (ANNs) to reduce the computational burden in optimization
- Procedure:
  1. construct an experimental plan of the different simulation input parameter settings that are to be tested using DoE
  2. simulate the system with the given input parameter values
  3. train the ANN using the simulated input-output samples
  4. optimize using an evolutionary algorithm

Application details

- Modelling objective: Optimise the schedule for the most efficient utilisation of the production
- Design factors: Lead time for five components
- Response variables: Utilisation, component shortage and total tardiness (delay)
- Evaluating the model results for these three cases:
  1. A 3^5 full factorial design
  2. A Latin hypercube design
  3. Randomly selected samples
- The objective function is specified from the three response variables:

$$\sum_{i \in C} = (w_s i_{shortage} + w_t i_{tardiness}) - w_u utilisation$$

- The w's are user-defined weights for importance
- 1000 samples where randomly generated as a test set
- Evaluation criterion: Minimise the Mean Square Error (MSE)

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- The optimisation could have been performed directly from the DoE model, also including constraints