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Application of NPMC Technique in System Dynamics

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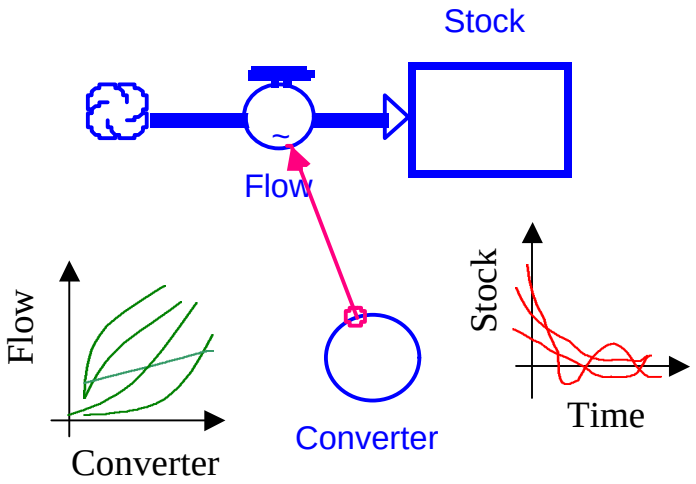
Abstract



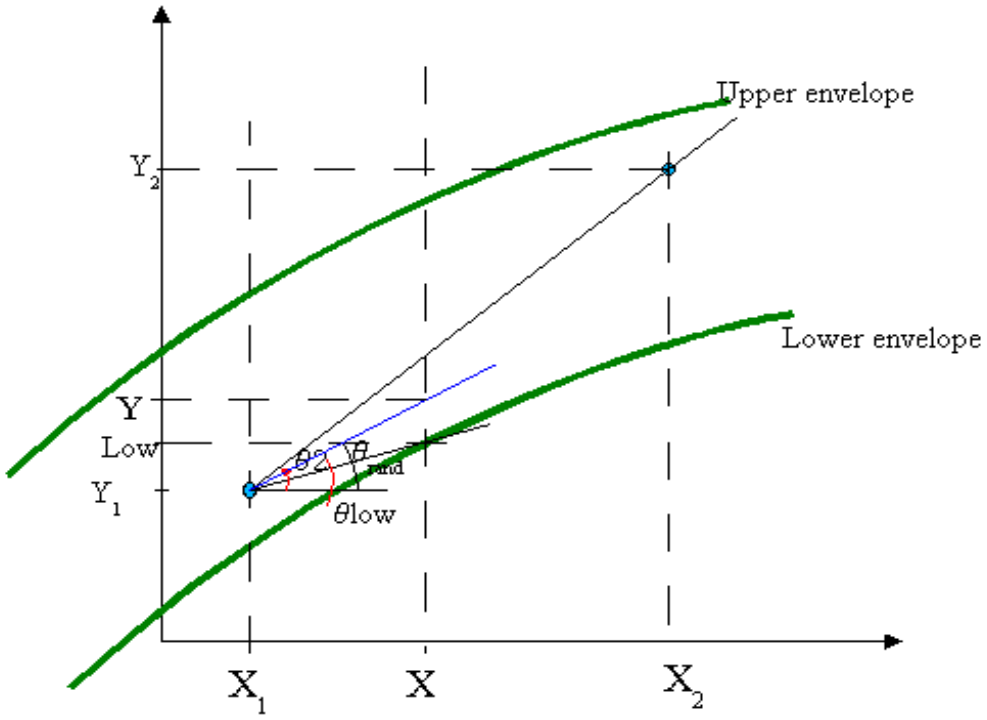
Most of the modeling efforts include quantification of soft data. If the parameters to be quantified are constant then analysis can be made easily by generating these constant parameters randomly at each run. However if these parameters are a function of a system variable or another non-constant parameter (i.e. value of a converter is a function of a stock or another converter) then effects of these assumptions are usually checked by a few trial runs with different curve shapes for the function. Therefore leaving effects of many function possibilities unchecked.

Non Parametric Monte Carlo (NPMC) Technique[1] randomly generates monotonically increasing/decreasing curves for incompletely defined differential equations. The NPMC technique we use generates curves whose points are determined randomly as the numerical integrator (e.g. Runge-Kutta algorithm) integrates the differential equation. Generation of curves can be limited to convex or concave curves. System is run for a sufficient number of times to see the effect of all possible curves.

NPMC Technique is applied to Market Growth Model. Effect of Delivery Delay on Sales Effectiveness vs. (Delivery Delay Perceived by Market) / (Market Target Delivery Delay) function is randomly generated in the Monte Carlo scheme. Changes in the behaviuor of Recent Revenue stock is analysed.

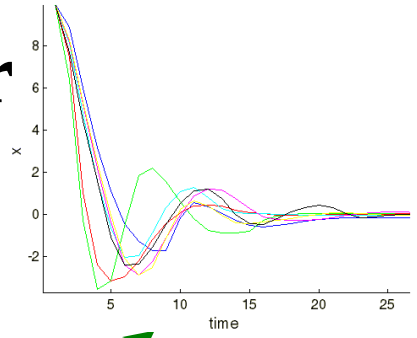
[1] Evangelia Gazi, Warren D. Seider, and Lyle H. Ungar (1996) Verification of Controllers in the Presence of Uncertainty: Application to Styrene Polymerization, Ind. Eng. Chem. Res. 35, 2277-2287

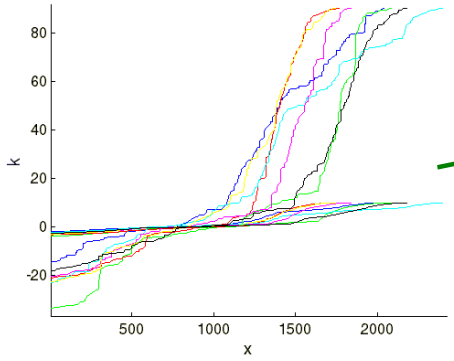
Non Parametric Monte Carlo

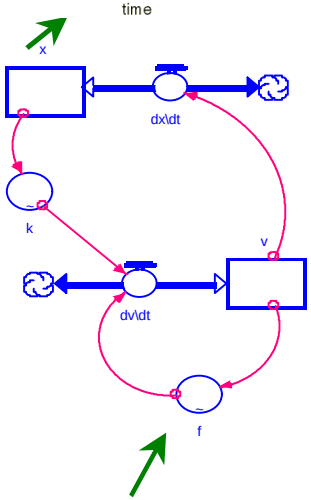


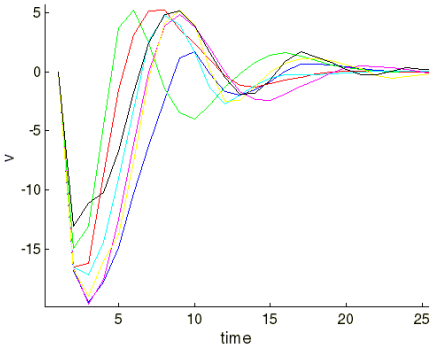
Numerical integrator asks for a Y value for a given X. If X_1 and X_2 are stored points X is found by randomizing an angle. If exists upper and lower envelopes are checked. New point is stored in to a database. Different algorithms are used when X is smallest or biggest in the database.

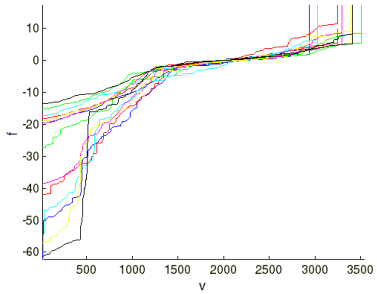
Simple Oscilator











k(x) and f(v) functions generated by NPMC

dx/dt = v

dv/dt = - k(x) - f(v)

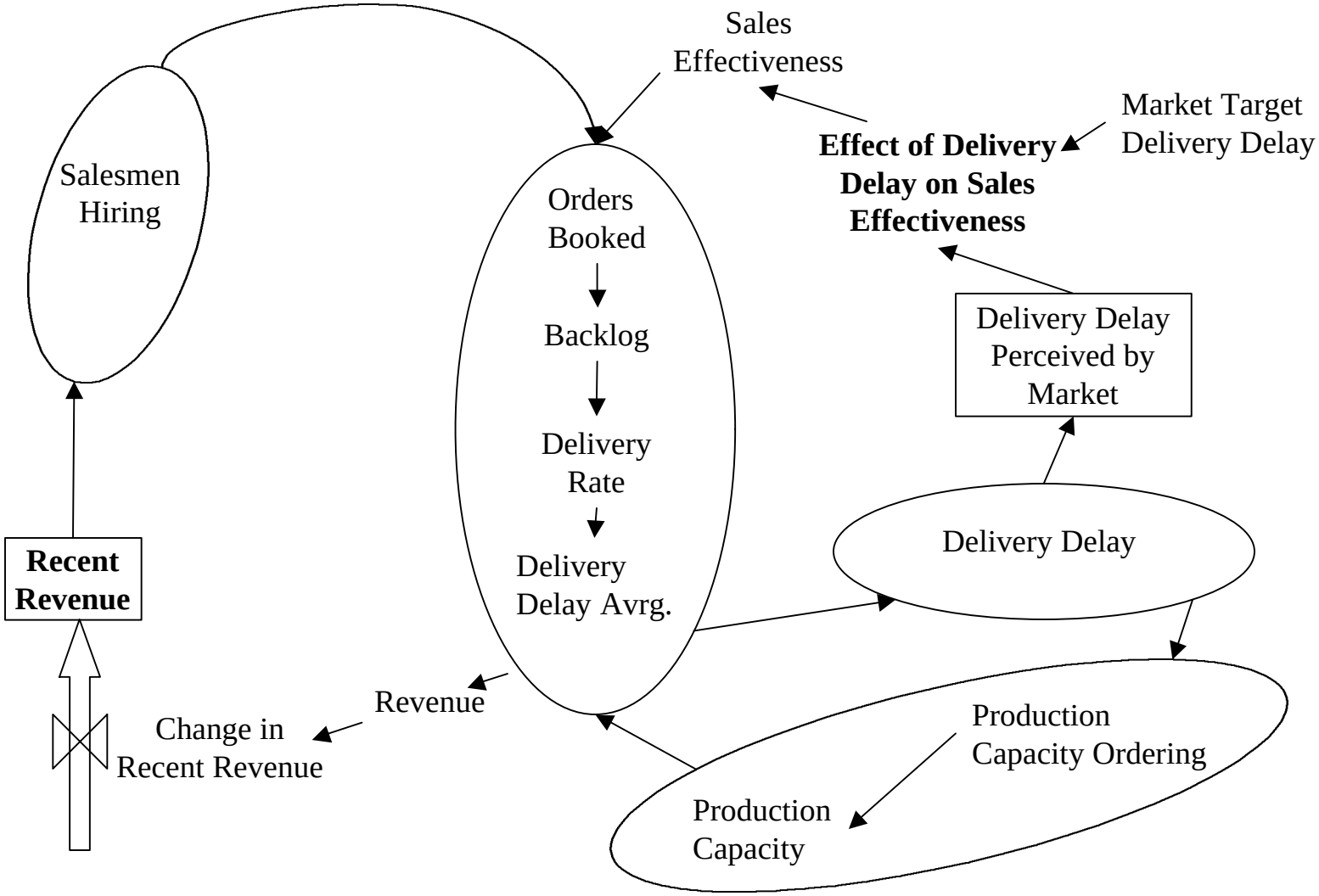
Market Growth Model

Market growth as influenced by capital investment model was created by Forrester[1]. In this work the model given by John D. Sterman[2] is used.

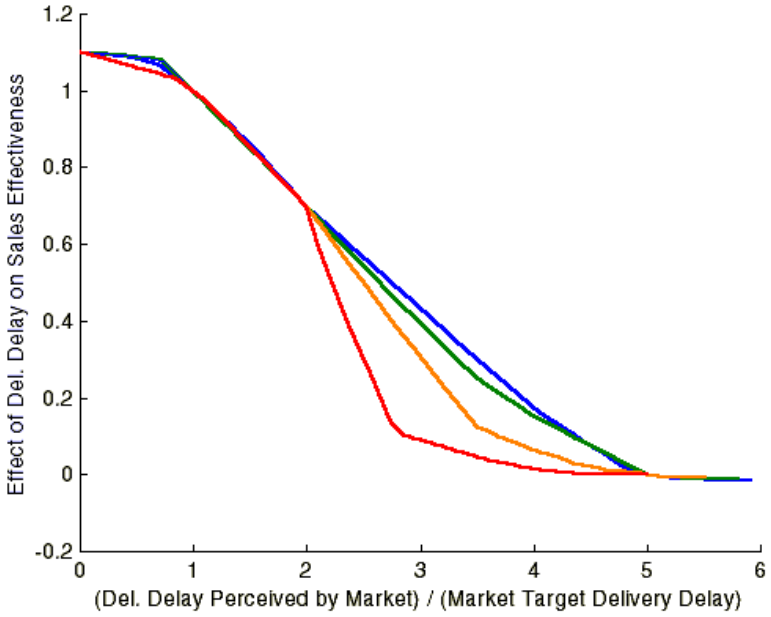
Model consists of eight system variables and three look-up functions. In this work the look-up function Effect of Delivery Delay on Sales Effectiveness vs. (Delivery Delay Perceived by Market) / (Market Target Delivery Delay) is feeded into the system as an unknown function. This function is generated by NPMC technique for each run of the system.

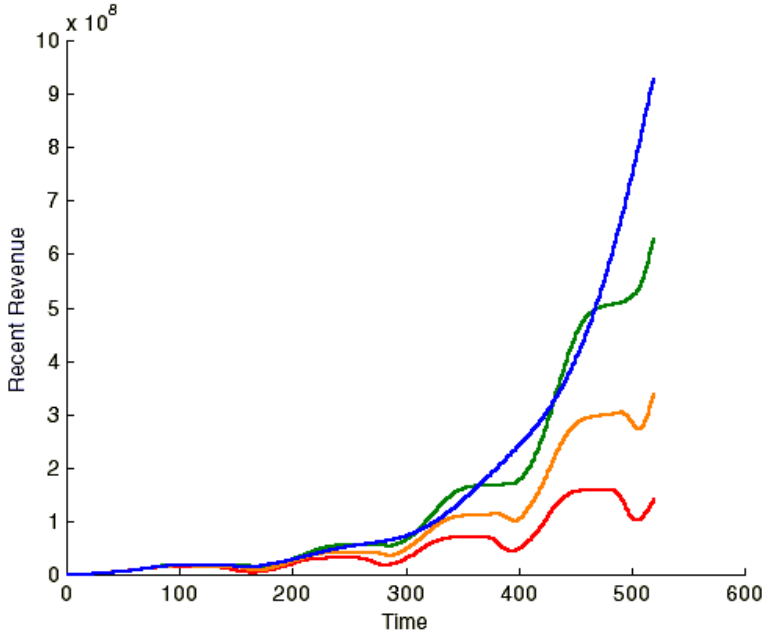
[1] Jay W. Forrester (1968) Market growth as influenced by capital investment, Industrial Management Review 9(2), 83-105.

[2] John D. Sterman (2000) Business Dynamics. Irwin McGraw-Hill


Sales
Effectiveness
Market Target
Delivery Delay
Effect of Delivery
Delay on Sales
Effectiveness
Salesmen
Hiring
Orders
Booked
Backlog
Delivery
Rate
Delivery
Delay Avrg.
Delivery Delay
Perceived by
Market
Delivery Delay
Recent
Revenue
Revenue
Change in
Recent Revenue
Production
Capacity Ordering
Production
Capacity

Market Growth Model Results





Steep curves in Effect of Delivery Delay on Sales Effectiveness function results in wild oscilations in Recent Revenue. An almost straigth blue line in function gives a straigth exponantial growth.

Conclusion

NPMC Technique randomly generates curves for the model. These curves can be limited by rules such as monoticly increasing, convex or concave. It is actually possible to implement more sophisticated rules in the generation of curves. These rules could represent another complex model (discrete event model or system dynamics model) and generate curves for the main model.

NPMC Technique makes it easy to test hundreds of different possible functions. Results can be clustered according to their behaviour and the functions generating these behaviour can be detected. Pattern recognition tecniques can be applied to cluster outputs and functions.