Temasek Defence Systems Institute

CONCEPT DRIFT FOR DISCRETE-EVENT SIMULATION MODELING OF MANUFACTURING SYSTEMS

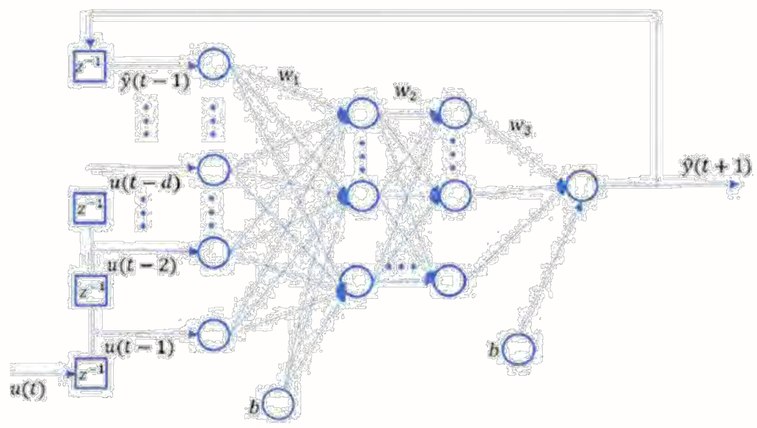
Author: Ng Wei Xiang Nicholas (ST Engineering)
Thesis Advisors: Dr. Devaushi I. Singham (Naval Postgraduate School)
Dr. Michael P. Atkinson (Naval Postgraduate School)

Introduction

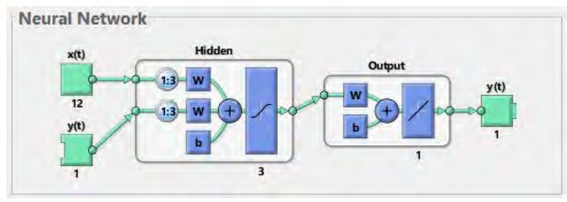
Concept drift denotes a significant change in system behaviour that may cause a model to be outdated due to changing conditions. In a manufacturing production setting, these system behaviours can be represented as delays in the production line due to work station unavailability. To detect concept drift, the nonlinear autoregressive exogenous (NARX) algorithm is used. The NARX algorithm uses past and current values of the variable that we wish to observe (primary time series) as well as exogenous data (secondary time series). Exogenous data are externally determined, but can influence or be influenced by the primary time series.

Approach

- Develop a discrete event simulation model (manufacturing setting) to generate data
- Create various scenarios (varying in time steps and primary variable) where the fluctuating variable changes differently (deterministic, random, dynamic)
- Utilize nearly orthogonal Latin hypercube (NOLH) sampling to determine NARX algorithm parameters (time lags for primary & secondary time series and number of hidden neurons)
- Evaluate the NARX algorithm's performance for each scenario using the mean square error (MSE) value

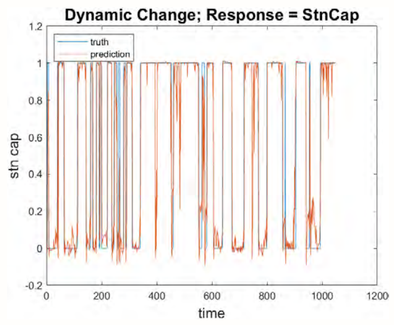


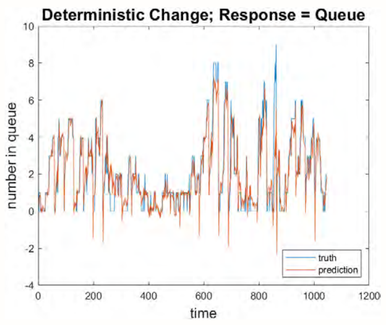
NARX Neural Network Framework

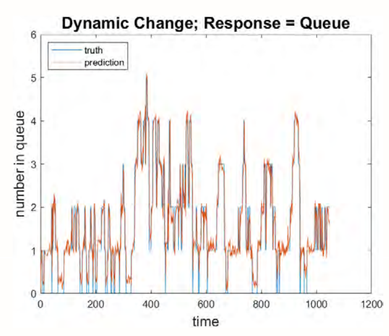


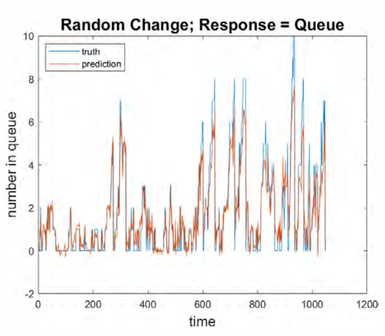
Results

- Predictions are more accurate when time step is small or when the fluctuating variable has fewer change-times
- Random changes are more difficult to predict than deterministic or dynamic
- Variables that can take a larger range of values are more difficult to predict
- Number of input variables could be reduced as long as there is a relationship between the variables that the algorithm can identify









Benefits/Potential Applications

Usage of the NARX algorithm to detect concept drift in real world settings can provide the ability to predict the future state of the system and take preventive actions early to address the issues before they occur.

Future Works

- Improve drift detection by incorporating additional information such as seasonal behaviours and trends
- Combine multiple machine learning algorithms (ensemble model) to produce more robust training and prediction values

NUS National University of Singapore