Probabilistic Graphical Model Applications in the Pharmaceutical Industry

How to improve predictability around sequential processes in the pharma industry: A Pharmaceutical company has many processes in various business functions that are sequential by their very nature and therefore warrant models that incorporate that information into predictions. Many predictive models try to encapsulate all this information with "point in time" estimates. These simply aren't appropriate for the scenario and don't provide the accuracy or interpretability businesses demand from Machine Learning to be effectively implemented.

Many domains in the pharmaceutical business have sequential processes that stand to benefit from Probabilistic Graphical process models

» **Drug Development:** predicting drug efficacy, safety, and chances of success

» **Supply Chain & Manufacturing:** Revealing clinically sensitive thresholds that are necessary to ensure product consistency and safety. Also, commonly implemented in supply chain optimization

» **Patient Adherence:** Identifying critical stages and patterns of drug observance reveals impact of delays or process breakdowns. This information can be used to predict future system shocks and recognize at risk patient cohorts

» **Regulatory Processes:** when moving through lengthy regulatory processes such as the FDA's sequence of discovery through approval, optimization of resource allocation is crucial to ensure maximum efficiency

Why do Typical Classifiers or "Point in Time" Estimates Fall Short?

» **Computationally Intractable:** to represent time as a feature that can be ingested & modeled by traditional classifiers

» **Predictive Feature Relevance:** varies on time of occurrence and the required node of prediction

How Do PGMs Have Superior Performance?

Traditional models only take the information at Step 3. PGMs incorporate patterns from inception to provide more representative predictions.
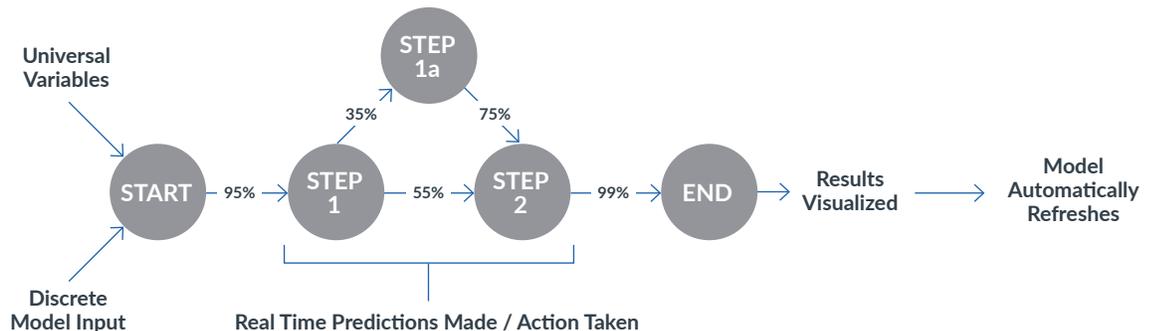
PGMs' Simplistic Process:

STEPS	Pattern 1:	1	2	3
	Pattern 2:		2	3

Patterns of Transition Embed Predictive Information About a Process

For all variables affecting a sequential process, a distribution is fitted to the record at the time a prediction is required. These distributions are then used in a simulation that calculates the probability at that time & incorporating the transition probabilities between steps. These predictions are aggregated for future iterations of the process and provide interpretability for targeted actions.

Example of Exceptional Methods: Probabilistic Graphical Models

Universal Variables

STEP 1a

35%   75%

Discrete Model Input

START → 95% → STEP 1 → 55% → STEP 2 → 99% → END → Results Visualized → Model Automatically Refreshes

Real Time Predictions Made / Action Taken

# Pharmaceutical Drug Adherence— Client Case Study

Problem Definition

A major drug manufacturer produces and sells a tightly regulated drug resulting in an abundance of sequential data describing its thorough process from manufacturer to patient. However, at many points in this process, consistent drug supply can be interrupted resulting in lost revenue and potential harm to the patients.

Project Goal

Maintaining consistent drug supply to patients by finding root causes of inefficiencies at the pharmacy, insurance companies and regulatory process. Then create a model to predict the occurrence of these inefficiencies and inform preventative actions.

Representative Solution

- » Increases or decreases in the system state can be predicted in real-time

- » Changes in aggregations of records informs timely interventions in the system

- » By minimizing the risk of failure in the process, the client was able to ensure timely supplies of drugs were received by patients to maintain adherence
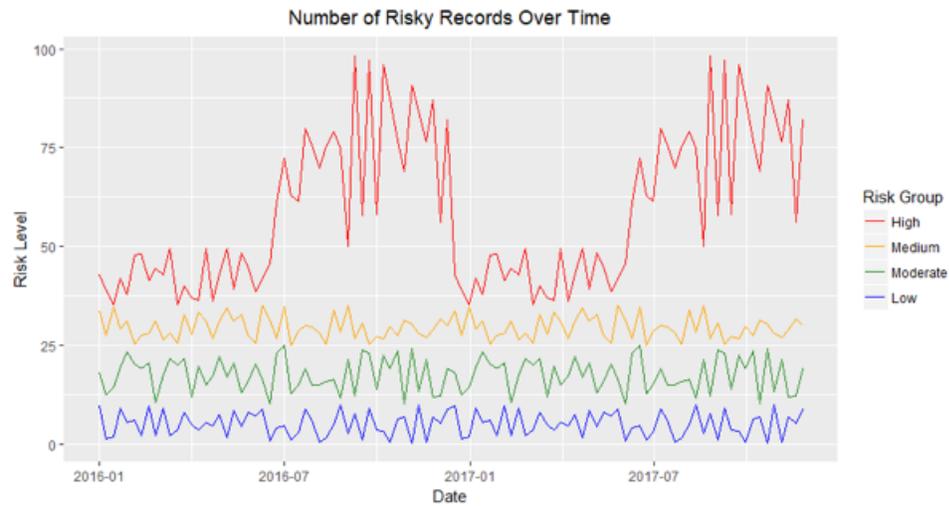
- » Changes in a risk groups behavior can be deconstructed into the component factors that are driving the predicted anomaly

Number of Risky Records Over Time

High Risk Orders by Associated Factor

Value Delivered

- » **Optimization:** Minimize the amount of waste and inefficiency. Identify root causes or detect anomalies in any sequential based process

- » **Forecasting:** provides real time updated values for business process target metrics

- » **Accuracy:** PGMs can outperform traditional time-agnostic modelling techniques

- » **Interpretability:** Identifies meaningful sub-groupings that business users can take timely action upon

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