Lecture 1: Introduction to Predictive Modeling

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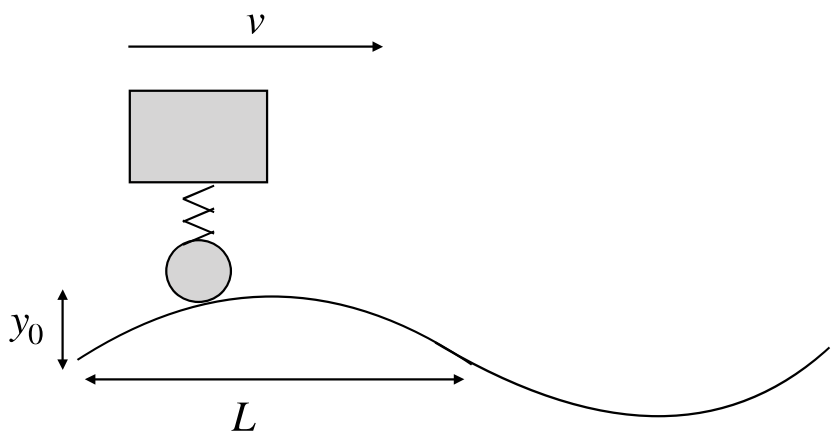
The uncertainty propagation problem

Example: Driving a trailer on a bumpy road

- m: mass
- k: spring constant
- v: velocity
- y_0: amplitude of road roughness
- L: "wavelength" of road roughness



Dynamics

$$\omega = \frac{2\pi v}{L}$$

Angular velocity

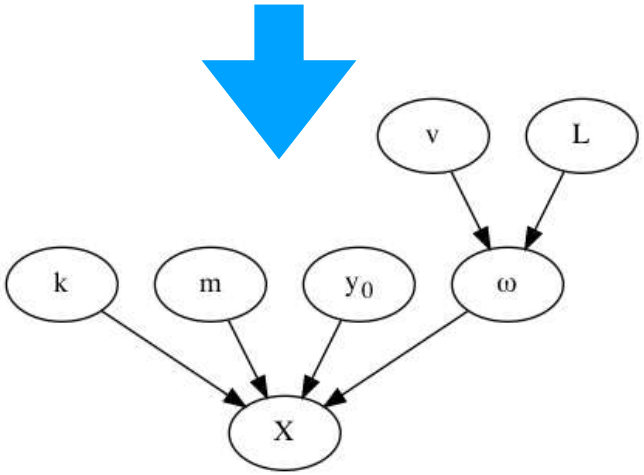
$$X = \left| \frac{k y_0}{k - m\omega^2} \right|$$

Amplitude

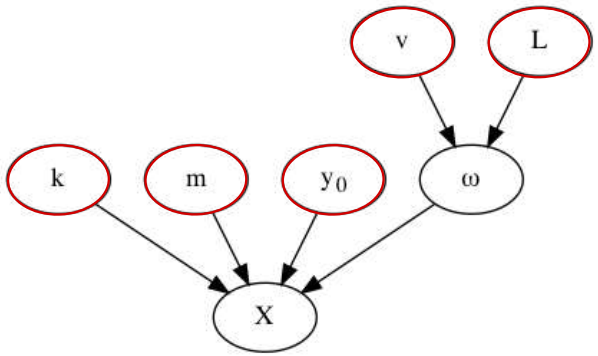
Example: Driving a trailer on a bumpy road

$$\omega = \frac{2\pi v}{L} \qquad X = \left| \frac{k y_0}{k - m\omega^2} \right|$$

← model (causal)



Example: Driving a trailer on a bumpy road



Variable	Type	Values
k	Manufacturing uncertainty	[159,999, 160,001] N/m
v	Operating condition	[80, 150] km/hour
m	Loading condition	[100, 200] kg
y	Road condition	[0, 100] mm
L	Road condition	[1, 2] m

nodes that have no parent

Our state of knowledge about the problem.

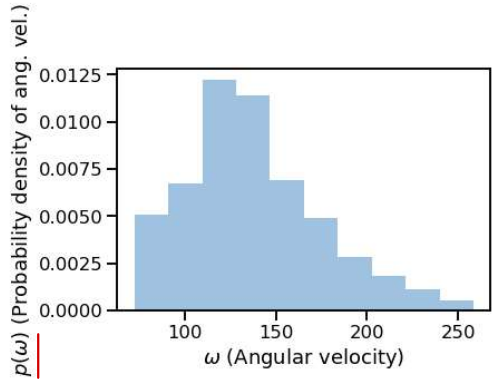
The uncertainty propagation problem

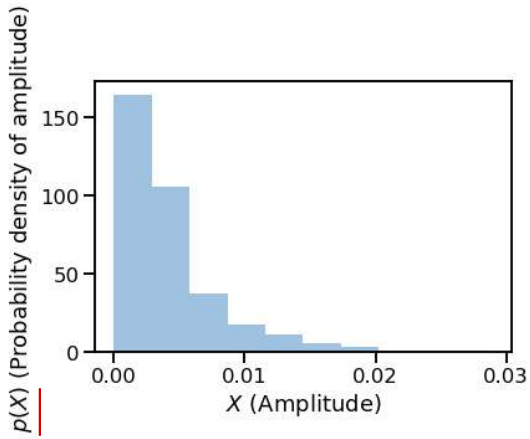
Having quantified our uncertainty about all unknowns, propagate this uncertainty through the causal model to characterize our uncertainty about a quantity of interest.

The Monte Carlo solution to the uncertainty propagation problem

- Sample random inputs many times.
- Evaluate model outputs at these inputs.
- Estimate any statistics of interest.

How uncertainty in the inputs propagates/translates to the outputs/derived quantities





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