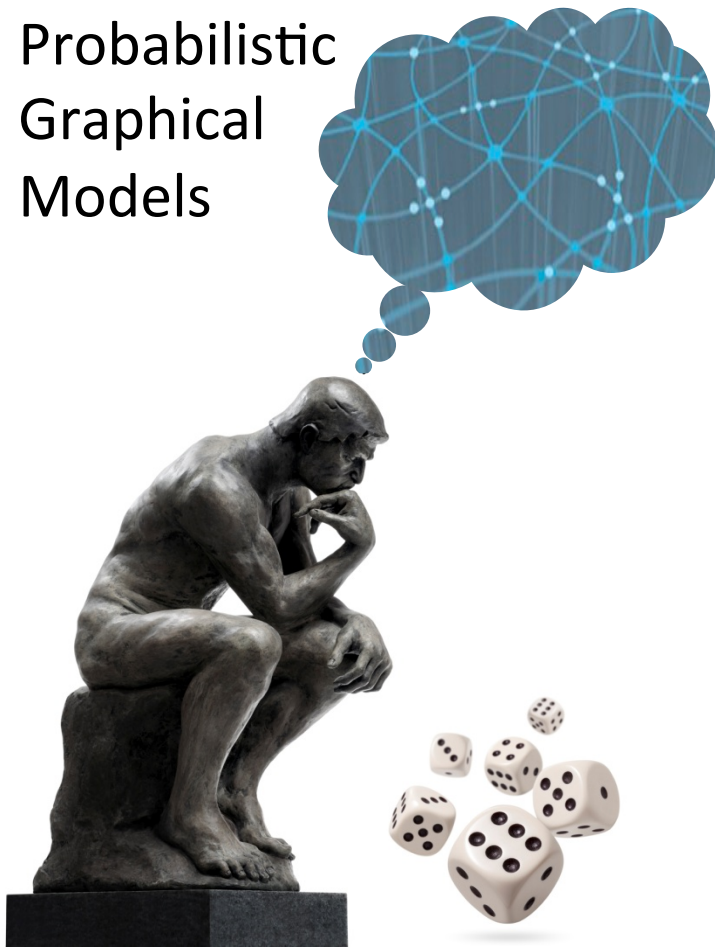
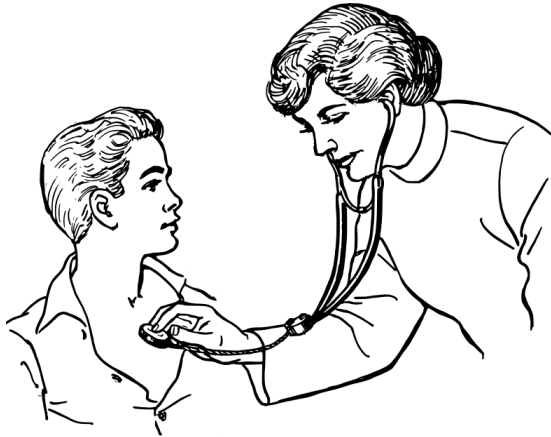


Probabilistic
Graphical
Models

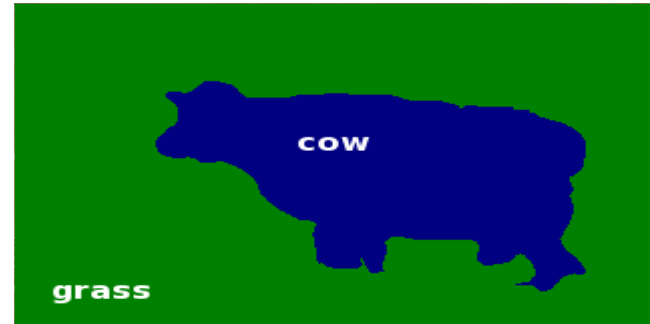


Introduction

Motivation and Overview



predisposing factors
symptoms
test results
diseases
treatment outcomes



millions of pixels or
thousands of superpixels

each needs to be labeled
{grass, sky, water, cow, horse, ...}

Probabilistic Graphical Models

domain expert

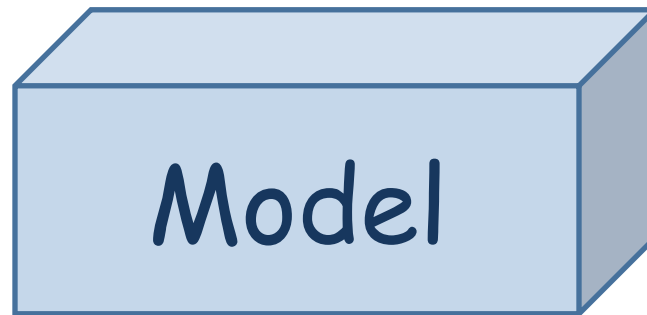


Models

Declarative representation



elicitation

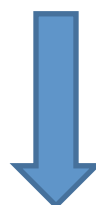


Learning

Algorithm



Algorithm



Algorithm



Uncertainty

- Partial knowledge of state of the world
- Noisy observations
- Phenomena not covered by our model
- Inherent stochasticity

Probability Theory

- Declarative representation with clear semantics
- Powerful reasoning patterns *conditioning*
decision making
- Established learning methods

Complex Systems

predisposing factors
symptoms
test results
diseases
treatment outcomes

class labels for
thousands of superpixels

Random variables X_1, \dots, X_n

Joint distribution $P(X_1, \dots, X_n)$

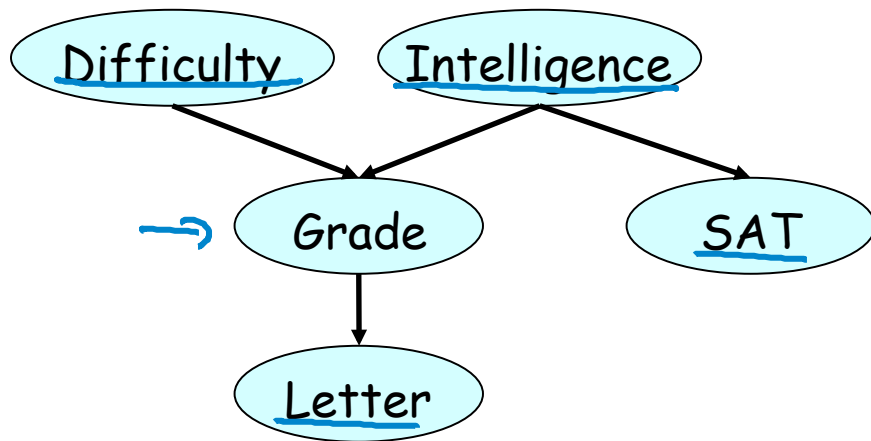
n binary valued
distribution
over 2^n
possible states

x_1, \dots, x_n - nodes

Graphical Models

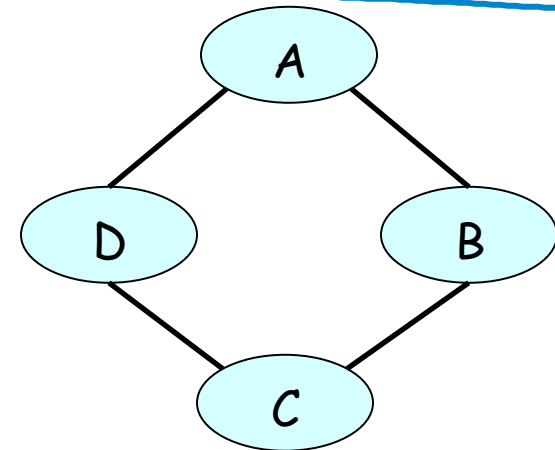
directed graph

Bayesian networks



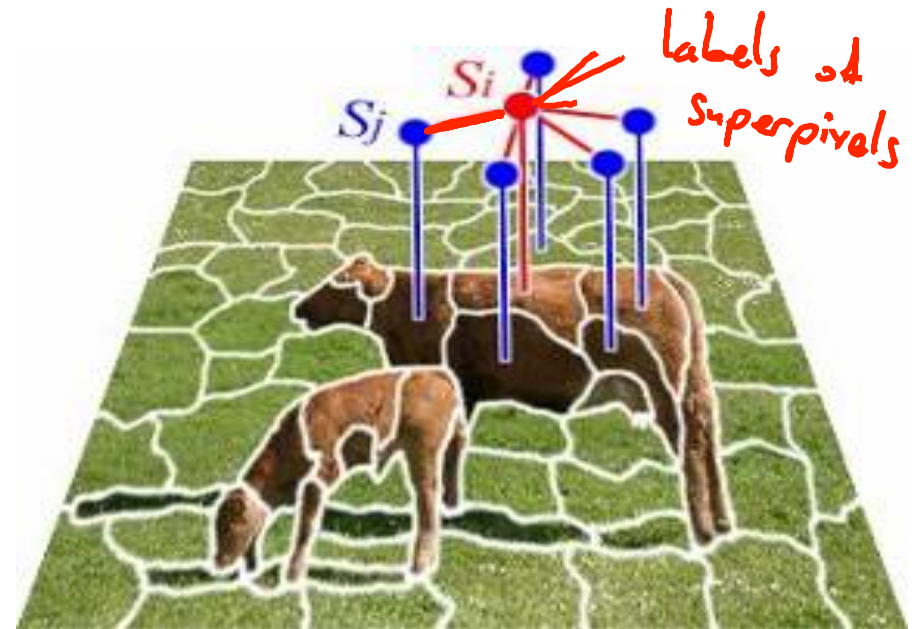
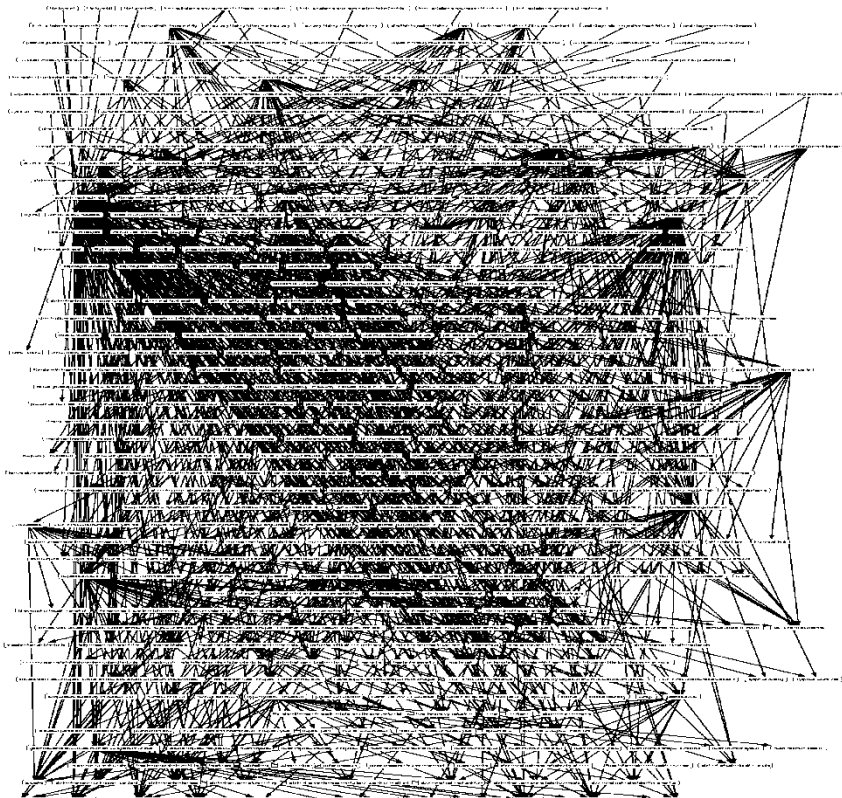
undirected graph

Markov networks



disjoint
CPUS

Graphical Models



M. Pradhan, G. Provan, B. Middleton, M. Henrion, UAI 94

Daphne Koller

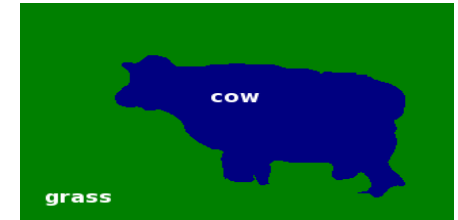
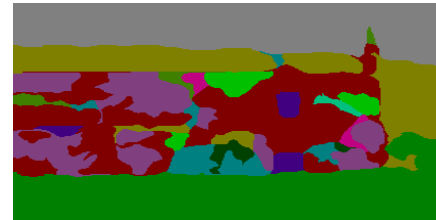
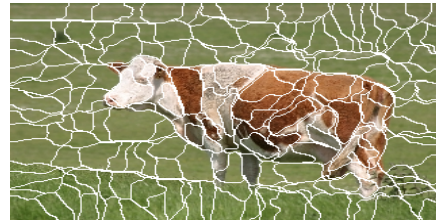
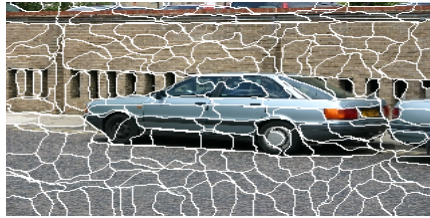
Graphical Representation

- Intuitive & compact data structure
- Efficient reasoning using general-purpose algorithms
- Sparse parameterization
 - feasible elicitation ← by hand
 - learning from data ← automatically

Many Applications

- Medical diagnosis
- Fault diagnosis
- Natural language processing
- Traffic analysis
- Social network models
- Message decoding
- Computer vision
 - Image segmentation
 - 3D reconstruction
 - Holistic scene analysis
- Speech recognition
- Robot localization & mapping

Image Segmentation



superpixels

machine learning
to separate superpixels

Thanks to: Eric Horvitz, Microsoft Research

Medical Diagnosis

MS Applet started

ON STAGE ESSENTIALS COMMUNICATE FIND

OnParenting May 14 - May 20, 1997

Fidelity Investments
Fidelity Distributors Corporation

Our home on the web [is where] click here

cover contents news experts fun handbook talk **find** help feedback

There are two ways to search for specific information in **OnParenting**. In **Find by Word**, type the word(s) you want to find and get a list of titles relevant to that word. **Find by Symptom** will help you get information about children's symptoms. [Help](#) has tips to target your search.

Find by Word

Find by Symptom ▶

Describe the child
in the drop-down boxes at the right. Relevant information will appear below.

Age: Sex:

Complaint:

Localized pain: Can the child localize, or point to, the site of the pain?

- No, unable to localize
- Below the navel to the child's left
- Above the child's navel
- Either of the child's sides
- Below the navel to the child's right
- Above the navel to the child's right
- Above the navel to the child's left
- Don't Know

Results so far

Disorder	Relevance
Viral gastroenteritis	<input type="text" value=""/>
Psychosomatic pain	<input type="text" value=""/>
Urinary tract infection	<input type="text" value=""/>
Other	<input type="text" value=""/>

Start Over Review

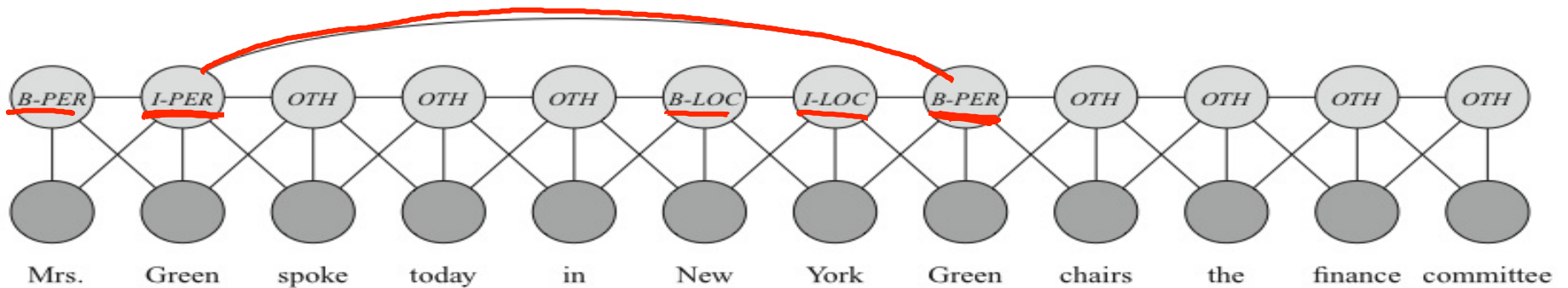
Next>> Finish

Daphne Koller

Textual Information Extraction

Mrs. Green spoke today in New York. Green chairs the finance committee.

Person *Location* *Person* *organization*



Multi-Sensor Integration: Traffic

Live Search Maps
washington dc
Businesses | People | Collections | Locations | Web

Washington, D.C. traffic map showing various colored lines (green, yellow, red) indicating traffic flow and speed. The map includes labels for various districts and landmarks.

- I95 corridor experiment: accurate to ± 5 MPH in 85% of cases
- Fielded in 72 cities

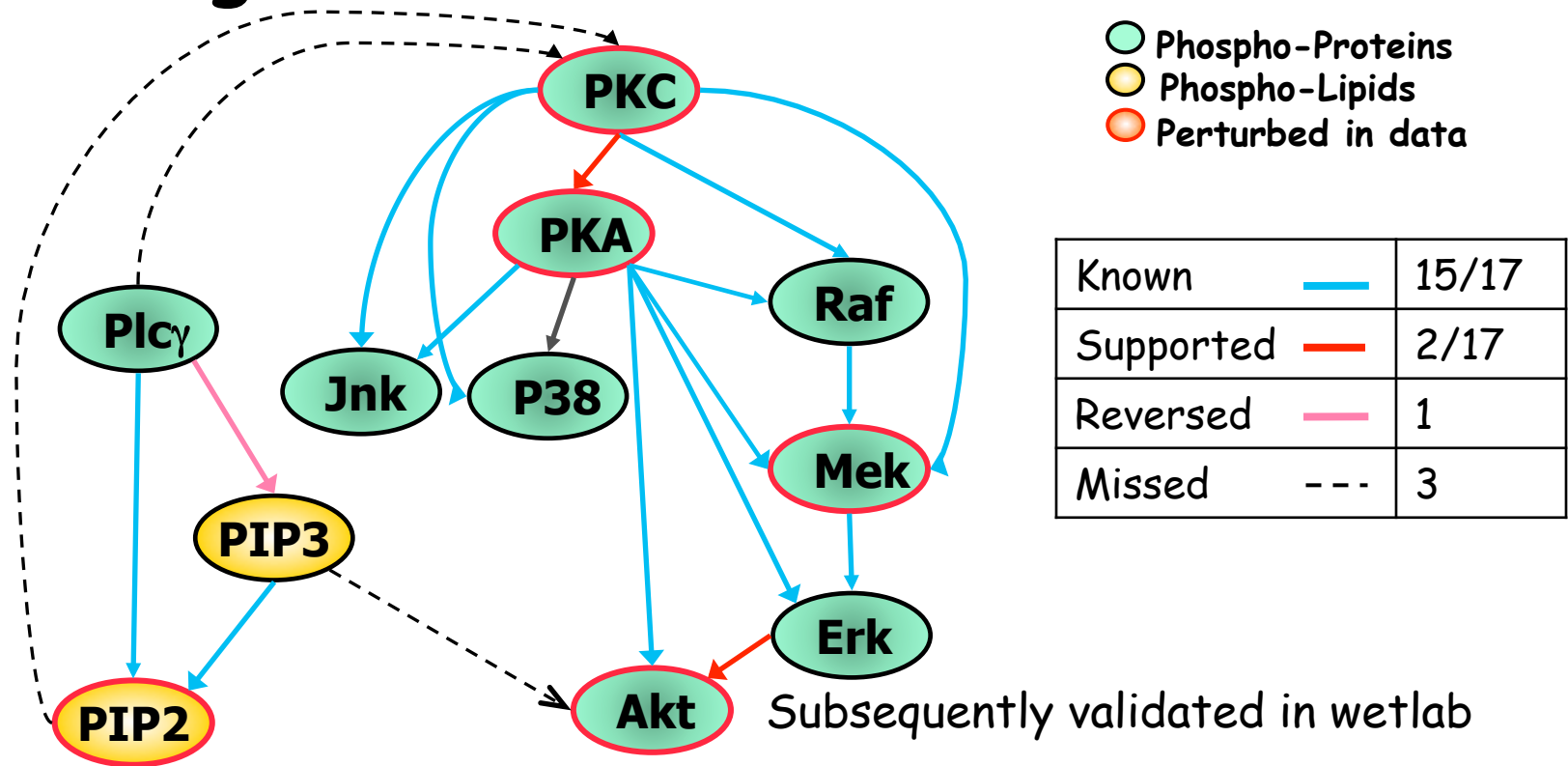
uding

Thanks to: Eric Horvitz, Microsoft Research



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Biological Network Reconstruction



Causal protein-signaling networks derived from multiparameter single-cell data
Sachs et al., *Science* 2005

Overview

- Representation
 - Directed and undirected
 - Temporal and plate models
- Inference *reasoning*
 - Exact and approximate
 - Decision making
- Learning
 - Parameters and structure
 - With and without complete data