AMiDST TOOLBOX

Session 3: Coding an Intelligent Fire Detector System

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Intelligent Fire Detector System

Fire Detection

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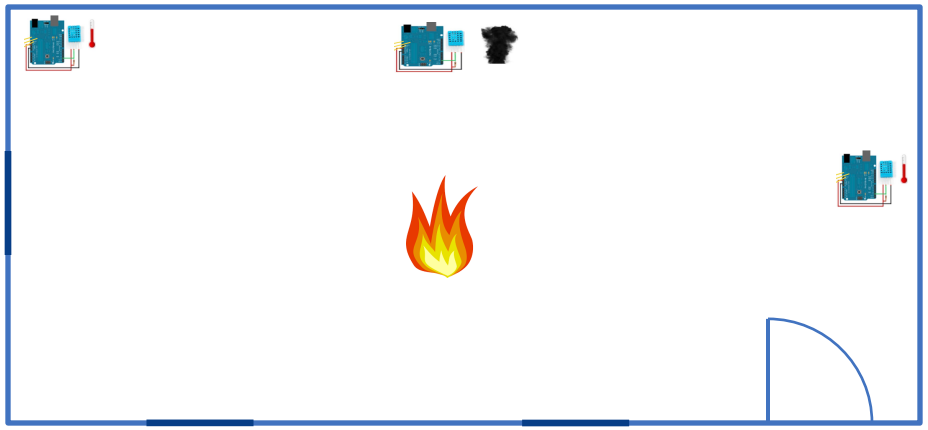
Fire Detection from smoke and temperature sensors



- Data Collected
  - Tons of observations in normal settings (no fire).
  - No observations in the presence of fire.

Fire Detection

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- Data Collected on Normal Conditions
  - Noisy Temperature sensor readings ever few milliseconds.
  - Noisy Smoke sensor readings ever few milliseconds.
  - No fire conditions.

- No Data Collected on Fire Conditions
  - Hard to collect data.
  - Lot of prior knowledge.
  - Fire implies much higher temperatures and presence of smoke.

Data Set

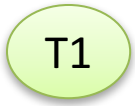
```
@relation dataset

@attribute Fire {0.0, 1.0}
@attribute SensorTemp1 real
@attribute SensorTemp2 real
@attribute SensorSmoke real


@data

0.0,18.633027714724676,19.400423814001343,-0.02701198878932973
0.0,18.298593115433658,20.40726110585825,0.6684046348595264
0.0,17.658384956098264,16.8448962949484,0.0841555701844007
0.0,18.39203485853405,17.855857296557993,0.12555453999886576
0.0,14.680969231785548,15.216145993817902,0.12198598050697214
0.0,15.65644513364921,18.900733207095623,0.25791060059142323
0.0,16.291732464378637,16.671241527508034,-0.3828607428218462
0.0,16.881376100703275,15.96326368868306,-0.754289707629689
0.0,18.392756588884964,20.248799056174818,-0.04612653474070432
0.0,21.746087507772568,20.029915815684824,-0.6006543157374465
0.0,16.88881671759228,17.108335707901386,0.14248132624399362
0.0,19.2708098751065,20.04036422884794,-0.08238909529367357
0.0,17.82532264741805,20.919998010412705,-0.1583914568166595
0.0,15.686577537423716,16.6930158413021,0.08858200127685115
0.0,17.635667765053007,17.527333382968898,0.19222365143796472
0.0,16.422751277159875,18.746707958578302,-0.3070751462098254
0.0,19.842704098779272,16.202081484293643,0.2855195495970611
0.0,18.28963876373175,19.606049680224288,0.2053927615899374
0.0,19.77427467574227,23.009652346666677,7.536915411803498
0.0,17.9229561688799,16.609486486349404,-0.339593744477432
0.0,12.360928638409725,15.355162791571903,0.2603535422419724
0.0,18.40060066203515,16.36977108609998,0.17271649816102733
0.0,18.700830721162834,17.542061776086605,-0.2942513743107443
```

- ARFF Format
  - ./datasets/sensorReadings.arff
  - Header detailing state space of the attributes.

Model Definition

Fire Detector Model

$$Fire \sim Binomial(\rho)$$



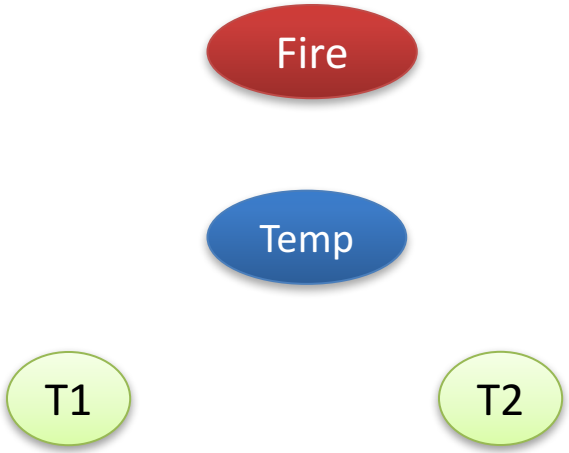
$$T1, T2 \sim Normal(\mu, \sigma)$$

Probabilistic Modeling

Every relevant object is a random variable.

Code: Session3.A_ModelLearning.java

Fire Detector Model



$$Fire \sim Binomial(\rho)$$

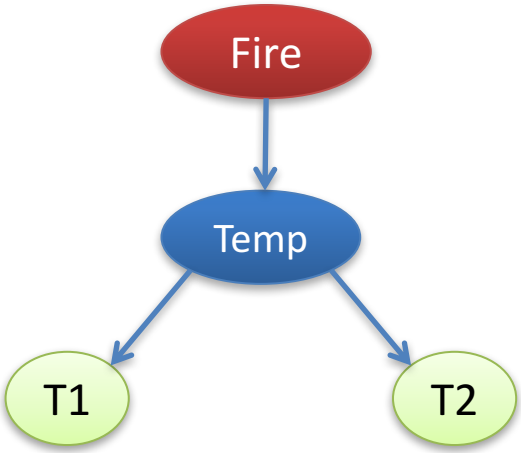
$$Temp \sim Normal(\mu, \sigma)$$

$$T1, T2 \sim Normal(\mu, \sigma)$$

Latent Variables

Non-observable relevant mechanisms

Code: Session3.A_ModelLearning.java



$$Fire \sim Binomial(\rho)$$

$$Temp|Fire \sim Normal(\mu_{Fire}, \sigma_{Fire})$$

$$T1, T2|Temp \sim Normal(\mu_{Temp}, \sigma)$$

Causal Relationships

They can be extracted for the mechanism itself

Code: Session3.A_ModelLearning.java

Learning from Data

Data Set

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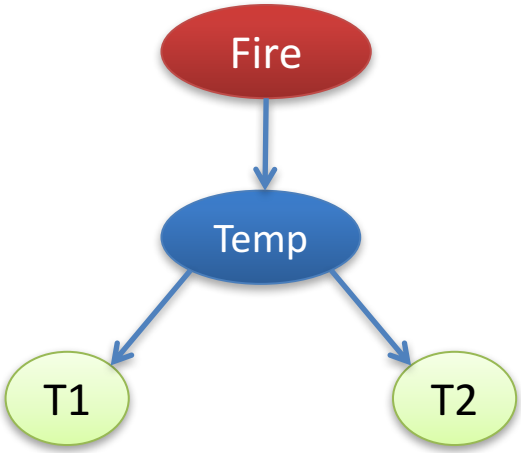
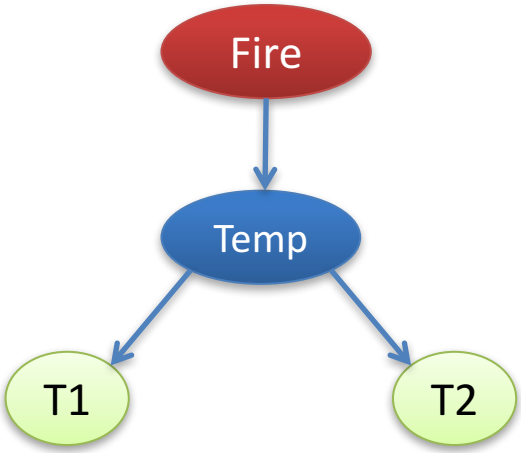


Learn the model from data

Using Streaming Variational Bayes

Code: Session3.A_ModelLearning.java

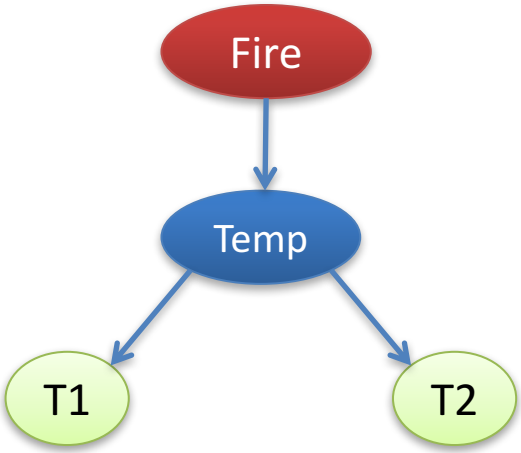
Learning from Data




```
P(Fire) follows a Multinomial
[ 0.99800796812749, 0.00199203187250996 ]
```

Code: Session3.A_ModelLearning.java

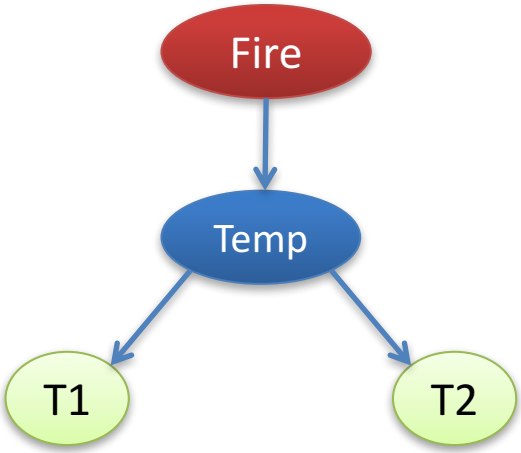
Learning from Data




```
P(Temperature | Fire) follows a Normal|Multinomial
Normal [ mu = 17.850398684425084, var = 2.7261903668047873 ] | {Fire = 0}
Normal [ mu = 0.0, var = 1.0 ] | {Fire = 1}
```

Code: Session3.A_ModelLearning.java

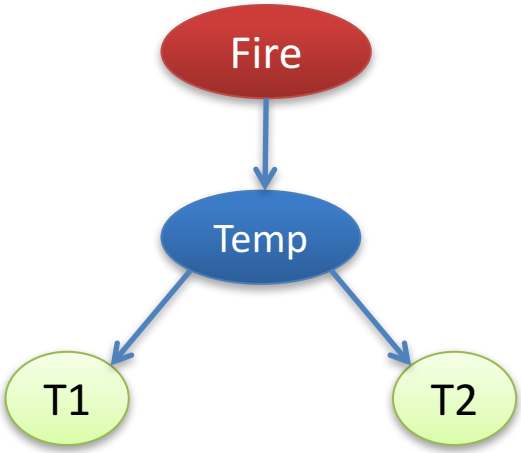
Learning from Data




```
P(SensorTemp1 | Temperature) follows a Normal|Normal
[ alpha = 0.0, beta1 = 1.0, var = 2.1200596403156617 ]
P(SensorTemp2 | Temperature) follows a Normal|Normal
[ alpha = 0.0, beta1 = 1.0, var = 2.157733884167721 ]
```

Code: Session3.A_ModelLearning.java

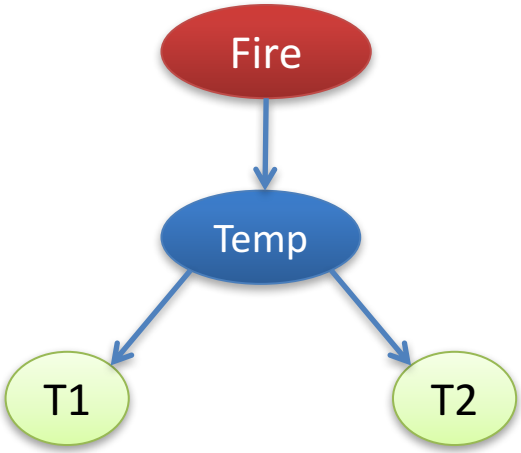
Learning from Data




```
P(SensorSmoke | Smoke) follows a Normal|Multinomial
Normal [ mu = -0.0038624730690733047, var = 0.09751495591088893 ] | {Smoke = 0}
Normal [ mu = 4.791637077454833, var = 3.583493438495509 ] | {Smoke = 1}
```

Code: Session3.A_ModelLearning.java

Integrating Expert Knowledge



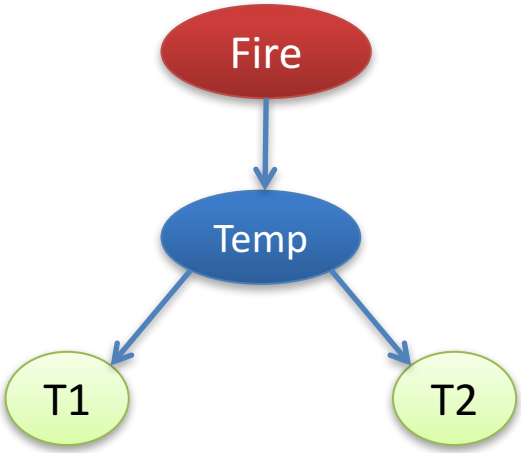
Modify the non-learnt conditional probabilities

Code: Session3.B_AddExpertKnowledge.java

Making Predictions

Code: Session3.C_ModelInference.java

Example of PGMs



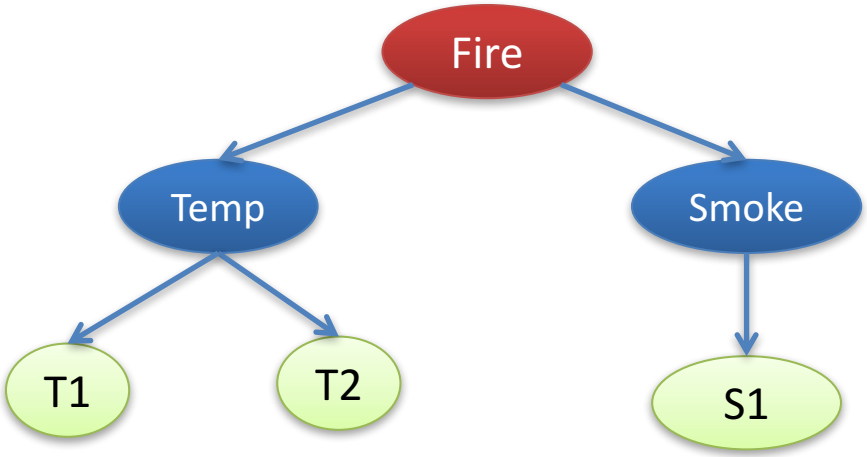
$$p(Fire = True|t_1, t_2)$$

Query the Model

Code Exercise

Code: Session3.C_ModelInference.java

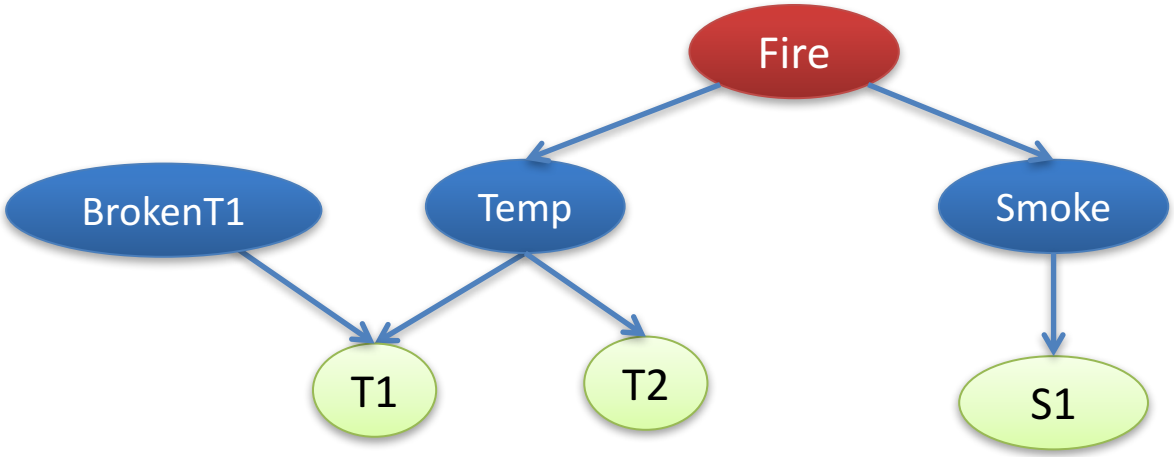
Fire Detector Model



What about Smoke Sensor?

Introduce Smoke Sensor into the model

Example of PGMs



Extend the model

Thanks for your attention

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