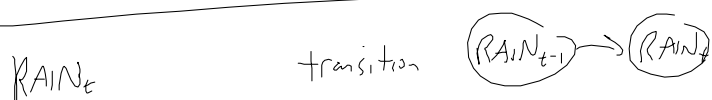


Brent Reasoning With Time

Monday, October 31, 2016 9:30 AM

$$P(RAIN_0) = 0.5, \dots, \text{uniform}$$



R_{t+1}	$P(R_t = TRUE R_{t-1})$	$P(R_t = FALSE R_{t-1})$
T	0.7	0.3
F	0.3	0.7

sensor model



R_t	$P(U_t = TRUE R_t)$	$P(U_t = FALSE R_t)$
T	0.9	0.1
F	0.2	0.8

Problems we can solve with

① BDN (HMM)

evidence

$$1) \text{Filtering: } P(X_{t+1} | \underline{e}_{1:t+1})$$

Hidden/belief state

$$2) \text{Prediction } P(X_{t+k} | e_{1:t})$$

3) Most likely explanation

Given sequence of evidence
find sequence of explanatory
hidden states

Filtering

$$P(X_t | e_{1:t})$$

$$P(X_{t+1} | e_{1:t+1}) =$$

$$P(X_{t+1} | \underbrace{e_{1:t}, e_{t+1}}_{\text{split evidence}})$$

hidden \nearrow evidence

$$= \propto P(e_{t+1} | X_{t+1}, e_{1:t}) P(X_{t+1} | e_{1:t})$$

* Bayes Rule

$$= \propto P(e_{t+1} | X_{t+1}) \underbrace{P(X_{t+1} | e_{1:t})}_{\text{Using sensor assumption 1-step prediction}}$$

$$= \propto P(e_{t+1} | X_{t+1}) \cdot \sum_{X_t} P(X_{t+1} | X_t, e_{1:t}) P(X_t | e_{1:t})$$

Sensor model \nearrow little

Final

$$P(X_{t+1} | e_{1:t+1}) = \propto$$

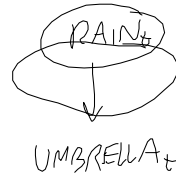
$$\propto P(e_{t+1} | X_{t+1}) \sum_{X_t} P(X_{t+1} | X_t) P(X_t | e_{1:t})$$

sensor model $\underbrace{\text{transition model}}_{\text{recursive call}}$

RAIN_t

transition	$(\text{RAIN}_{t-1}) \rightarrow \text{RAIN}_t$	0.3
r	$P(R_t = \text{TRUE} R_{t-1})$	$P(R_t = \text{FALSE} R_{t-1})$
δ	0.7	0.3
	R_t	U_t
	$P(U_t = \text{TRUE} R_t)$	$P(U_t = \text{FALSE} R_t)$
	0.9	0.1

sensor model



$$\begin{array}{|c|c|c|} \hline F & 0.2 & 0.8 \\ \hline \end{array}$$

$$P(RAIN_t) \\ \langle 0.5, 0.5 \rangle$$

$$Ex \ P(RAIN_2 | umbrella_{1:2}) \\ \rightarrow Hour_0 \rightarrow P(RAIN_0) = \langle 0.5, 0.5 \rangle \\ - Hour_1 \rightarrow \text{Transition portion}$$

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$$\sum_{r_0} P(RAIN_{t_0}) P(r_0) \\ \begin{array}{l} \text{rain} \rightarrow r_0 \\ \text{rain} \rightarrow \text{rain} \\ \text{transition function} \\ \text{Because no evidence} \end{array}$$

$$= \langle 0.7, 0.3 \rangle \times 0.5 + \langle 0.3, 0.7 \rangle \times 0.5$$

$$\begin{array}{l} \text{transition} \\ \rightarrow \langle 0.5, 0.5 \rangle \end{array} \quad \begin{array}{l} \text{probability table} \\ \text{prior} \end{array}$$

$$\text{sensor: } P(Umbrella_t | RAIN_t) = \langle 0.9, 0.2 \rangle \quad 0.182$$

$$\text{Hour 2 given transition } \langle 0.9, 0.2 \rangle \times \langle 0.5, 0.5 \rangle$$

$$P(RAIN_2 | Umbrella_{1:2}) = \sum_{r_1} P(RAIN_1 | r_1) P(r_1 | r_0) P(RAIN_2 | Umbrella_2, r_1) \\ \begin{array}{l} \text{transition} \\ \text{funct} \end{array} \quad \begin{array}{l} \text{comes from hour} \\ 1 \end{array}$$

$$= 2 \langle 0.7, 0.3 \rangle \times 0.818 + \langle 0.3, 0.7 \rangle \times 0.182 =$$

$$\approx \langle 0.627, 0.373 \rangle$$

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$$\langle 0.4, 0.2 \rangle \langle 0.627, 0.373 \rangle$$
$$\approx \langle \underline{0.883}, \underline{\cancel{0.257}} \underline{0.117} \rangle$$

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✕