SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

23AMB201 - MACHINE LEARNING

II YEAR IV SEM

UNIT V – Reinforcement Learning
TEMPORAL MODEL

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UNCERTAIN KNOWLEDGE AND REASONING

- Uncertainty
- Review of probability
- Probabilistic Reasoning
- Bayesian networks
- Inferences in Bayesian networks
- Temporal models
- Hidden Markov models

Temporal Models

- Two sections in Temporal Model,
  - Time and Uncertainty
    - **States and observations**
    - **Stationary processes and the Markov assumption**
  - Inference in Temporal Model

Temporal Models - Time and Uncertainty

- A changing world is modeled using a random variable for each aspect of the environment state, *at each point in time.*
- The relations among these variables describe how the state evolves.

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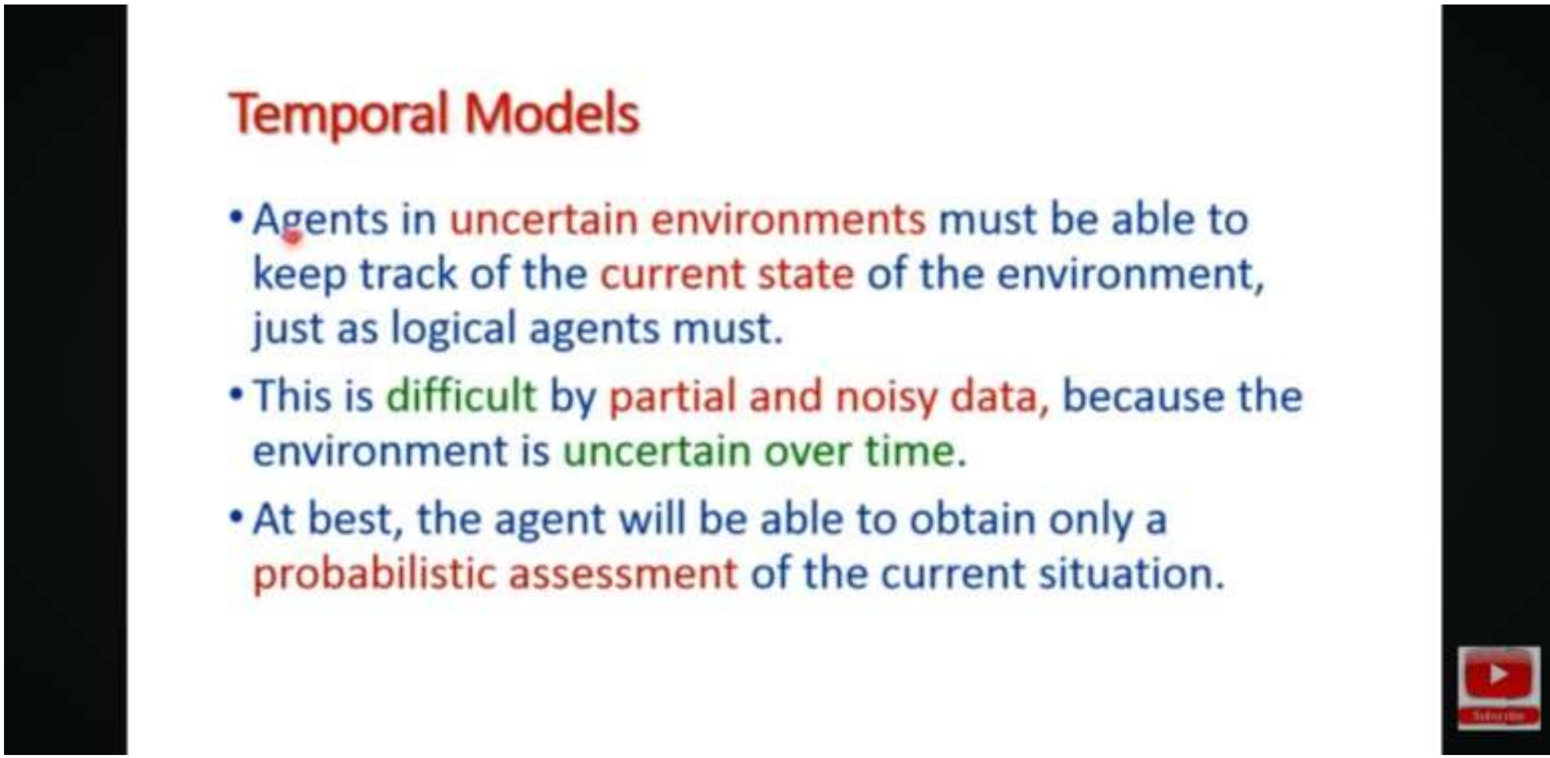

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Example - Treating a Diabetic Patient.

- We have evidence, such as, recent insulin doses, food intake, blood sugar measurements, and other physical signs.
- The task is to assess the current state of the patient, including the actual blood sugar level and insulin level.
- Given this information, the doctor (or patient) makes a decision about the patient's food intake and insulin dose.

Example - Treating a Diabetic Patient...

- The dynamic aspects of the problem are essential.
- Blood sugar levels and measurements thereof can change rapidly over time, depending on one's recent food intake and insulin doses, one's metabolic activity, the time of day, and so on.
- To assess the current state from the history of evidence and to predict the outcomes of treatment actions, we must model these changes.

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- Two sections in Temporal Model,
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States and Observations

- The process of change can be viewed as a series of snapshots (results), describes the state of the world at a particular time.
- Each snapshot or time slice, contains a set of random variables, some of which are observable and some of which are not.

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State and observation …

- Example: **Umbrella and Rain**
- Suppose you are a security guard for some secret underground installation
- You want to know whether it is raining today
- But, your only access to the outside world occurs each morning, when you see the director coming in with, or without an umbrella.

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State and observation ...

- We will assume that the same subset of variables is observable in each slice
- X_t – set of unobservable state variable at time t
- E_t – set of observable evidence variable
- The observation at time t is $E_t = e_t$ for some set of values e_t

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Example: Umbrella and Rain...

- For each day t, the set E_t (observable evidence variables) thus contains a single evidence variable U_t (whether the umbrella appears) and the set X_t (unobservable state variable) contains a single state variable R_t (whether raining or not)
- Hence we can assume Et = Ut and Xt = Rt
- And if Et = true then Xt = true
- i.e. if Ut = true then Rt = true

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State and observation ...

- The interval between time slices also depends on the problem.
- For diabetes monitoring, a suitable interval might be an hour rather than a day.
- We generally assume a fixed, finite interval; this means that times can be labeled by integers.
- We will assume that evidence starts arriving at t = 1 rather than t = 0.
- Hence, our umbrella world is represented by state variables Ro will be, R1, R2, . . . and evidence variables *U1* , U2, ...
- We will use the notation a:b to denote the sequence of integers from *a* to b and the notation Xa:b to denote the corresponding set of variables from Xa, to Xb.
- For example, $U_{1:3}$ corresponds to the variables U1, U2, U3.

- Two section in Temporal Model:
  * Time and Uncertanity
  *States and Observations
  *Satitionary process and the Markow assumpton
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Stationary Processes and the Markov assumption

- With the set of state and evidence variables for a given problem, we need to specify the dependencies among the variables.
- Order the variables in their natural temporal order
- Since cause usually precedes effect so we need to add the variables in causal order.

Stationary Processes and the Markov assumption…

- Solution for the problems
- The first problem is solved by assuming that changes in the world state are caused by a stationary process-that is, a process of change that is governed by laws that do not themselves change over time.
- In the umbrella world, the conditional probability that the umbrella appears, P(Ut | Parents(Ut)), is the same for all t.

Stationary Processes and the Markov assumption…

- The set of variables is unbounded, because it includes the state and evidence variables for every time slice.
- This actually creates two problems:
  - **first**, we might have to specify an unbounded number of conditional probability tables (CPT), one for each variable in each slice;
  - **second,** each one might involve an unbounded number of parents.

Stationary Processes and the Markov assumption...

- Solution for the problems
- The first problem is solved by assuming that changes in the world state are caused by a stationary process-that is, a process of change that is governed by laws that do not themselves change over time.
- In the umbrella world, the conditional probability that the umbrella appears, $P(U_t \mid Parents(U_t))$, is the same for all t.

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Stationary Processes and the Markov assumption...

- The second problem, handling the infinite number of parents, is solved by making a Markov assumption-that is, that the current state depends on only a finite history of previous states.
- the simplest is the first-order Markov process
- **in which the current state depends only on the previous state and not on any earlier states.**
- Using our notation, the corresponding conditional independence assertion states that, for all *t*,

$$\mathbf{P}(\mathbf{X}_t|\mathbf{X}_{0:t-1}) = \mathbf{P}(\mathbf{X}_t|\mathbf{X}_{t-1})$$

Stationary Processes and the Markov assumption…

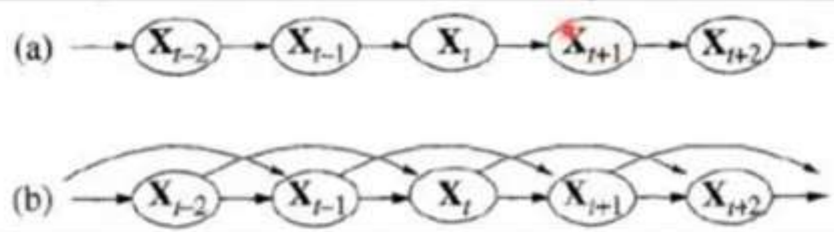

Figure 15.1 (a) Bayesian network structure corresponding to a first-order Markov process with state defined by the variables $\mathbf{X}_t$. (b) A second-order Markov process.

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Stationary Processes and the Markov assumption...

- The transition model for a second-order Markov process is the conditional distribution $P(X_t \mid X_{t-2}, X_{t-1})$.
- current state depends on only two previous states

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Stationary Processes and the Markov assumption...

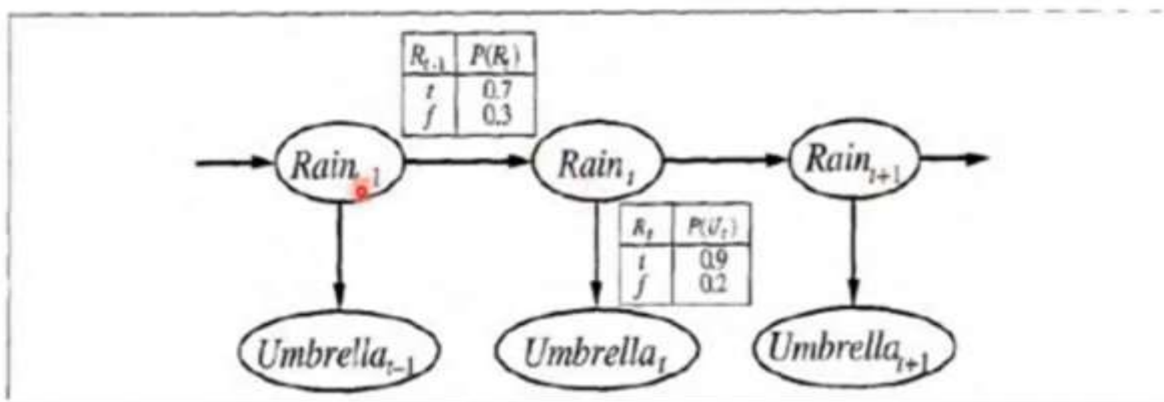

Figure 15.2 Bayesian network structure and conditional distributions describing the umbrella world. The transition model is $P(Rain_t|Rain_{t-1})$ and the sensor model is $P(Umbrella_t|Rain_t)$.