Network Management

Lecture 13

MACHINE LEARNING TECHNIQUES

Introduction

- Subfield of Artificial Intelligence
- Concerned with the design and development of algorithms and techniques that allow computers to learn
- **Inductive Reasoning**
  - Extract rules and patterns out of massive data sets
- **Deductive Reasoning**
  - Uses arguments (premises) which are assumed to be true

    All men are mortal (**Major Premise**)

    Atiq is a man (**Minor Premise**)

    Atiq is mortal (**Conclusion**)

Applications of ML

- NLP
- Pattern recognition
- Search engines
- Medical diagnosis
- Bioinformatics
- Brain-Machine interfaces
- Detecting credit card fraud
- Speech and handwriting
- Recognition
- Object recognition in computer vision
- Game playing
- Robot locomotion
- Stock market analysis,
- Classifying DNA sequences

Fault management, self-configuration, and optimization

Machine learning algorithms

- **Supervised learning**
  - Algorithm generates a function that maps inputs to desired outputs
- **Unsupervised learning**
  - An agent that models a set of inputs; labeled examples are not available
- **Semi-supervised learning**
  - Combines both labeled and unlabeled examples to generate an appropriate function or classifier
- **Reinforcement learning**
  - Algorithm learns a policy of how to act given an observation of the world

Machine learning algorithms

- **Transduction**
  - Similar to supervised learning but does not explicitly construct a function
  - Tries to predict new outputs based on training inputs, training outputs
  - Test inputs which are available while training

- **Learning to learn**
  - Algorithm learns its own inductive bias based on previous experience

ARTIFICIAL NEURAL NETWORK TECHNIQUES

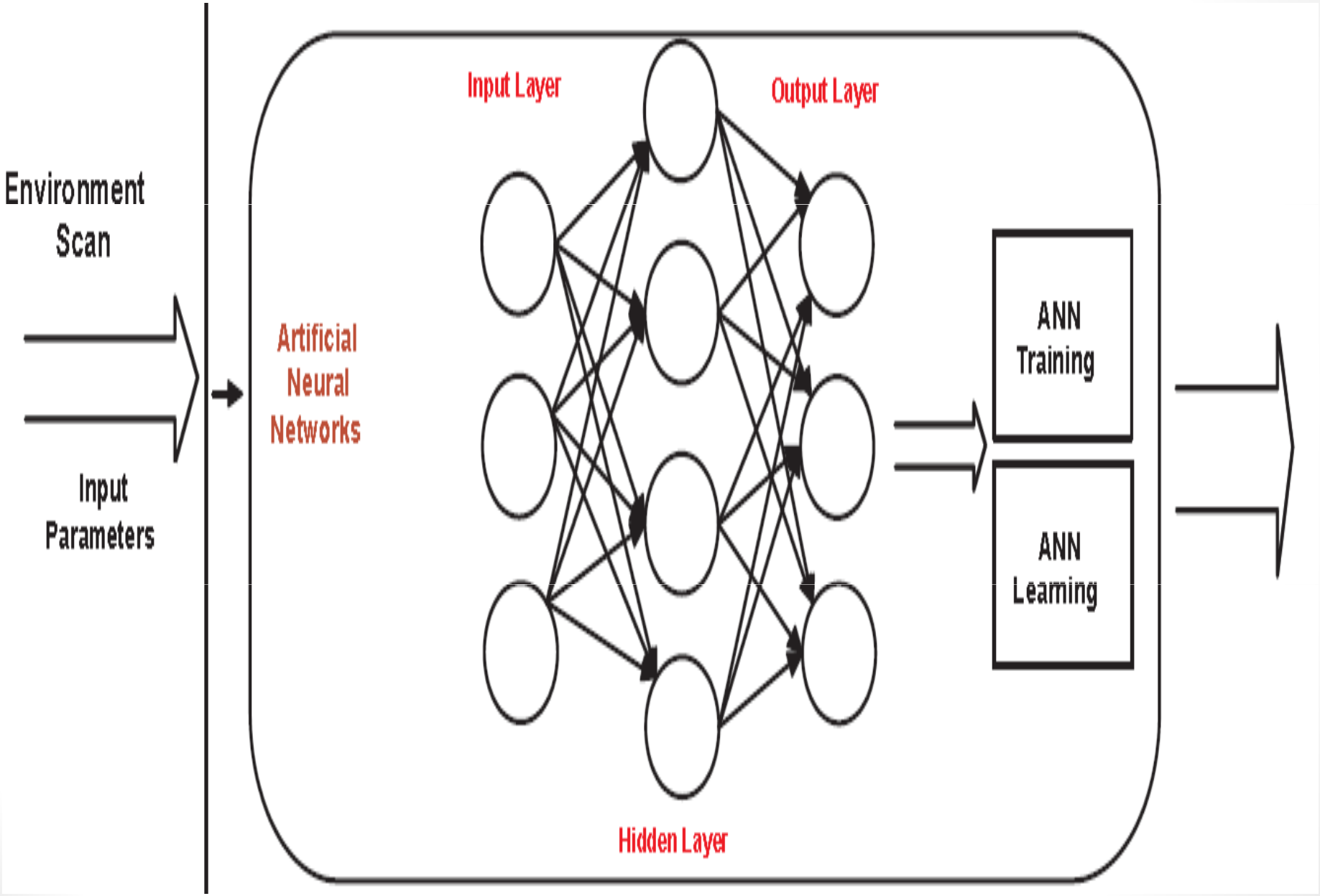
Introduction

- A system constituted of elements (neurons) interconnected according to a model that tries to reproduce the functioning of the neural network existing in the human brain
- Each neuron may be considered as an autonomous processing unit
  - Local memory
  - Unidirectional channels for the communication with other neurons
- Distributed control, storage of data & parallelism
- Do not require previous knowledge

Features of ANNs

- Recognize conditions similar to previous conditions for which the solution is known (i.e., pattern matching)
- Generalize well & learn an approximation of a given function, without requiring a deep understanding of the knowledge domain
- Provide a fast & efficient method for analyzing incoming alarms
- Can handle incomplete, ambiguous & imperfect data

Architecture of an ANN



Graph-theoretic Techniques

- Rely on a graph model of the system, called a Fault Propagation Model (FPM)
  - Describes which symptoms may be observed if a specific fault occurs
  - Represents all the faults and symptoms that occur in the system
  - Observed symptoms are mapped into the FPM nodes
  - FPM creation requires an accurate knowledge of current dependencies among system components

Graph-theoretic Techniques

- Network management consists mainly of monitoring, interpreting, and handling events
  - Directly observable events
  - Indirectly observable from their symptoms
- Symptoms are defined as the observable events however, a symptom cannot be directly handled; instead its root cause problem needs to be handled

Causality Graph Model

- Induces a partial order relationship between events
- Causality graph is a directed acyclic graph

$G_c(E, C)$ **E corresponds to events & C describe cause-effect relationships between events**

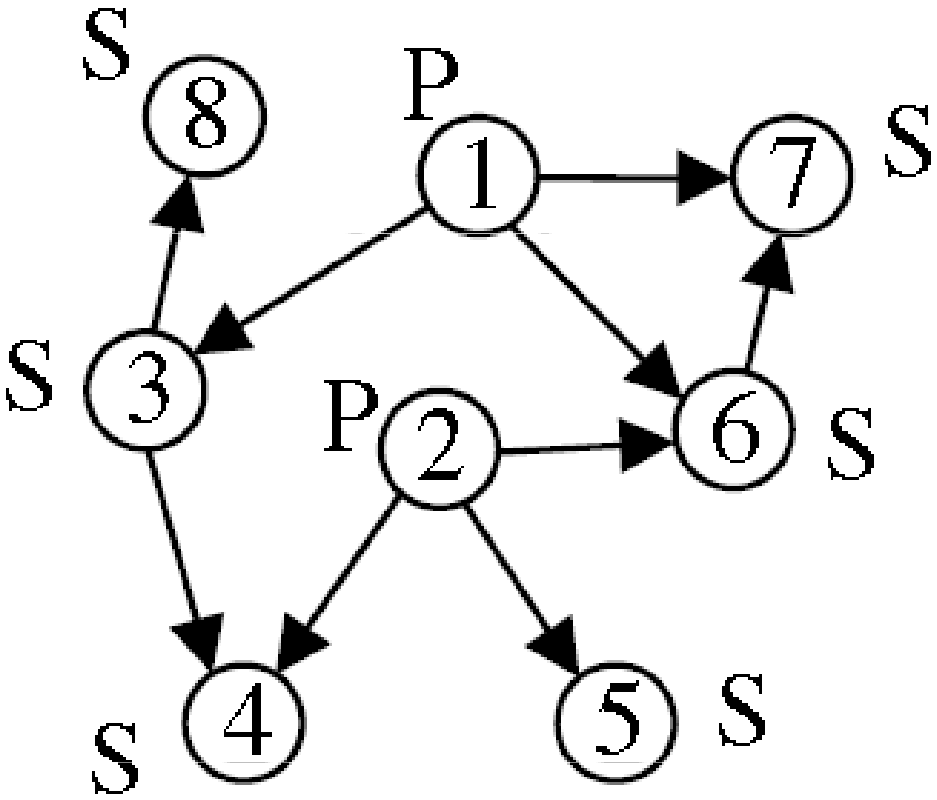
- Represents the fact that event ei causes event ej

$$(e_i, e_j) \in C$$

$$e_i \rightarrow e_j$$

Causality Graph Model

- Nodes of a causality graph may be marked as problems or symptoms
- Some nodes are neither problems nor symptoms, while others may be marked as problems and symptoms at the same time
- Causality graph edges may be labeled with a probability of the causal implication


S
8
P
1
7
S
S
3
P
2
6
S
S
4
5
S

Dependency Graph Model

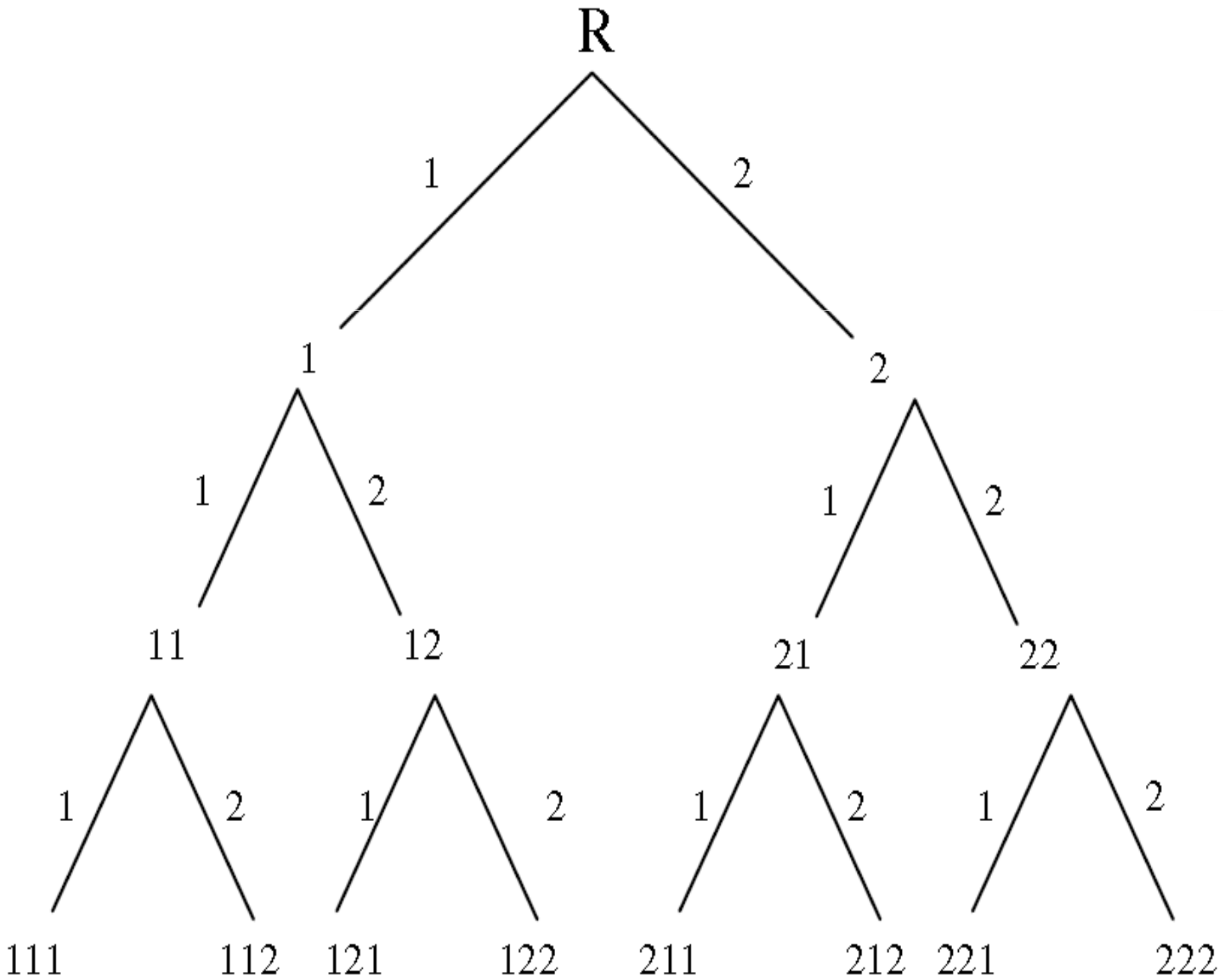
- Directed graph $$G = (O, D)$$
  - O is a finite, non-empty set of objects
  - D is a set of edges between the objects
- Each object may be associated with a probability of its failure independent of other objects

$$(O_i, O_j) \in D$$

- Every directed edge is labeled with a conditional probability that the object at the end of an edge fails, provided that the object at the beginning of an edge fails

Decision Trees

- Graphical representation in which all possible outcomes and the paths may be reached
- Often used in classification tasks
- The top layer consists of input nodes (e.g., status observations in networks)
- Decision nodes determine the order of progression through the graph
- The leaves of the tree are all possible outcomes or classifications, while the root is the final outcome (for example, a fault prediction or detection)


R
1
2
1
2
1
2
1
2
11
12
21
22
1
2
1
2
1
2
1
2
111
112
121
122
211
212
221
222

$$V = \{R, 1, 2, 11, 12, 21, 22, 111, 112, 121, 122, 211, 212, 221, 222\}$$

SET OF VERTICES

$$(x_1, x_2), (x_2, x_3), \ldots, (x_k, x_{k+1})$$

from the root

$$x_1 \text{ to } v = x_{k+1}$$