Lecture 28

Modeling (3):
Expert System and Reinforcement Learning
Outline

• ANN and Knowledge Based Expert System (KBES)
  – A Brief Introduction to rule-based KBES
  – Integrating KBES and ANN
Knowledge Based Expert System

- A Knowledge Based Expert System (KBES) is a Computer Program which solves a specific type of problems by codifying human experts knowledge in a knowledge base, and by mimicking the human problem solving process.
KBES (Cont'd)

- An KBES consists of a database which stores problem dependent facts, a human interface to communicate with user, and two special modules:

  Knowledge Base – a special data base where human experts' knowledge is codified.

  Inference Engine – a mechnism which enables the utilization of knowledge and facts to solve a given problem.
KBES Structure

• The Knowledge base consists of "RULES":

Rule 0021: IF
(1) QRS ≥ .11sec. on any two limb leads AND
(2) Sd. ≥ .04sec. on lead I or aVL AND
(3) terminal R present lead VI
THEN
(a) QRS .11 seconds; AND
(b) terminal QRS rightward and anterior; AND
(c) incomplete right bundle branch block

• Rules are elicited from human experts' knowledge.
• Inference engine provides search and binding mechanism to perform "logic reasoning" – A process in which a chain of rules are invoked (fired) based on given facts.
ANN and KBES

Any rule based expert system can be realized with a MLP network with threshold activation function to implement AND, OR, and NOT logic operations:

OR operation

\[\begin{array}{c}
\uparrow \\
\downarrow \\
\ldots \\
1 \\
1 \\
\end{array} \quad -0.5 \]

AND operation

\[\begin{array}{c}
\uparrow \\
\downarrow \\
\ldots \\
1 \\
1 \\
\end{array} \quad -n+.5 \]

NOT operation

\[\begin{array}{c}
\uparrow \\
\downarrow \\
\ldots \\
-1 \\
\end{array} \quad 0.5 \]

n: # of inputs
ANN and Rules

MLP implementation of Rule 0021. The hidden layer performs AND operation, the output layer performs OR operation.
EXtract KBES from An ANN

- KBNN (Knowledge Based Neural Network) – A rule based KBES can be used to initialize a MLP. Then its performance can be fine-tuned using learning. For example, if a trained MLP has the following form:

What will be the corresponding rules?
Extracting Rules

• One possible rule derived directly from the hyperplane:
  If $0.8a + 0.3b - 0.9c + 1 > 0$, then $z$ is TRUE
  Not quite a comprehensible rule!

• Rule Extraction Approaches:
  Eliminating weights with small magnitude (pruning)
  Training network with quantized weights ($-1, 0, +1$)
  N_of_M rule extraction – Determine whether an OR gate or an AND gate should be used.