

Week 12 Rule Learning

1. Introduction

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Here we briefly look at learning methods that are designed to learn rules as expressive and readable class descriptions.

2. Rule-Based Classification (Text 8.4)

In this section, we look at rule-based classifiers, where the learned model is represented as a set of IF-THEN rules.

IF-THEN rules for classification

Rules are a good way of representing information or bits of knowledge. A rule-based classifier uses a set of IF-THEN rules for classification.

How to Represent the knowledge in the form of IF-THEN rules

Example

R: IF *age* = *youth* AND *student* = *yes* THEN *buys_computer* = *yes*

- ○ "IF" part
 - Rule antecedent / precondition
 - Condition consists of one or more attribute tests that are logically ANDed
- "Then" part
 - Rule consequent
 - Contains a class prediction

Rule Evaluation

How to measure the quality of a single rule **R**? Use both *coverage* and *accuracy*. The key thing to note is that the accuracy of a rule is in proportion to its coverage, not to the size of the dataset as a whole.

- n_{covers} = number of tuples covered by **R**
- $n_{correct}$ = number of tuples correctly classified by **R**

- D = training data set
- **coverage**(R) = $n_covers / |D|$
 - the proportion of tuples that are covered by the rule
- **accuracy**(R) = $n_correct / n_covers$

Evaluation measures other than accuracy can be similarly adapted to using coverage just as for accuracy here.

How to measure the quality of a set of rules?

Conventional accuracy (correct tuples as a proportion of all tuples in the dataset) is used to evaluate a rule based classifier comprising a set (or sequence) of rules. Other conventional classification quality measures can also be used for for a set of rules that together form a classifier.

Conflict Resolution

If more than one rule is triggered, need conflict resolution

- Size ordering: assign the highest priority to the triggering rules that has the “toughest” requirement
 - i.e., with the most attribute tests
- Rule ordering: prioritise the rules beforehand by class-based or rule-based
 - Class-based ordering: prioritise classes beforehand. If a tuple is classified into multiple classes, choose a class by the class order.
 - Rule-based ordering: the rules are organised into one long priority list, according to some measure of rule quality

Default Rule

A default rule can be applied if there is no rule satisfied by a tuple.

3. Rule Extraction from a Decision Tree (Text: 8.4.2)

We have seen before how rules may be derived from a decision tree classifier.

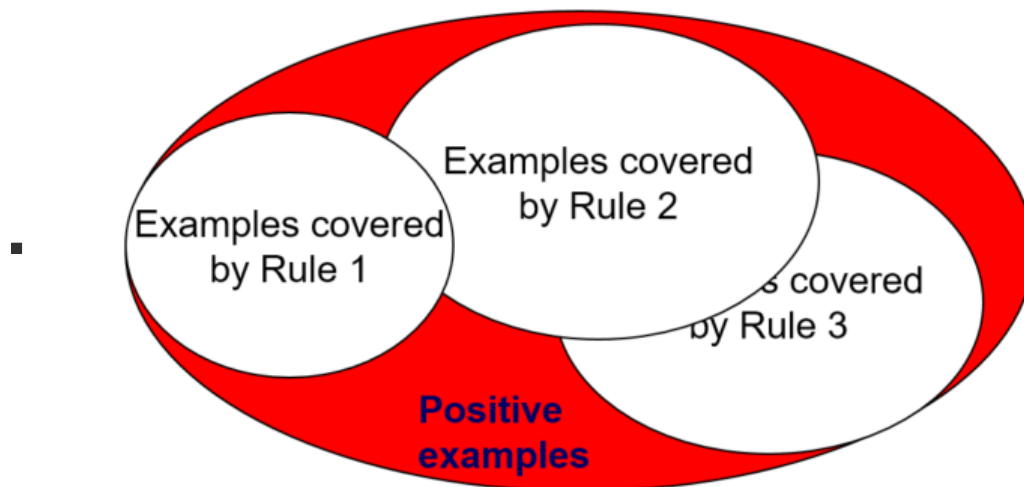
ACTION: Revisit this idea where we studied DecisionTrees.

4. Rule Induction (Text 8.4.3)

IF-THEN rules can also be derived directly from the training data (i.e., without having to generate a decision tree first) using a sequential covering algorithm. Sometimes this is called *induction* or *abduction*, by reference to the language of logical inference, where rule languages have been extensively studied over a very long period.

Sequential covering algorithm

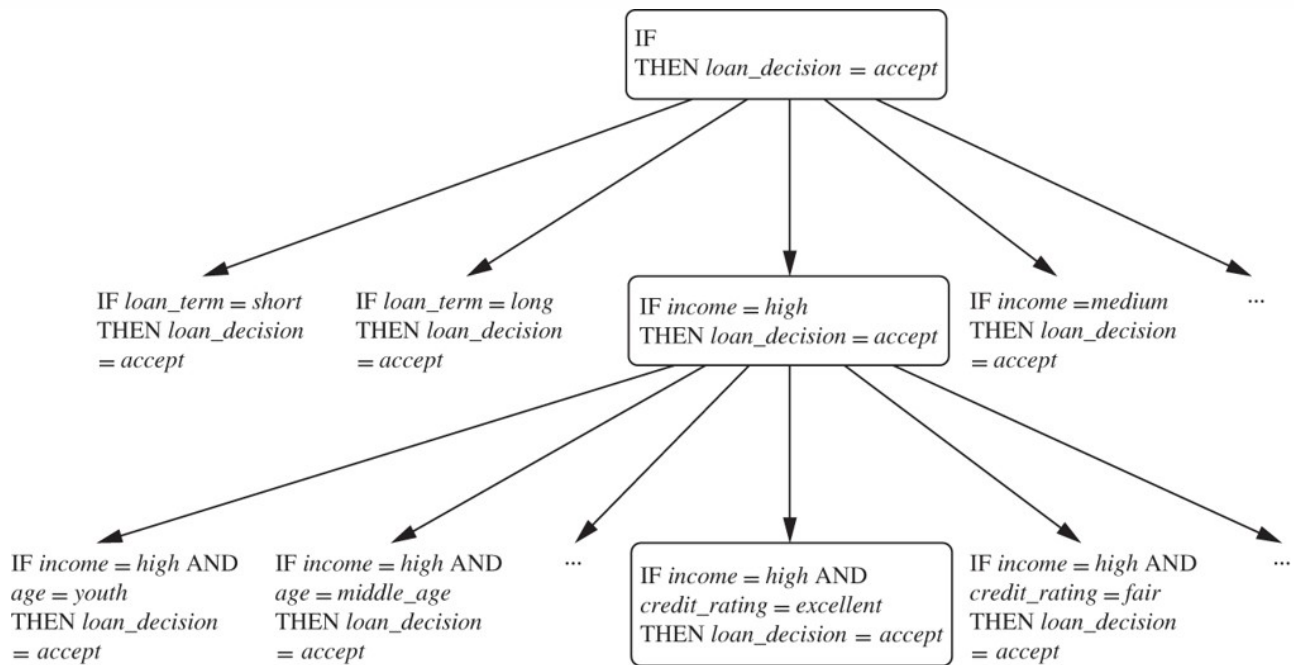
- Extracts rules directly from training data
- Typical sequential covering algorithms: FOIL, AQ, CN2, RIPPER
- Rules are learned sequentially, each for a given class C_i will cover many tuples of C_i but none (or few) of the tuples of other classes.
- Steps:
 - Rules are learned one at a time
 - Each time a rule is learned, the tuples covered by the rules are removed from the training set
 - The process repeats on the remaining tuples until a termination condition
 - e.g., when no more training examples or when the quality of a rule returned is below a user-specified threshold



How each rule is learned

- Rules are grown in a general-to-specific manner.
- Start off with an empty rule and then gradually keep appending attribute tests to it.
- Adding the attribute test to the existing condition of the rule antecedent

Example



Compared to rules derived from a Decision Tree

- Rules may be presented in a more expressive language, such as a relational language (e.g. can use relations like "adjacent" or "greater than" that relate attributes of covered tuples)
- Rules may be more compact and readable (do not branch from a common stem and tuples covered by an earlier rule are removed from training set)