On Decision Trees

Alexander G. Ororbia II

Introduction to Machine Learning

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The Decision Tree Hypothesis

Decision Tree Hypotheses

Propose a function representing the mapping for *(input, output)* pairs in the training data.

- Classification: (attributes, class), e.g. 'restaurant'
- Regression: (attributes, value), e.g. $ prediction

Geometry of Decision Boundaries

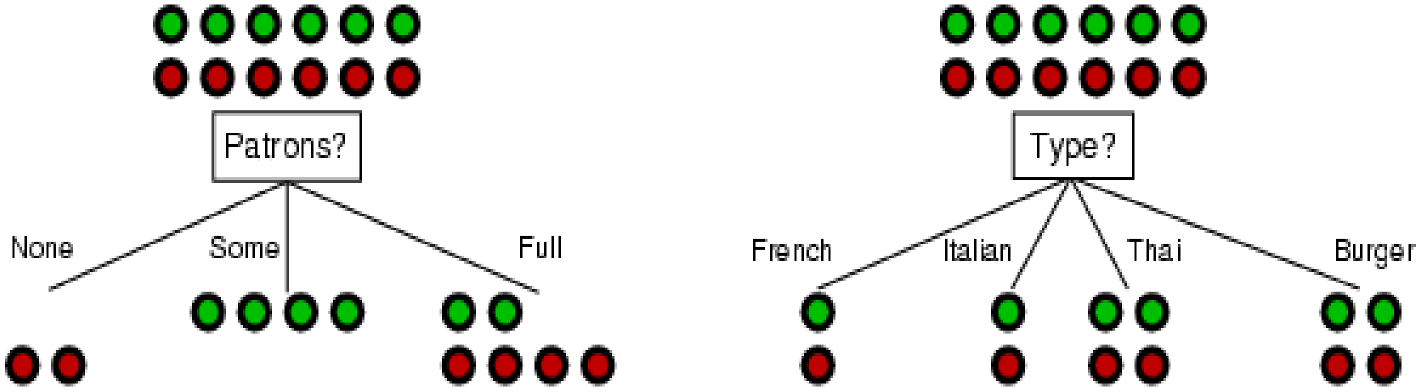
Our decision trees *split* individual attribute domains, producing axis-aligned rectangular decision regions

Some attributes are *correlated* (i.e. vary together), leading to non-rectangular regions (e.g. for classes)

However, even with an arbitrary linear separator, we cannot always represent the target function *f*.

Attribute Selection for Decision Tree Learning

- A Good Attribute
  - Splits examples into (***ideally***) "all positive" or "all negative" subsets

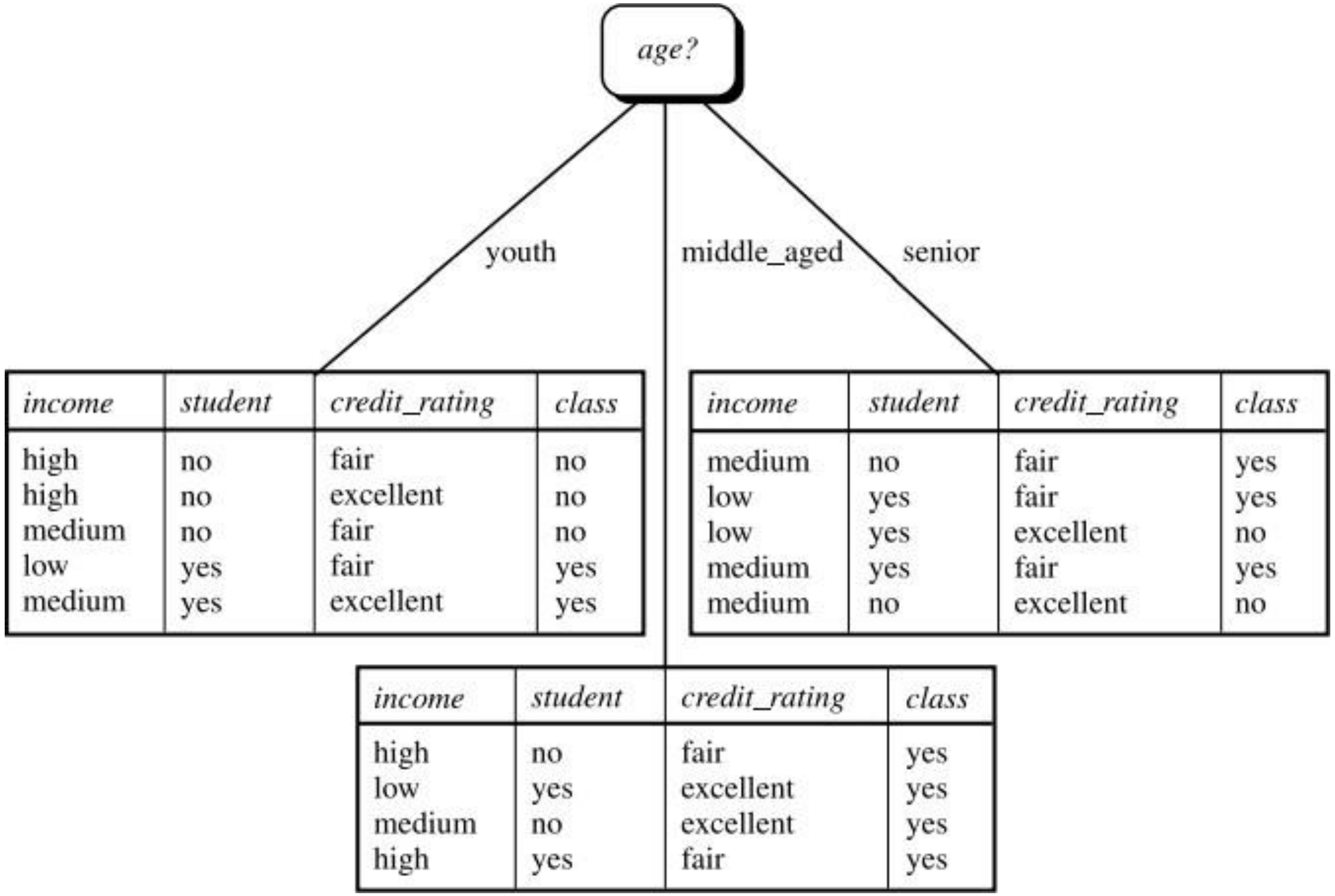


- For Example Above (Selecting Tree Root Node)
  - *Patrons?* is a better choice than *Type?* as attribute to select

It's white board time! Crafting ***top-down induction*** *for decision trees!*

Class-Labeled Training Tuples from the *AllElectronics* Customer Database

RID	*age*	*income*	*student*	*credit_rating*	*Class: buys_computer*
1	youth	high	no	fair	no
2	youth	high	no	excellent	no
3	middle_aged	high	no	fair	yes
4	senior	medium	no	fair	yes
5	senior	low	yes	fair	yes
6	senior	low	yes	excellent	no
7	middle_aged	low	yes	excellent	yes
8	youth	medium	no	fair	no
9	youth	low	yes	fair	yes
10	senior	medium	yes	fair	yes
11	youth	medium	yes	excellent	yes
12	middle_aged	medium	no	excellent	yes
13	middle_aged	high	yes	fair	yes
14	senior	medium	no	excellent	no



income	*student*	*credit_rating*	*class*
high	no	fair	no
high	no	excellent	no
medium	no	fair	no
low	yes	fair	yes
medium	yes	excellent	yes

income	*student*	*credit_rating*	*class*
medium	no	fair	yes
low	yes	fair	yes
low	yes	excellent	no
medium	yes	fair	yes
medium	no	excellent	no

income	*student*	*credit_rating*	*class*
high	no	fair	yes
low	yes	excellent	yes
medium	no	excellent	yes
high	yes	fair	yes

The Top-Down Induction Algorithm

Algorithm: Generate_decision_tree. Generate a decision tree from the training tuples of data partition, D.

Input:

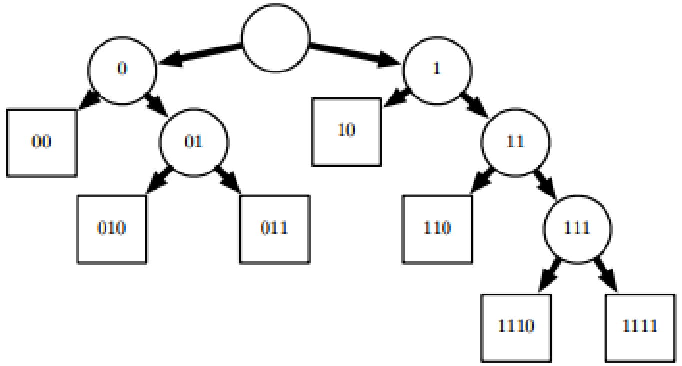
- Data partition, D, which is a set of training tuples and their associated class labels;
- *attribute_list*, the set of candidate attributes;
- *Attribute_selection_method*, a procedure to determine the splitting criterion that "best" partitions the data tuples into individual classes. This criterion consists of a *splitting_attribute* and, possibly, either a *split-point* or *splitting subset*.

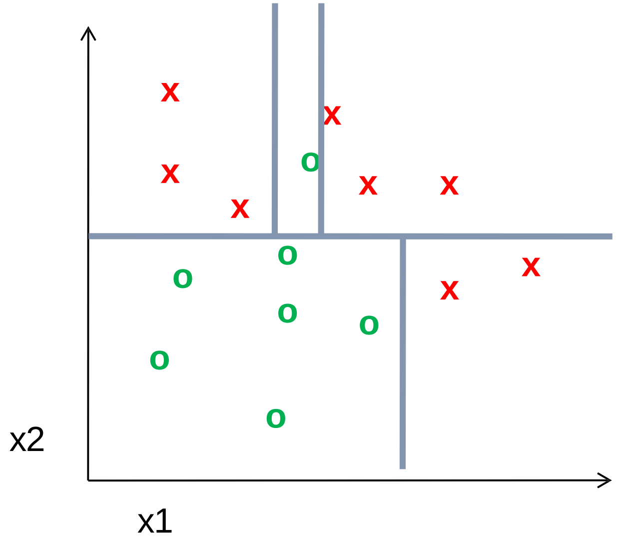
Output: A decision tree.

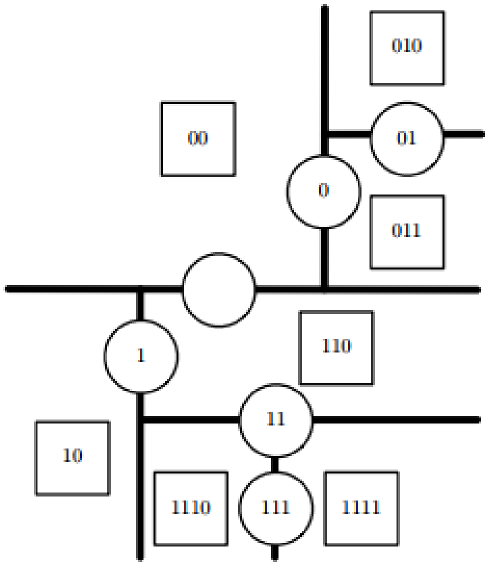
Method:

(1) create a node N;
(2) **if** tuples in D are all of the same class, C, **then**
(3)   return N as a leaf node labeled with the class C;
(4) **if** *attribute_list* is empty **then**
(5)   return N as a leaf node labeled with the majority class in D; // majority voting
(6) apply **Attribute_selection_method**(D, *attribute_list*) to **find** the "best" *splitting_criterion*;
(7) label node N with *splitting_criterion*;
(8) **if** *splitting_attribute* is discrete-valued **and**
    multiway splits allowed **then** // not restricted to binary trees
(9)   *attribute_list* $\leftarrow$ *attribute_list* $-$ *splitting_attribute*; // remove *splitting_attribute*
(10) **for each** outcome j of *splitting_criterion*
// partition the tuples and grow subtrees for each partition
(11)   let D_j be the set of data tuples in D satisfying outcome j; // a partition
(12)   **if** D_j is empty **then**
(13)   attach a leaf labeled with the majority class in D to node N;
(14)   **else** attach the node returned by **Generate_decision_tree**(D_j, *attribute_list*) to node N;
endfor
(15) return N;

Decision Trees – Aggregated Piecewise Functions







Divides (input) space into regions (nodes on lines categorize samples, leaf nodes on regions correspond to examples received). Piecewise-constant function (cannot learn function with more local maxima than number of training samples).

QUESTIONS?