Title: Preference learning

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Preference learning is a subfield of machine learning that focuses on modeling and predicting preferences based on observed preference information. [1] Preference learning typically involves supervised learning using datasets of pairwise preference comparisons, rankings, or other preference information.

Tasks

The main task in preference learning concerns problems in " learning to rank ". According to different types of preference information observed, the tasks are categorized as three main problems in the book Preference Learning : [2]

Label ranking

In label ranking, the model has an instance space X = { x i } {\displaystyle X=\{x_{i}\}\,\!} and a finite set of labels Y = { y i | i = 1 , 2 , ■ , k } {\displaystyle Y=\{y_{i}|i=1,2,\cdots ,k\}\,\!} . The preference information is given in the form y i ■ x y j {\displaystyle y_{i}\succ _{x}y_{j}\,\!} indicating instance x {\displaystyle x\,\!} shows preference in y i {\displaystyle y_{i}\,\!} rather than y j {\displaystyle y_{j}\,\!} . A set of preference information is used as training data in the model. The task of this model is to find a preference ranking among the labels for any instance.

It was observed that some conventional classification problems can be generalized in the framework of label ranking problem: [3] if a training instance x {\displaystyle x\,\!} is labeled as class y i {\displaystyle y_{i}\,\!} , it implies that ∀ j ≠ i , y i ■ x y j {\displaystyle \forall j\neq i,y_{i}\succ _{x}y_{j}\,\!} . In the multi-label case, x {\displaystyle x\,\!} is associated with a set of labels L ⊆ Y {\displaystyle L\subseteq Y\,\!} and thus the model can extract a set of preference information { y i ■ x y j | y i ∈ L , y j ∈ Y ■ L } {\displaystyle \{y_{i}\succ _{x}y_{j}|y_{i}\in L,y_{j}\in Y\backslash L\}\,\!} . Training a preference model on this preference information and the classification result of an instance is just the corresponding top ranking label.

Instance ranking

Instance ranking also has the instance space X {\displaystyle X\,\!} and label set Y {\displaystyle Y\,\!} . In this task, labels are defined to have a fixed order y 1 ■ y 2 ■ ■ ■ y k {\displaystyle y_{1}\succ y_{2}\succ \cdots \succ y_{k}\,\!} and each instance x l {\displaystyle x_{l}\,\!} is associated with a label y l {\displaystyle y_{l}\,\!} . Giving a set of instances as training data, the goal of this task is to find the ranking order for a new set of instances.

Object ranking

Object ranking is similar to instance ranking except that no labels are associated with instances. Given a set of pairwise preference information in the form x i ■ x j {\displaystyle x_{i}\succ x_{j}\,\!} and the model should find out a ranking order among instances.

Techniques

There are two practical representations of the preference information A ■ B {\displaystyle A\succ B\,\!} . One is assigning A {\displaystyle A\,\!} and B {\displaystyle B\,\!} with two real numbers a {\displaystyle a\,\!} and b {\displaystyle b\,\!} respectively such that a > b {\displaystyle a>b\,\!} . Another one is assigning a binary value V (A , B) ∈ { 0 , 1 } {\displaystyle V(A,B)\in \{0,1\}\,\!} for all pairs (A , B) {\displaystyle (A,B)\,\!} denoting whether A ■ B {\displaystyle A\succ B\,\!} or B ■ A {\displaystyle B\succ A\,\!} . Corresponding to these two different representations, there are two different techniques applied to the learning process.

Utility function

If we can find a mapping from data to real numbers, ranking the data can be solved by ranking the real numbers. This mapping is called utility function . For label ranking the mapping is a function f : X × Y → R {\displaystyle f:X\times Y\rightarrow \mathbb {R} \,\!} such that y i ■ x y j ⇒ f (x , y i) > f (x , y j) {\displaystyle y_{i}\succ _{x}y_{j}\Rightarrow f(x,y_{i})>f(x,y_{j})\,\!} . For instance ranking and object ranking, the mapping is a function f : X → R {\displaystyle f:X\rightarrow \mathbb {R} \,\!} .

Finding the utility function is a regression learning problem [citation needed] which is well developed in machine learning.

Preference relations

The binary representation of preference information is called preference relation. For each pair of alternatives (instances or labels), a binary predicate can be learned by conventional supervised learning approach. Fürnkranz and Hüllermeier proposed this approach in label ranking problem. [4] For object ranking, there is an early approach by Cohen et al. [5]

Using preference relations to predict the ranking will not be so intuitive. Since observed preference relations may not always be transitive due to inconsistencies in the data, finding a ranking that satisfies all the preference relations may not be possible or may result in multiple possible solutions. A more common approach is to find a ranking solution which is maximally consistent with the preference relations. This approach is a natural extension of pairwise classification. [4]

Uses

Preference learning can be used in ranking search results according to feedback of user preference. Given a query and a set of documents, a learning model is used to find the ranking of documents corresponding to the relevance with this query. More discussions on research in this field can be found in Tie-Yan Liu 's survey paper. [6]

Another application of preference learning is recommender systems . [7] Online store may analyze customer's purchase record to learn a preference model and then recommend similar products to customers. Internet content providers can make use of user's ratings to provide more user preferred contents.

References