Hybrid recommendation systems based on bayesian network

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Canonical weighted sum

Let X_i be a node in a BN, let $Pa(X_i)$ be the parent set of X_i, and Y_k be the k^{th} parent of X_i in the BN. By using a canonical weighted sum, the set of conditional probability distributions stored at node X_i are then represented by means of

$$Pr(x_{ij} \mid pa(X_i)) = \sum_{Y_k \in Pa(X_i)} w(y_{k,l}, x_{i,j})$$

where $w(y_{k,l}, x_{i,j})$ are weights(effects) measuring how this l^{th} value of variable Y_k describes the j^{th} state of node X_i.

$$\sum_{j=1}^{r} \sum_{Y_k \in Pa(X_i)} w(y_{k,l}, x_{i,j}) = 1$$

Related theorems

Theorem 1 $Pr(x_{a,s} \mid ev) = \sum_{j=1}^{m_{x_a}} \sum_{k=1}^{l_{Y_j}} w(y_{j,k}, x_{a,s}) \cdot Pr(y_{j,k} \mid ev)$

Theorem 2
if $F_k \notin Pa(I_j)$
$Pr(f_{k,1} \mid i_{j,1}) = Pr(f_{k,1})$

if $F_k \in Pa(I_j)$
$Pr(f_{k,1} \mid i_{j,1}) = Pr(f_{k,1}) + \frac{w(f_{k,1}, i_{j,1}) Pr(f_{k,1}(1 - Pr(f_{k,1}))}{Pr(i_{j,1})}$

where $Pr(i_{j,1}) = \sum_{F_k \in Pa(I_j)} w(f_{k,1}, i_{j,1}) Pr(f_{k,1})$

Algorithm(Now we've completed CB and we'll further develop CF and hybrid part later)

1.Content-based propagation:

-$ev_{cb} == I_j \quad Pr(i_{j,1} \mid ev) = 1$

Compute $Pr(F_k \mid ev)$ using Theorem 2

-Propagate to items using Theorem1.

-Propagate to A_{CB} and $U_i \in U_1^-$ using Theorem 1.

2.Collaborative propagation

-For each $U_K \in U_I^+$ set $Pr(U_k = r_{k,j} \mid ev) = 1$.

-Propagate to $A_C F$ node using Theorem 1.

3.Combine content-based and collaborative likelihoods at hybrid node A_H

4.Select the predicted rating.

example data

- features $\{f_1, f_2, f_3, f_4\}$
- movies $\{i_1, i_2, i_3, i_4, i_5\}$
- users $\{u_1, u_2, u_3\}$

table1: row:movies; column:features; entry:$\{0,1\}$

$$\begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 \end{pmatrix}$$

table2: row:user; column:movies; entry:$\{0,1\text{-}5\}$

$$\begin{pmatrix} 0 & 3 & 5 & 1 & 4 \\ 2 & 2 & 4 & 1 & 0 \\ 1 & 5 & 1 & 4 & 4 \end{pmatrix}$$

algorithm example

```
##       movie1 movie2 movie3 movie4 movie5
## user1      3      3      5      1      3
## user2      2      2      2      1      1
## user3      1      1      1      4      3
```