Positive and Unlabeled Relational Classification through Label Frequency Estimation

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Goal:

Learn a classifier from positive and unlabeled relational data (relational PU learning)

Shortcoming of current solution [1]:

Cannot learn disjunctive concepts

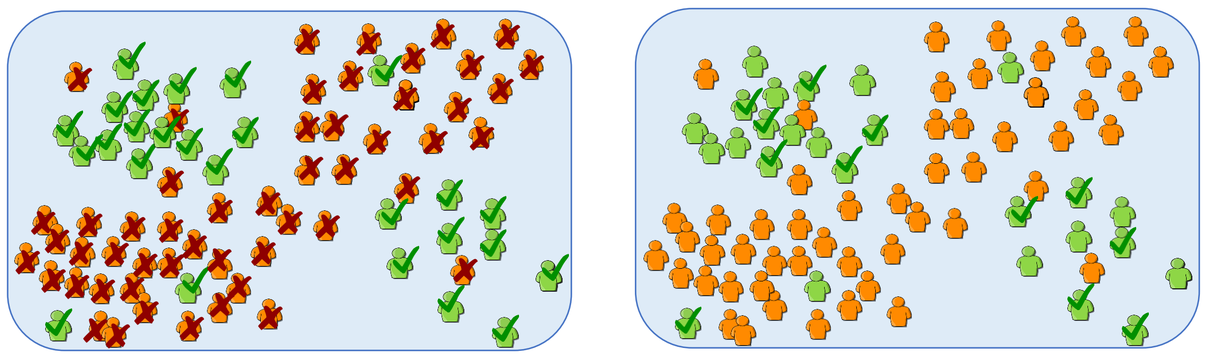
Solution:

Use the label frequency to adjust standard learning algorithms to the PU scenario. This is a common approach in propositional PU learning

Challenge:

Estimate the label frequency in relational PU data

Positive and Unlabeled (PU) Learning



Supervised Data Positive and Unlabeled Data

Common assumption:

Positive examples get labeled with constant probability c, the *label frequency*

$$c = P(labeled \mid positive, facts) = P(labeled \mid positive)$$

Estimate Label Frequency *c* from PU data

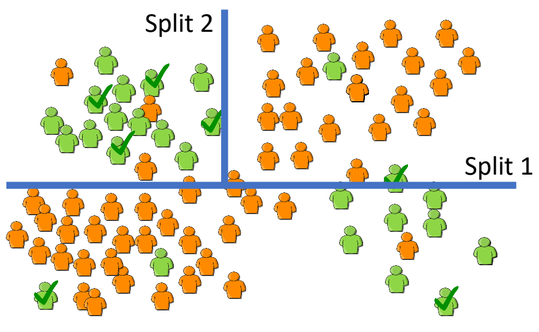
Insight 1: Data subset implies lower bound on c

$$P \leq T \quad \Rightarrow \quad c \geq \frac{L}{T} - \underbrace{\varepsilon(T)}_{\text{Error term from 1-sided Chebyshev inequality}}$$

Insight 2: Positive subsets give very tight bounds

Insight 3: Highly labeled subsets are likely positive

→ Look for those through decision tree induction (Tilde)
Use subsets to tighten lower bound



Init : $c \geq \frac{7}{78} - \varepsilon(78) = 0.09 - \varepsilon(78)$

Split 1: $c \geq \frac{5}{39} - \varepsilon(39) = 0.13 - \varepsilon(39)$

Split 2: $c \geq \frac{4}{17} - \varepsilon(17) = 0.24 - \varepsilon(17)$

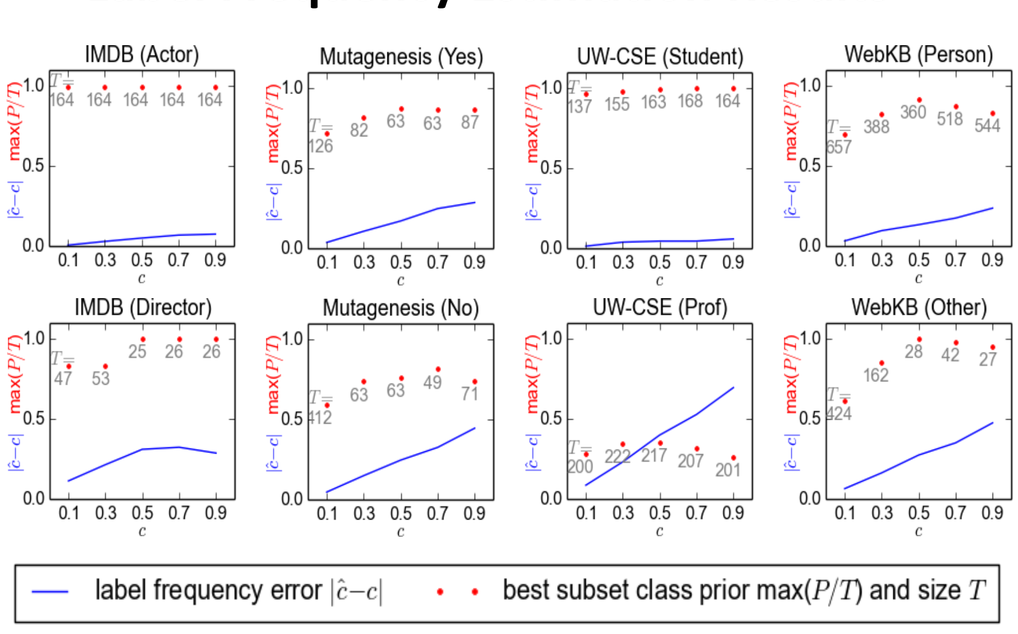
Simple PU Learning using the Label Frequency *c* [2]

$$P(positive|facts) = \frac{P(labeled|facts)}{c}$$

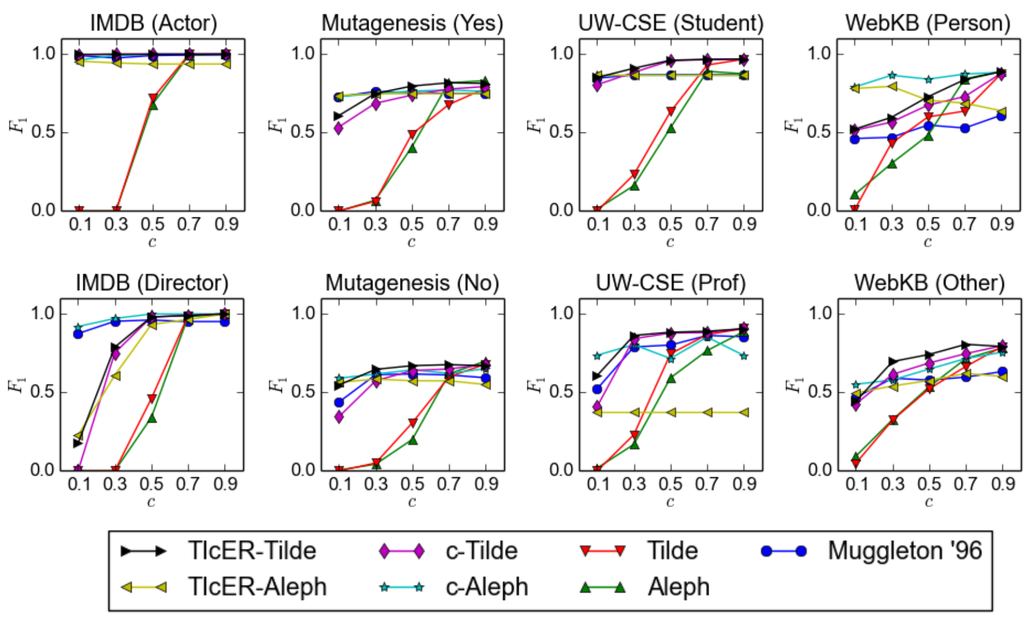
Method 1: Probabilistic classifier that learns $P(labeled|facts)$
Adjust output probabilities using the formula
E.g. Tilde: Probabilistic Relational Decision Trees

Method 2: Adjust learning algorithm using *c*:
P=L/c and N=T-P
E.g. Aleph: adjust score function
Supervised: Coverage = P-N
PU: Coverage = L/*c*-(T-L/c) = 2L/c - T

Label Frequency Estimation Results



Method Comparison



References

[1] Muggleton, Stephen. Learning from positive data. ILP, 1996.

[2] Elkan, Charles, and Noto, Keith. Learning classifiers from only positive and unlabeled data. KDD, 2008.