Transformation-based error-driven learning (TBL)

LING 572

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Outline

- Basic concept and properties
- Case study

Basic concepts and properties

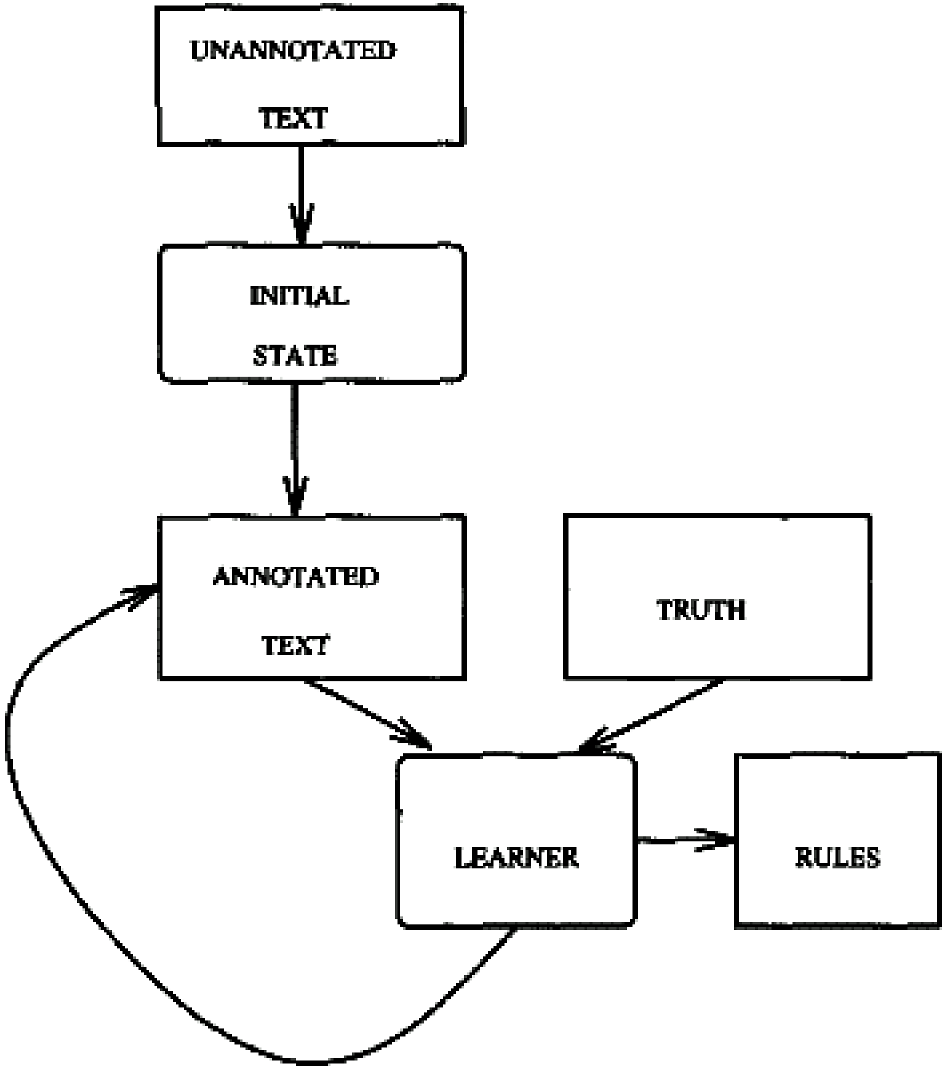
TBL overview

- Introduced by Eric Brill (1992)

- Intuition:
  - Start with some simple solution to the problem
  - Then apply a sequence of transformations to improve the results

- Applications:
  - Classification problem
  - Sequence labeling problem: e.g., POS tagging

TBL flowchart for training



Transformations

- A transformation has two components:
  - A trigger environment: e.g., the previous tag is DT
  - A rewrite rule: **change** the current tag from MD to N

  If (prev_tag == DT) then MD ➔ N

- Similar to a rule in decision tree, but the rewrite rule can be complicated (e.g., change a parse tree)

  ➔ TBL can be more powerful than a classifier

Training time: learn transformations

1. Initialize each instance in the training data with an initial annotator

2. Consider all the possible transformations, and choose the one with the highest score.

3. Append it to the transformation list and apply it to the training corpus to obtain a “new” corpus.

4. Repeat steps 2-3.

➔ Steps 2-3 can be expensive. Various ways to address the problem.

Testing time: applying transformations

1. Initialize each example in the test data with the same initial annotator

2. Apply the transformations in the same order as they were learned.

Using TBL

- Pick the initial state-annotator

- Decide the space of allowable transformations
  - Triggering environments
  - Rewrite rules

- Choose an objective function: (e.g., minimize error rate).
  - for comparing the corpus to the truth
  - for choosing a transformation

Using TBL (cont)

- Two more parameters:
  - Whether the effect of a transformation is visible to following transformations
  - If so, what’s the order in which transformations are applied to a corpus?
    - left-to-right
    - right-to-left

The order matters

- Transformation:

  If prevLabel=A

  then change the curLabel from A to B.

- Input: A A A A
- Output:
  - “Not immediate” results: A B B B
  - Immediate results, left-to-right: A B A B
  - Immediate results, right-to-left: A B B B

Case study

TBL for POS tagging

- The initial state-annotatator: most common tag for a word.

- The space of allowable transformations
  - Rewrite rules: change cur_tag from X to Y.
  - Triggering environments (feature types): unlexicalized or lexicalized

Unlexicalized features

- t_{-1} is z
- t_{-1} or t_{-2} is z
- t_{-1} or t_{-2} or t_{-3} is z
- t_{-1} is z and t_{+1} is w
- …

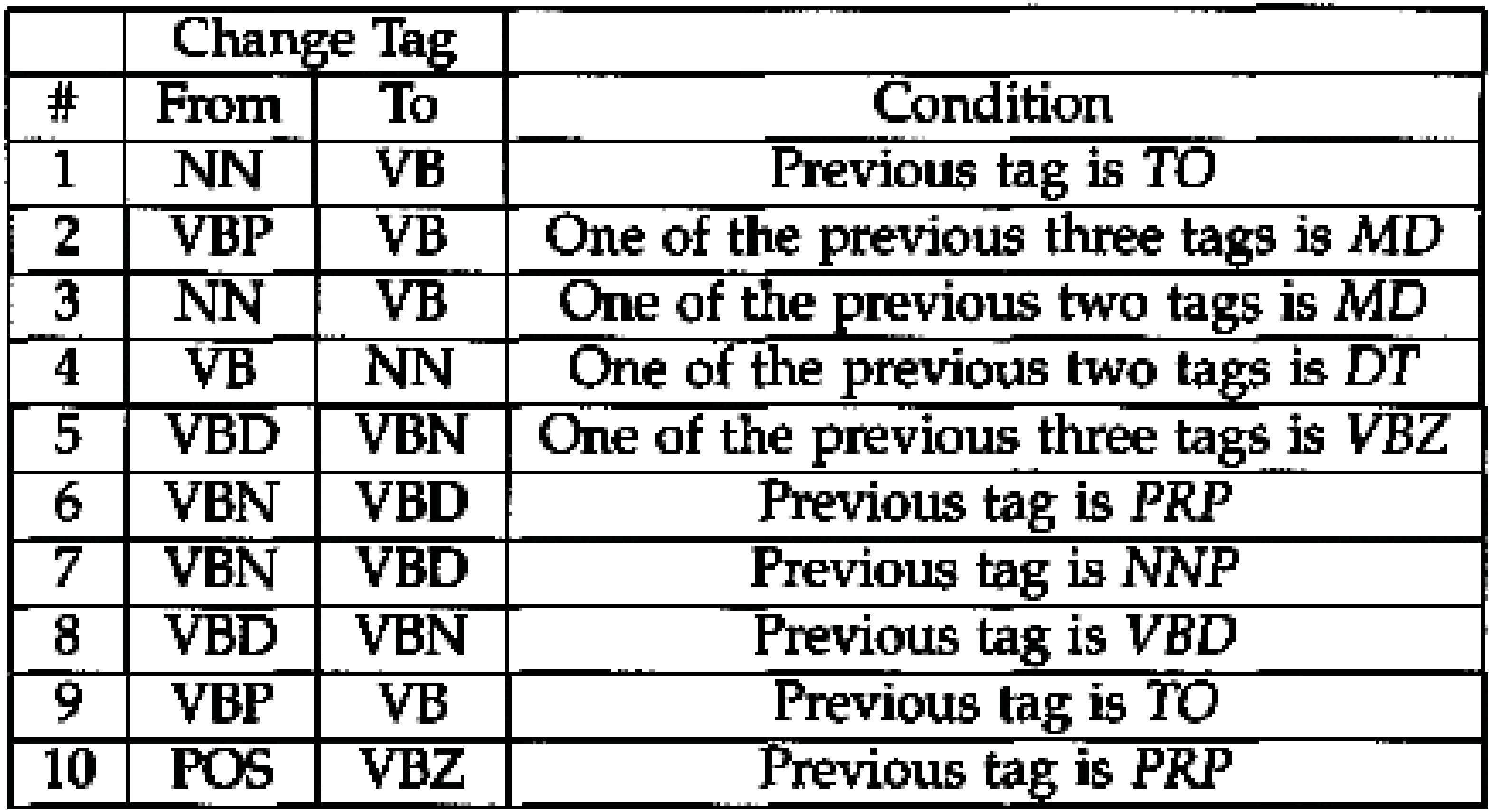
Lexicalized features

- w_0 is w.
- w_{-1} is w
- w_{-1} or w_{-2} is w
- t_{-1} is z and w_0 is w.
- …

TBL for POS tagging (cont)

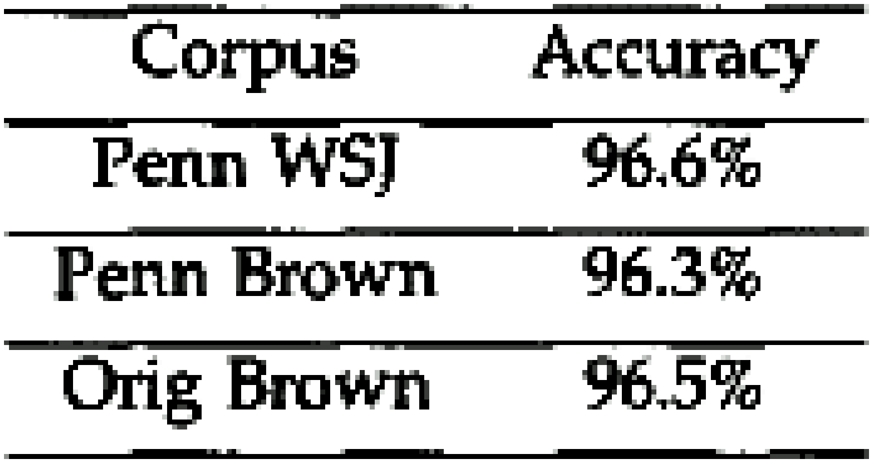
- The objective function: tagging accuracy
  - for comparing the corpus to the truth:
  - For choosing a transformation: choose the one that results in the greatest error reduction.
- The order of applying transformations: left-to-right.
- The results of applying transformations are not visible to other transformations.

Learned transformations



	Change Tag		
#	From	To	Condition
1	NN	VB	Previous tag is *TO*
2	VBP	VB	One of the previous three tags is *MD*
3	NN	VB	One of the previous two tags is *MD*
4	VB	NN	One of the previous two tags is *DT*
5	VBD	VBN	One of the previous three tags is *VBZ*
6	VBN	VBD	Previous tag is *PRP*
7	VBN	VBD	Previous tag is *NNP*
8	VBD	VBN	Previous tag is *VBD*
9	VBP	VB	Previous tag is *TO*
10	POS	VBZ	Previous tag is *PRP*

Experiments



Corpus	Accuracy
Penn WSJ	96.6%
Penn Brown	96.3%
Orig Brown	96.5%

Summary

Properties

- Existence of initial annotator
- Existence of current label: those labels are updated in each iteration.
- Sequence labeling
- Features can refer to the current label of **any** token in the sequence.

Strengths of TBL

- TBL is very different from other learners covered so far:
  - Existence of initial annotator.
  - Transformations are applied in sequence
  - Results of previous transformations are visible to following transformations.
  - Existance of current label ➔ It can handle dynamic problems well.
- TBL is more than a classifier
  - Classification problems: POS tagging
  - Other problems: e.g., parsing
- TBL performs well because it minimizes (training) errors directly.

Weaknesses of TBL

- Learning can be expensive ➔ various methods

- TBL is not probabilistic, and it cannot produce topN hypotheses or confidence scores.

Hw9

Hw9

- Task: the text classification task

- Transformation:

```
if feat is present in the document
    then change from class1 to class2

if (feat is present) && (CurLabel == class1)
   then set CurLabel=class2
```

Q1: TBL trainer

- TBL_train.sh train_data model_file min_gain

  if net_gain < min_gain

  then do not keep the transformation

- The format of model_file:

  init_class_name

  featName from_classname to_classname net_gain

  ….

- Ex:

  guns

  talk guns mideast 89

Q2: TBL decoder

- TBL_classify.sh test_data model_file sys_output > acc

- The format of sys_output:

  instanceName trueLabel SysLabel rule1 rule2 ….

  rule has the format: featName from_class to_class

- Ex:

  file1 guns mideast we guns misc talk misc mideast