Pairwise Webpage Coreference Classification using Distant Supervision

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Introduction

A person or other entity is often associated with multiple URL endpoints on the web

- Barack Obama ⇔ `https://barackobama.com/` and `https://en.wikipedia.org/wiki/Barack_Obama`
- Donald Trump ⇎ `https://twitter.com/realDonaldTrump` and `https://www.instagram.com/ivankatrump`

Motivates the task of **webpage coreference classification** for a given entity!

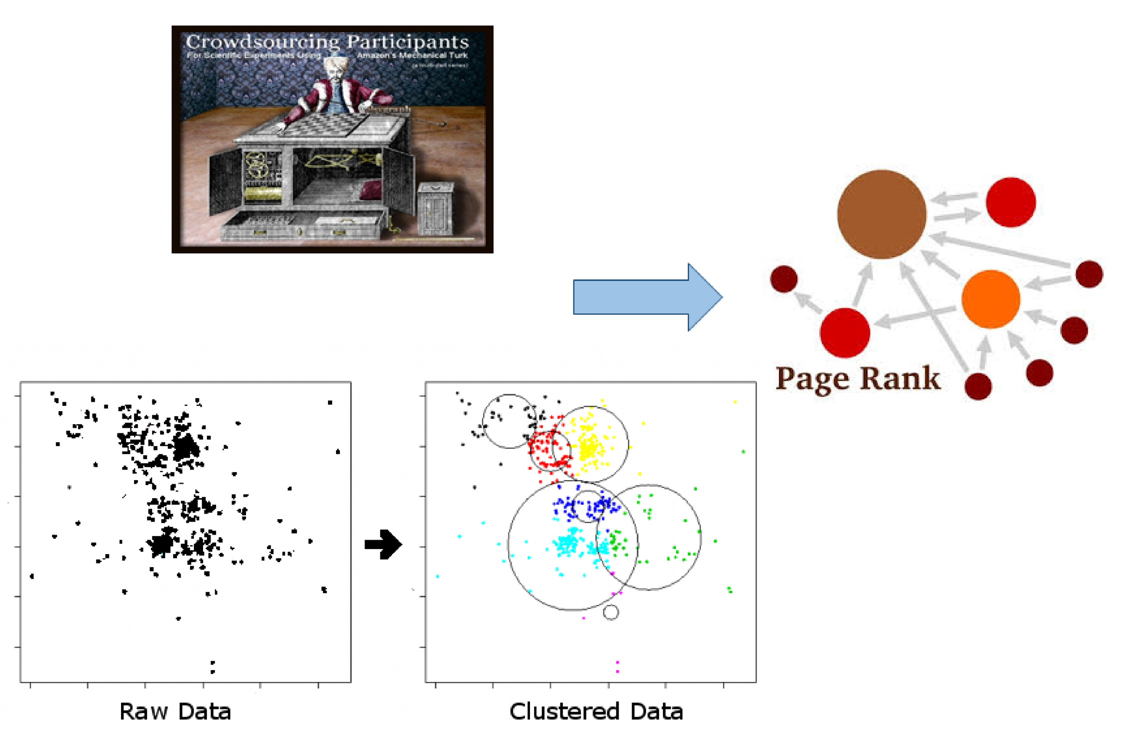
Problem Setup

- We assume access to web KBs based on automatic crawling
  - social networks (e.g. `facebook.com/*`), news aggregation endpoints (e.g. `nytimes.com/topic/person/*`) and organisation directories (e.g. `www.gtlaw.com/People/*`)
- Given a training dataset D with pairs of web URLs
  - Initially all the pairs are unlabeled ($D_u \leftarrow D$, $D_p, D_n = \phi$)
  - Learn a model $f(\phi(U_i, U_j)) \rightarrow y$, for URL pair U_i and U_j
  - Target $y \in \{0, 1\}$

Distant Supervision

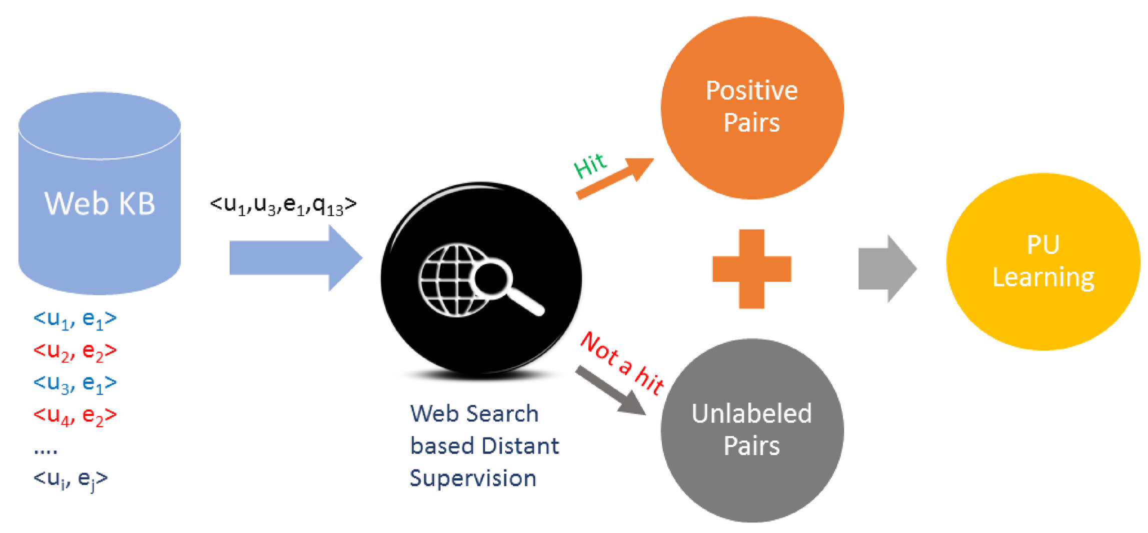
To strike a balance between unsupervised and supervised methods that require annotated data

- We obtain positive examples using web-search-based distant supervision
- Search query George Clinton AND P-Funk fetches `https://en.wikipedia.org/wiki/George_Clinton_(musician)`
  - But not `http://www.biography.com/people/george-clinton-537674`
- We build a positive and unlabelled (PU) learning model



Proposed Approach

- We generate queries for URL pairs that share same entity name
- Employ a label propagation technique to expand the set of positive examples



- Any binary classifier can be trained on the expanded labeled set

Query Generation

- We construct web search queries for distant supervision as follows:
  - Q_i: Using the target entity name and context information from U_i
  - Q_j: Similar to the above, we generate context information from U_j.
- E.g., for URL pairs: `www.imperial.ac.uk/people/f.allen` and `https://www.linkedin.com/in/franklin-allen-0557906` a query constructed is *"Franklin Allen Brevan Howard Centre"*

Initialize Labels

- For each query in Q_i, we check to see if U_j is present in the top-K search results S_{ij}
- Conversely if U_i is present in the top-K results, S_{ji} for each query in Q_j
  - $[\exists q \in Q_i, \quad \exists S_{ji} \mid U_j \in S_{ji} \vee \exists q \in Q_j, \quad \exists S_{ij} \mid U_i \in S_{ij}] \implies \hat{y}_{ij} = 1$
  - $D_p \leftarrow D[\hat{y}_{ij} = 1]$, $D_u \leftarrow D_u \setminus D[\hat{y}_{ij} = 1]$.

Labelling Unlabelled Pairs

- Step 1: Randomly select N instances from D_p, and hold them out in S_p.
- Step 2: Train a binary classifier θ, taking $D'_p = D_p \setminus S_p$ as positive instances and D_u as negative instances.
- Step 3: $\mu_p = \frac{1}{|S_p|} \sum_{i:S_p} p(x_i = 1|\theta)$, (using Platt scaling)
  - $D^*_p = x_u \in D_u : p(x_u = 1) > \mu_p$.
  - $D_p \leftarrow D_p \cup D^*_p$, $D_n \leftarrow D_u \setminus D^*_p$

Datasets

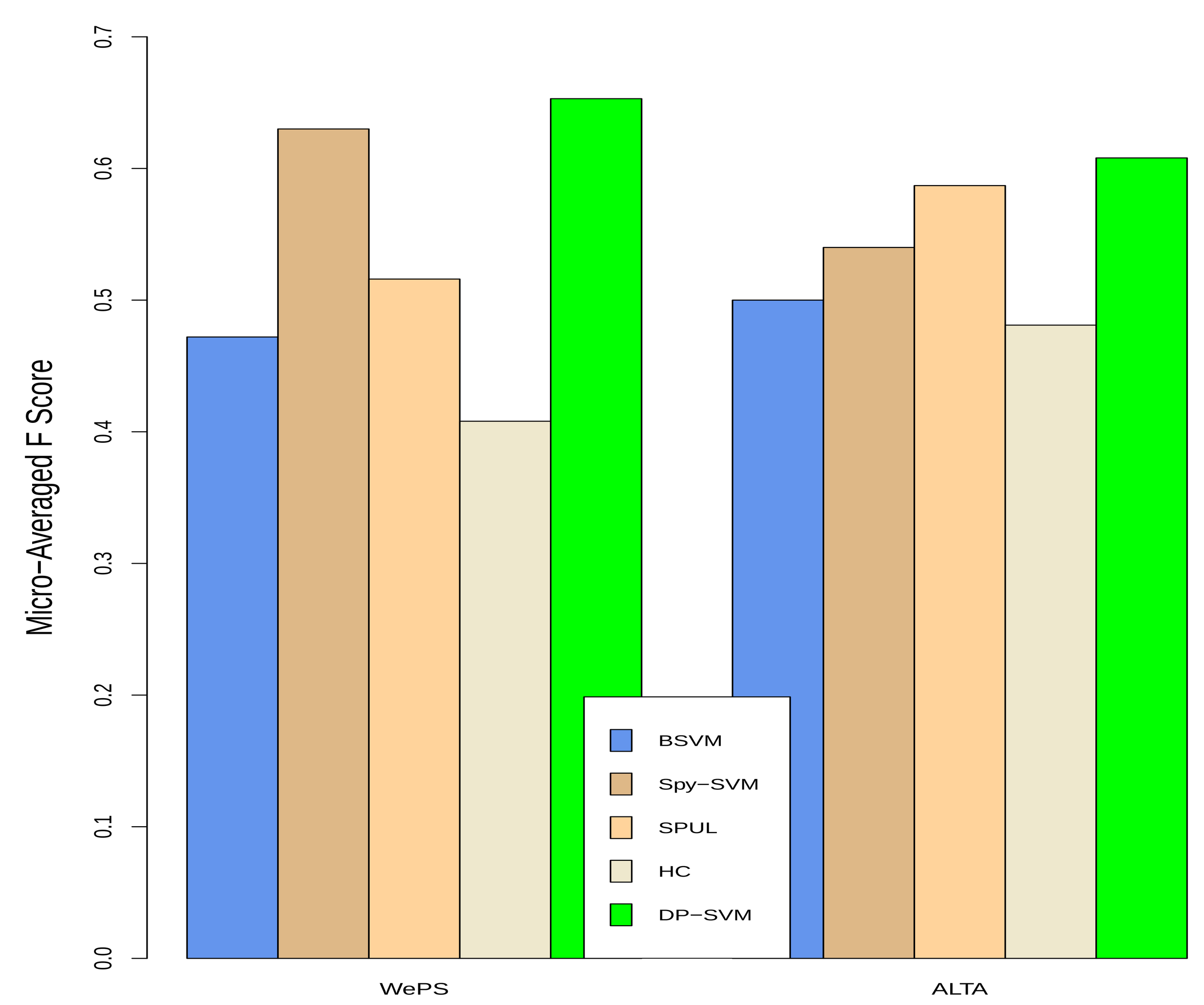
- SemEval-2007 WePS development set
  - Balanced 1000 end-point URL-pairs dataset from webpages for 49 people.
- ALTA-2016 shared task dataset
  - Balanced 400 end-point URL-pairs dataset that can refer to any entity

Feature Representation

- Structural features such as document length difference, URL path length difference
- Semantic features such as unigram cosine similarity, cosine similarity over an average word-level word2vec representation, machine translation scores (BLEU, METEOR, TER)

Experimental Results

- Baselines
  - Hierarchical Clustering (HC) - Unsupervised Approach
  - Biased SVM (BSVM) with costs for positive and negative classes
  - Spy-SVM (B. Liu et. al., ICML 2002)
  - SPUL (C. Elkan et. al., KDD 2008)
- Proposed Approach
  - DP-SVM (Linear Kernel SVM built using propagated distant labels)



Conclusions

- Approach to determining whether two endpoint URLs refer to the same entity.
- Two key contributions:
  - use of distant supervision
  - application of PU Learning to the task