

Introduction

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

- ▶ Barack Obama \Leftrightarrow barackobama.com/ and en.wikipedia.org/wiki/Barack_Obama
- ▶ Donald Trump \nLeftrightarrow twitter.com/realDonaldTrump and [instagram.com/ivankatrump](https://www.instagram.com/ivankatrump)

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

Problem Setup

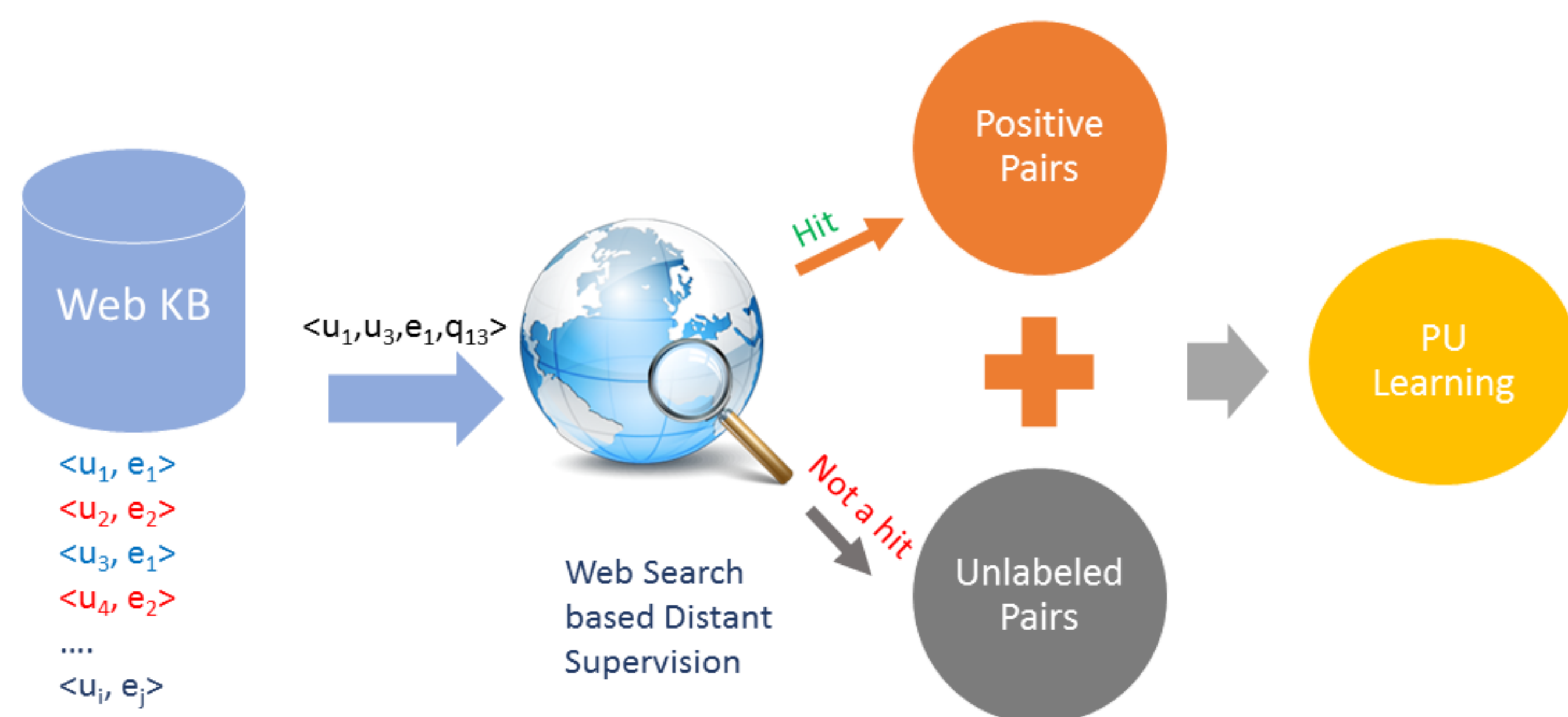
- ▶ We assume access to web KBs based on automatic crawling
 - ▶ social networks (e.g. [facebook.com/](https://www.facebook.com/)), news aggregation endpoints (e.g. [nytimes.com/topic/person/](https://www.nytimes.com/topic/person/)) and organisation directories (e.g. [gtlaw.com/People/](https://www.gtlaw.com/People/))
- ▶ 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

- ▶ We obtain positive examples using web-search-based distant supervision
- ▶ Search query George Clinton AND P-Funk fetches [en.wikipedia.org/wiki/George_Clinton_\(musician\)](https://en.wikipedia.org/wiki/George_Clinton_(musician))
 - ▶ But not [biography.com/people/george-clinton-537674](https://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: imperial.ac.uk/people/f.allen and [linkedin.com/in/franklin-allen-0557906](https://www.linkedin.com/in/franklin-allen-0557906) a query constructed is "Franklin Allen Brevan Howard Centre"

Label Propagation using Distant Supervision

- ▶ 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
 - ▶ $[\exists q \in Q_i, \exists S_{ji} \mid U_j \in S_{ji} \vee \exists q \in Q_j, \exists S_{ij} \mid U_i \in S_{ij}] \implies \hat{y}_{ij} = 1$
 - ▶ $D_p \leftarrow D[\hat{y}_{ij} = 1], D_u \leftarrow D_u \setminus D[\hat{y}_{ij} = 1]$.

Expand Positive Labeled Set:

- ▶ 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

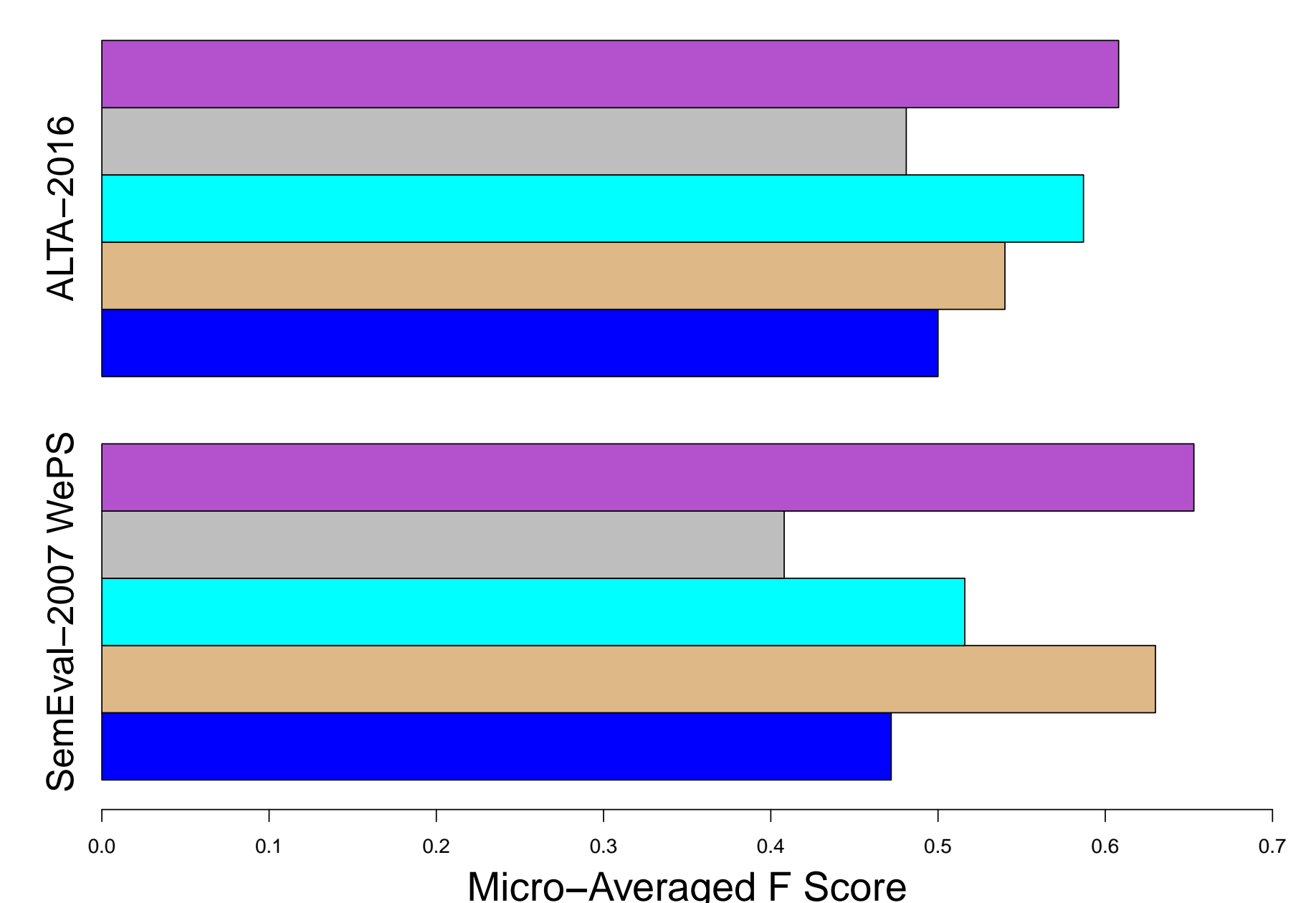
- ▶ SemEval-2007 WePS development set
 - ▶ Balanced 1000 end-point URL-pairs dataset from webpages for 49 people.
- ▶ ALTA-2016 shared task dataset
 - ▶ Balanced 400 end-point URL-pairs dataset that can refer to any entity

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

- ▶ Benchmark Approaches
 - ▶ 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)
 - ▶ Hierarchical Clustering (HC) - Unsupervised Approach
- ▶ 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