Stacking With Auxiliary Features (SWAF)

Nazneen Fatema Rajani and Ray Mooney

nrajani@cs.utexas.edu and mooney@cs.utexas.edu

Dept. of Computer Science at the University of Texas at Austin

INTRODUCTION

- Stacking (Wolpert, 1992) is a well known **ensembling** algorithm
- However, it does not adequately discriminate between **base systems** and **input instances**
- Stacking With Auxiliary Features (SWAF) integrates information from multiple sources
- Auxiliary Features enable the stacker to leverage relevant information to improve prediction
- We use two types of auxiliary features :
    - Instance features – enable the stacker to discriminate across instances
    - Provenance features – enable the stacker to discriminates across base systems

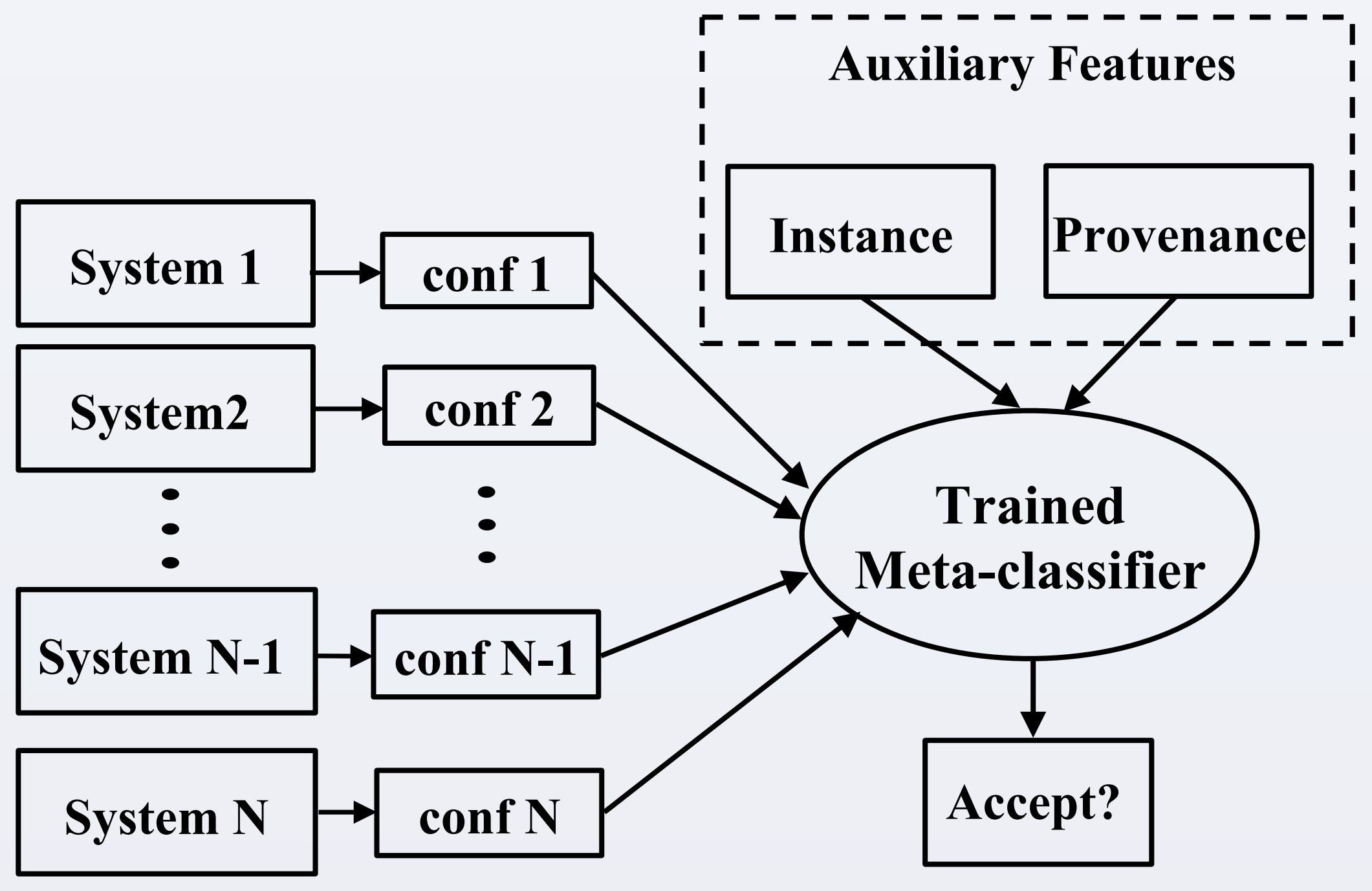
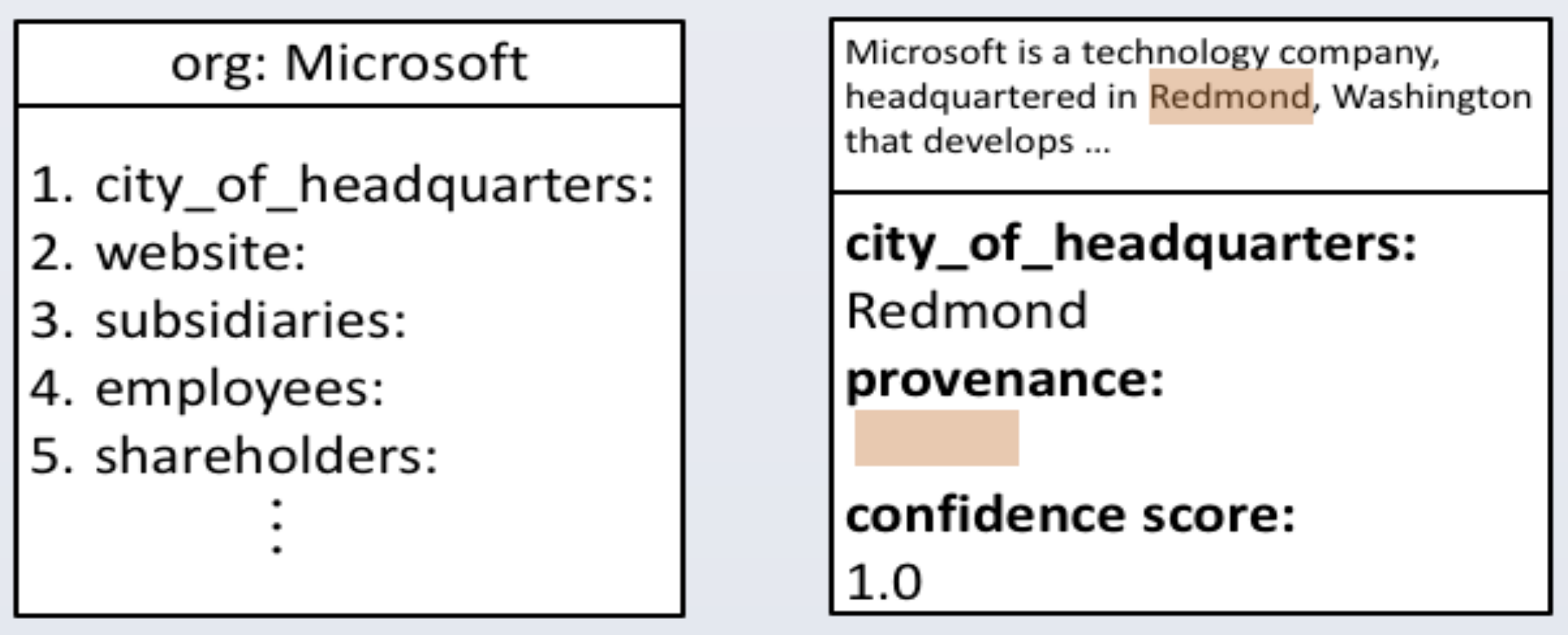


Figure 1: Our stacking approach to combining system outputs using confidence scores and two types of auxiliary features for improving prediction

TASK OVERVIEW

- We demonstrate SWAF on three very different machine learning problems
- Two of them are in NLP and third is a well known computer vision problem

Slot Filling (SF)



org: Microsoft

1. city_of_headquarters:
2. website:
3. subsidiaries:
4. employees:
5. shareholders:

⋮

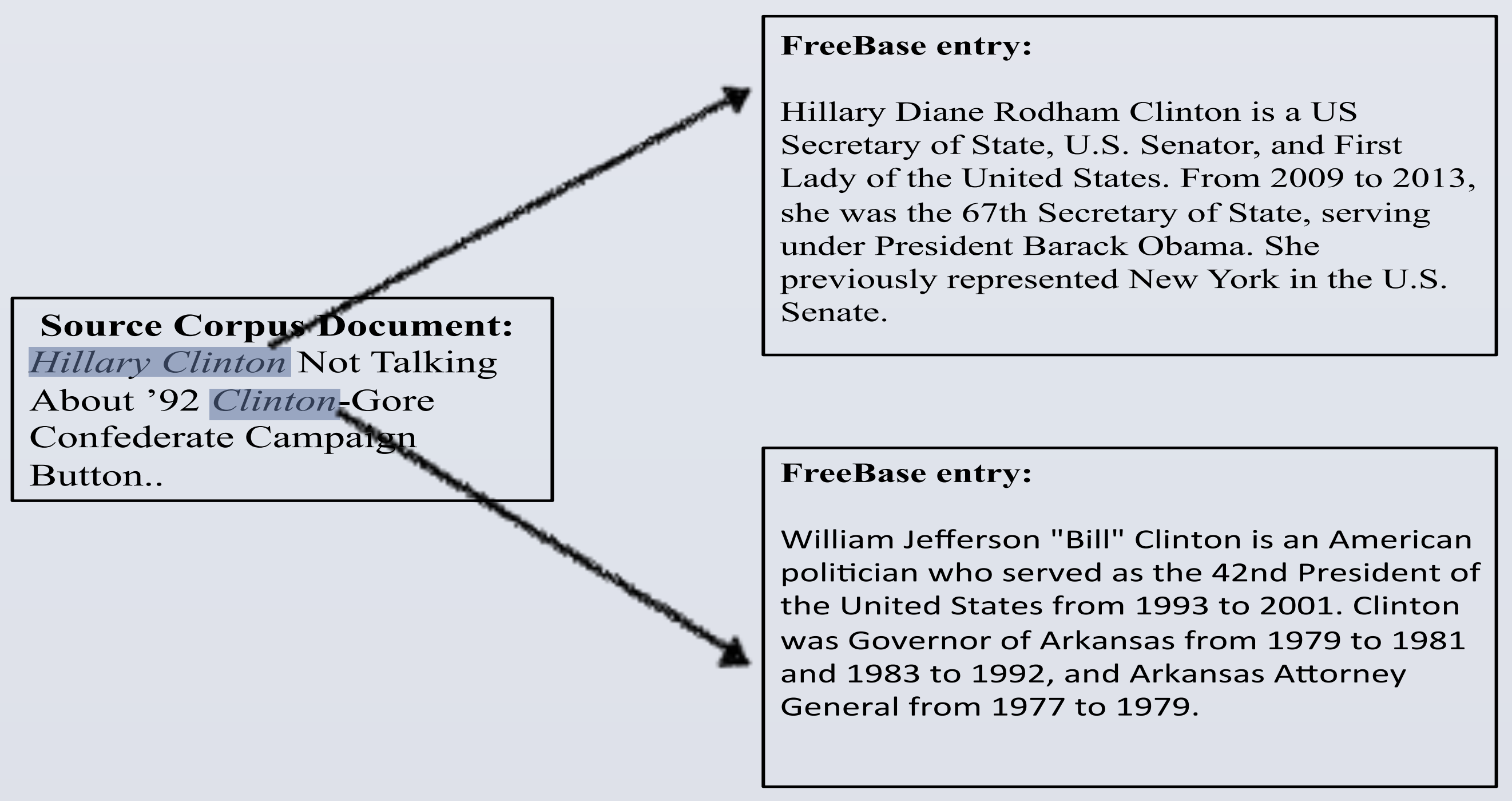
Microsoft is a technology company, headquartered in Redmond, Washington that develops ...

city_of_headquarters:
Redmond
provenance:

confidence score:
1.0

Figure 2: SF involves building a Knowledge Base (KB) from scratch using pre-defined slots. Systems provide confidence score and provenance

Entity Discovery and Linking (EDL)



Source Corpus Document:
Hillary Clinton Not Talking About '92 *Clinton*-Gore Confederate Campaign Button..

FreeBase entry:

Hillary Diane Rodham Clinton is a US Secretary of State, U.S. Senator, and First Lady of the United States. From 2009 to 2013, she was the 67th Secretary of State, serving under President Barack Obama. She previously represented New York in the U.S. Senate.

FreeBase entry:

William Jefferson "Bill" Clinton is an American politician who served as the 42nd President of the United States from 1993 to 2001. Clinton was Governor of Arkansas from 1979 to 1981 and 1983 to 1992, and Arkansas Attorney General from 1977 to 1979.

Figure 3: EDL involves detecting entity mentions in a corpus and linking them to an English KB (FreeBase). Systems provide confidence score and provenance

ImageNet Object Detection

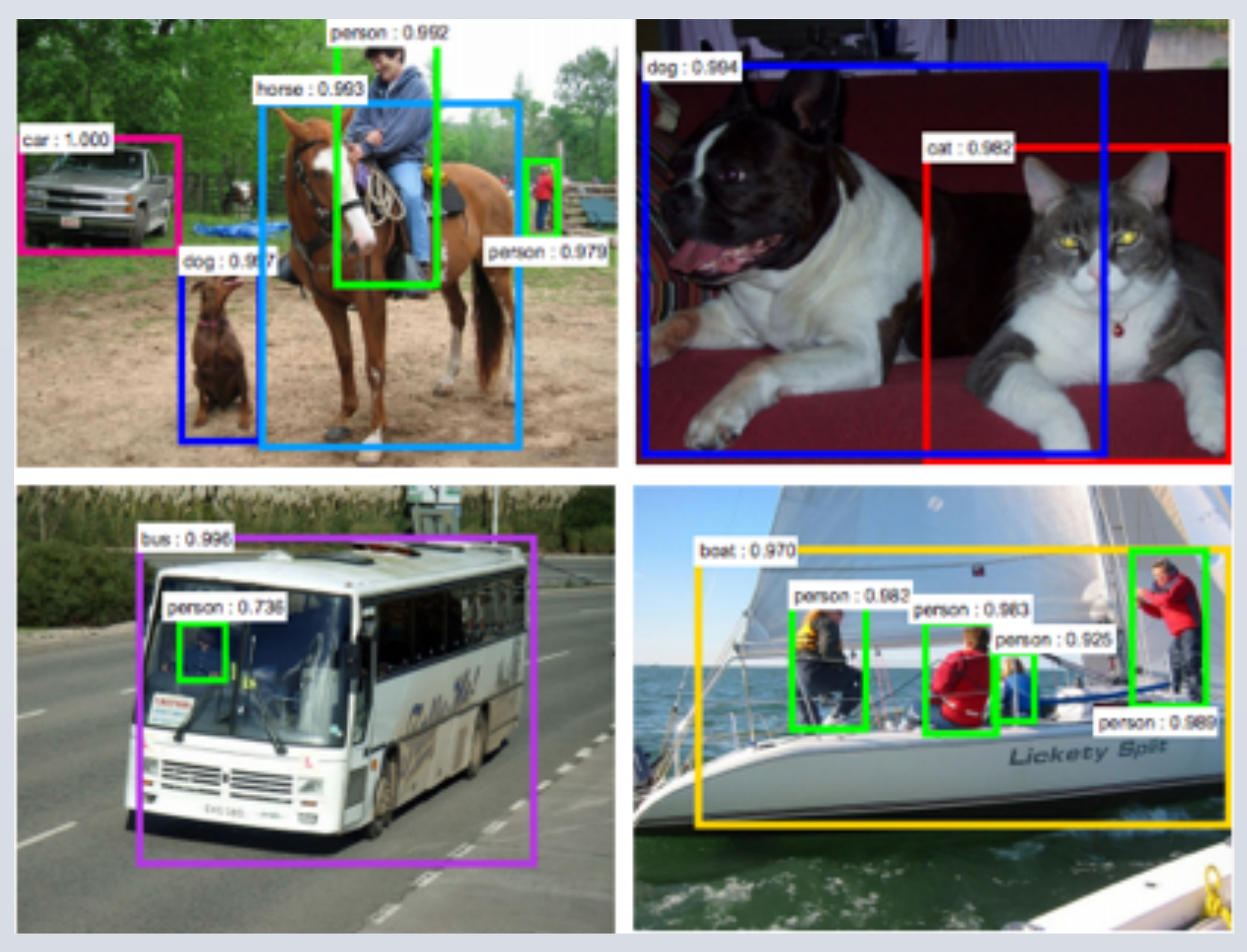


Figure 4: Detect all instances of object categories (total 200) in images and localize using bounding boxes

AUXILIARY FEATURES

Instance Features

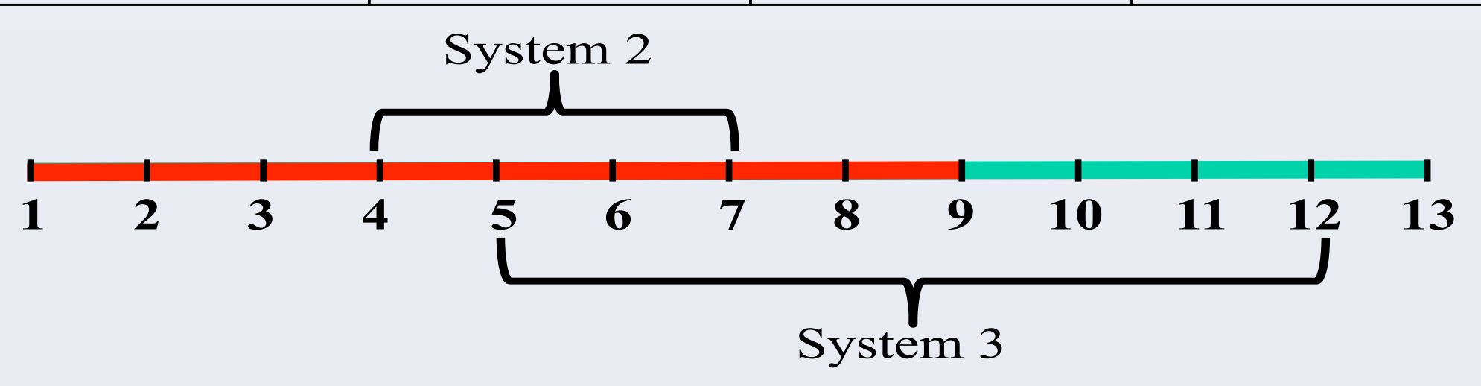
- Enables the stacker to discriminate between **input instance types**
- The intuition is that some systems are **better** at certain inputs that other systems
- **Information** about the input type would allow the classifier to make a better prediction
- Slot Filling – slot type (per: age, org: headquarters)
- Entity Detection and Linking – entity type (PER, ORG, GPE)
- Object Detection – object category (200) and VGGNet's *fc7* features

Provenance Features

- Enables the stacker to discriminate between **component systems**
- The intuition is that output is **reliable** if systems agree on the source or provenance
- **Information** about provenance or source of the output would allow the classifier to make a better prediction
- Slot Filling :-

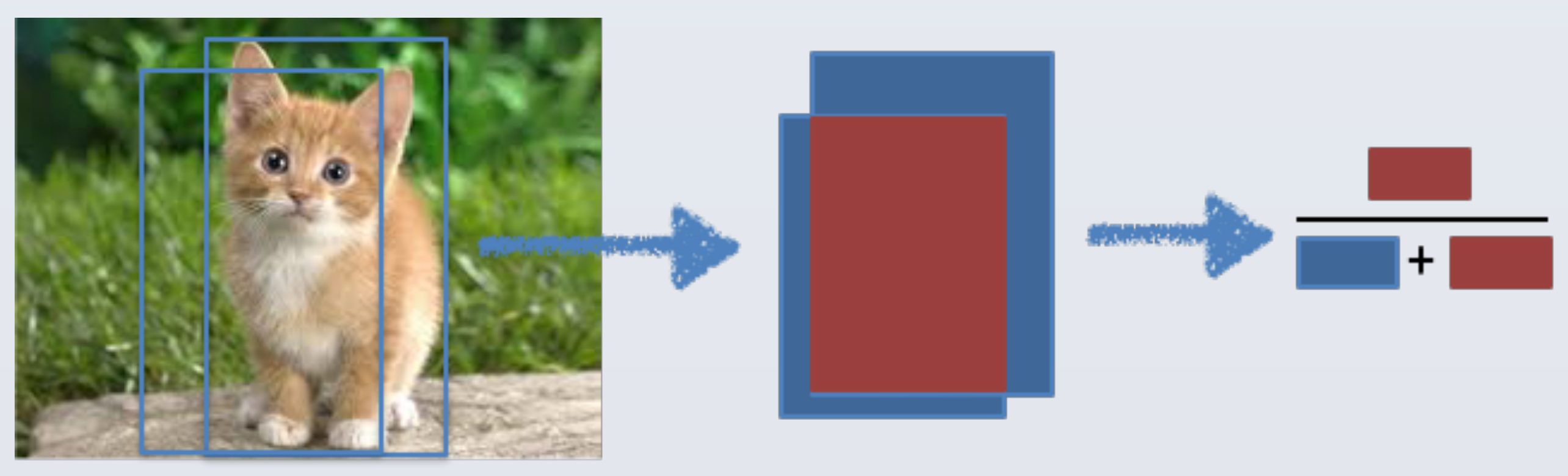
1. Document provenance – For a given query and slot, for each system, *i,* there is a feature Dp_i :
    - *N* systems provide a fill for the slot.
    - Of these, *n* give same provenance *docid* as *i*.
    - $DP_i = n/N$ is the document provenance score.
2. Offset provenance - Degree of overlap between systems' provenance strings. Uses Jaccard similarity coefficient.

Offsets	System 1	System 2	System 3
Start Offset	1	4	5
End Offset	9	7	12



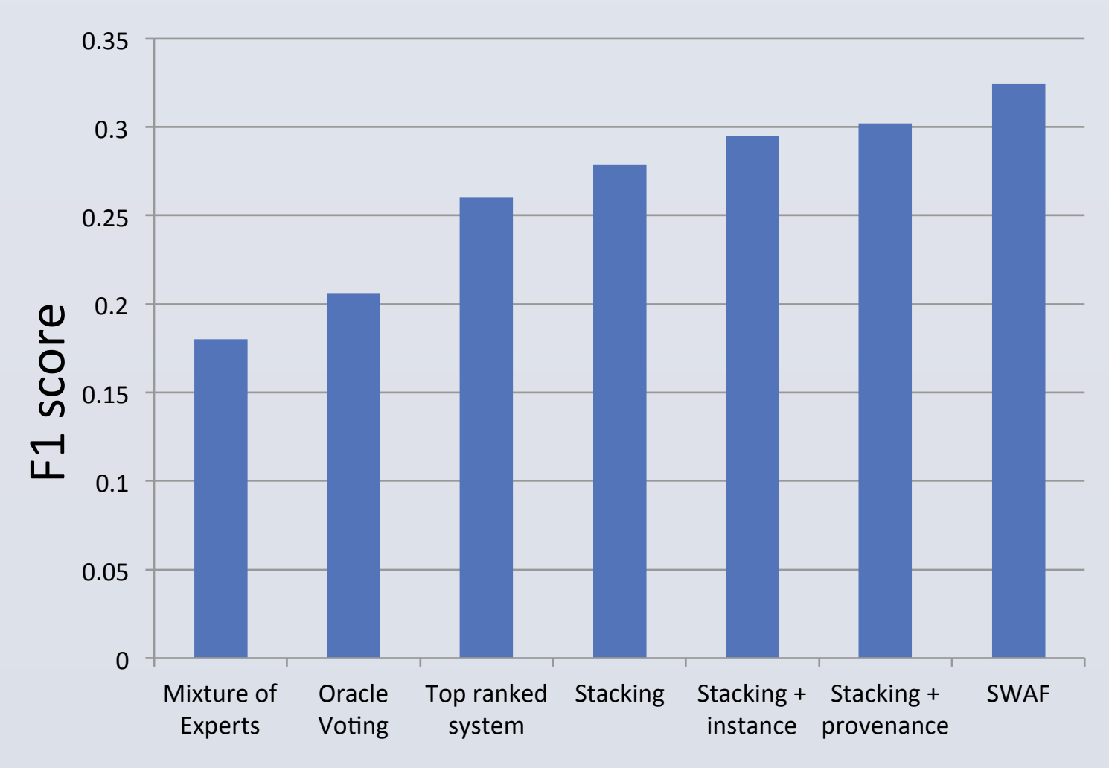
$$OP_1 = \frac{1}{2}\times\left(\frac{4}{9}+\frac{5}{12}\right)$$

- Entity Detection and Linking (EDL) :- Same as Slot Filling using the entity mention as provenance
- Object Detection :- Bounding box overlap measured using Jaccard similarity coefficient

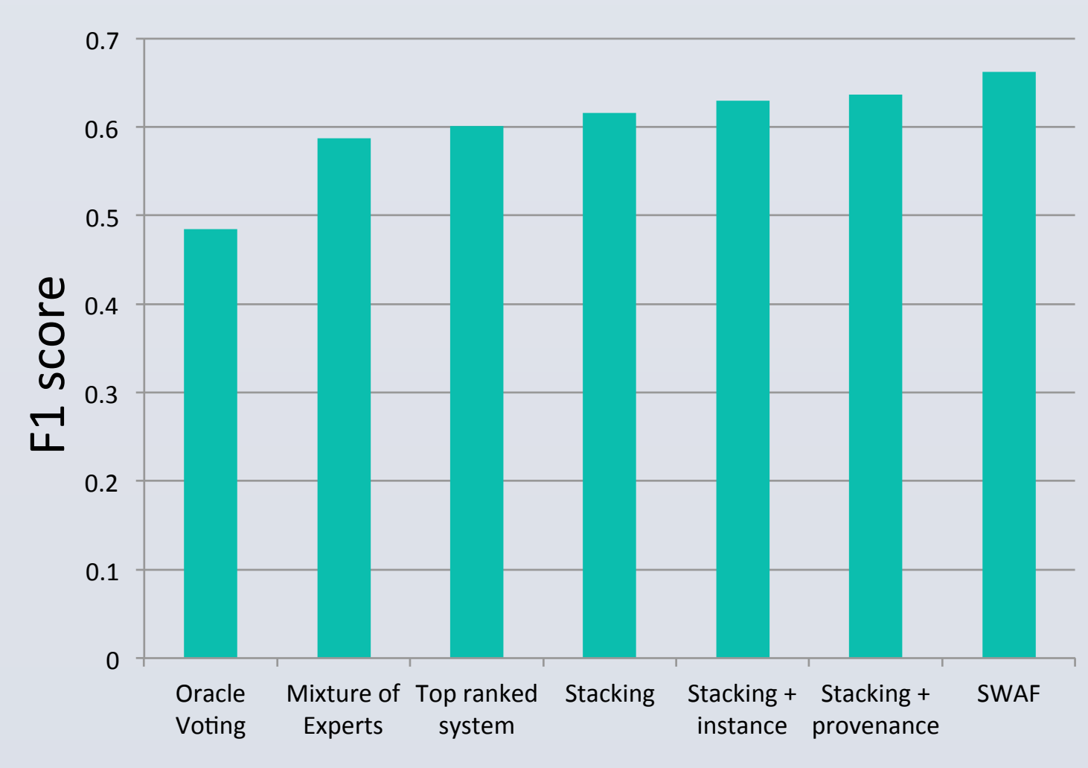


RESULTS

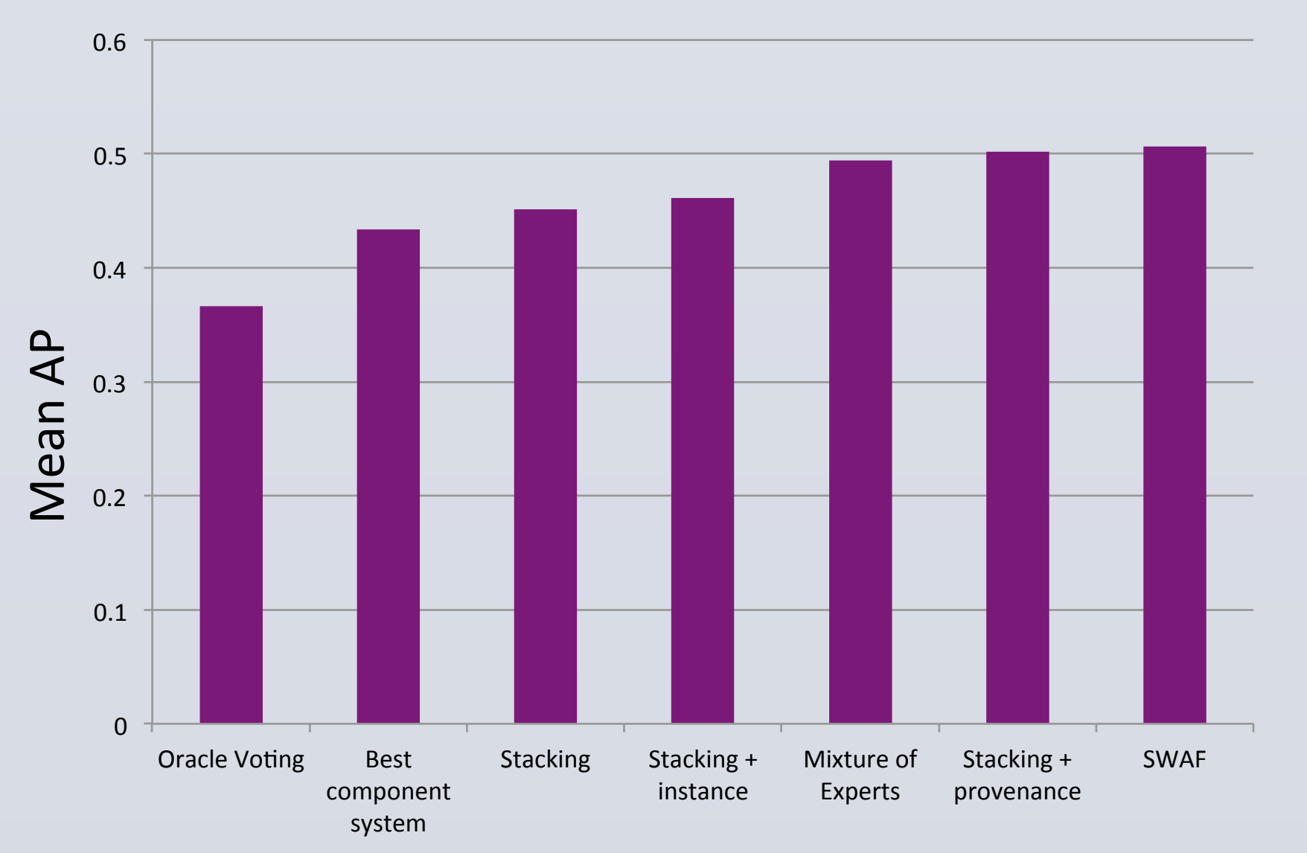
Slot Filling



Entity Discovery and Linking



ImageNet Object Detection


Mean AP
Oracle Voting
Best component system
Stacking
Stacking + instance
Mixture of Experts
Stacking + provenance
SWAF