

# Autonomously Reviewing and Validating the Knowledge Base of a Never-Ending Learning System

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# Outline

- 1 Introduction
- 2 Motivation
- 3 Proposed Work
- 4 Experiments
- 5 Conclusion

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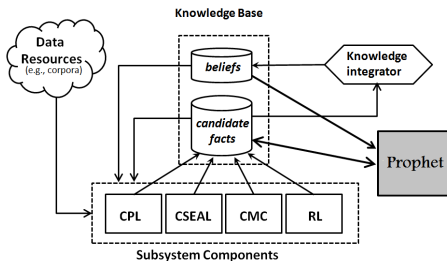
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# NELL (Never-Ending Language Learner)

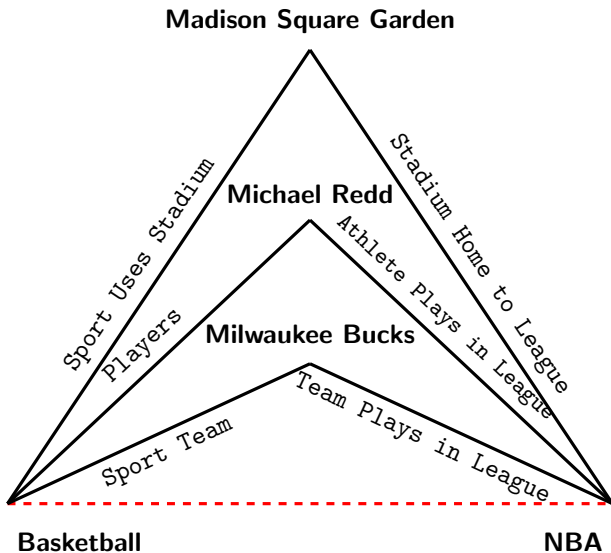
- A computer system that runs 24/7;
- Gather knowledge from web pages to acquire knowledge to become a *better learner* each day;
- The content available on the web is not always reliable - can lead a false beliefs propagation because of noisy data;
- Part of the knowledge extracted by NELL should be supervised by humans to be incorporated definitely in KB.

# Prophet

- Implements link prediction on NELL to **finding** new relations in the NELL's KB and **identifying** the anomalies, → misplaced edges
- The relations and categories extracted by NELL are mapped as an ontology → complex network
- Use graph properties to investigate if the knowledge learned by NELL is correct or not.



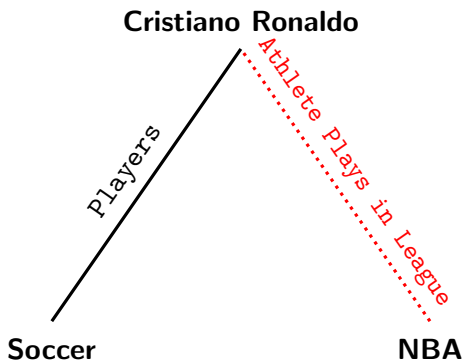
# Prophet Example



# Prophet Rules

- R12a(sport, sportsleague):- players(sport, athlete),  
athletheplaysinleague(athlete, sportsleague),  
numberof(athlete)  $\geq$  10;
- R12b(sport, sportsleague):- sportteam(sport, sportsteam),  
teampaysinleague(sportsteam, sportsleague),  
numberof(sportsteam)  $\geq$  10;
- R12c(sport, sportsleague):- sportusesstadium(sport,  
stadiumeventvenue),  
stadiumhometoleague(stadiumeventvenue, sportsleague),  
numberof(stadiumeventvenue)  $\geq$  10
- R12d(sport, sportsleague):- players(sport, athlete),  
athletheplaysinleague(athlete, sportsleague),sportteam(sport,  
sportsteam), teampaysinleague(sportsteam, sportsleague),  
sportusesstadium(sport, stadiumeventvenue),  
stadiumhometoleague(stadiumeventvenue, sportsleague);

# Prophet Misplaced Edges



When *Prophet* identifies an outliers, it means that the its algorithm was able to determine a new rule but there are a few instances that do not match all the requirements of rule found by *Prophet* → **misplaced edges**.



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# Motivation

There are two possible scenarios for the anomalies:

- at least one relation (edge) in the anomaly should be wrong
- the two rules are right but because of combination made by *Prophet* the relation predicted is wrong

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The information gathered by *Prophet* could be just sent to human supervision. But we want to take:

- best profit from these anomalies
- advantage human opinion through Web communities thus configuring a self-supervision approach

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# *Prophet* + *SS-Crowd*

## Problem Description

How Conversing Learning techniques can be used to help reviewing and validating facts that were learned by NELL and were flagged as possible mistakes by *Prophet*.

# Prophet + SS-Crowd

## Problem Description

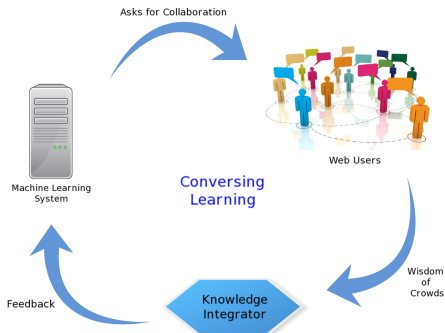
How Conversing Learning techniques can be used to help reviewing and validating facts that were learned by NELL and were flagged as possible mistakes by *Prophet*.

## Proposed Work

A method to combine the knowledge gathered from web communities through the *SS-Crowd* component with the outliers identified by *Prophet*, i.e., use web QA users opinion to validate the anomalies.

# Conversing Learning

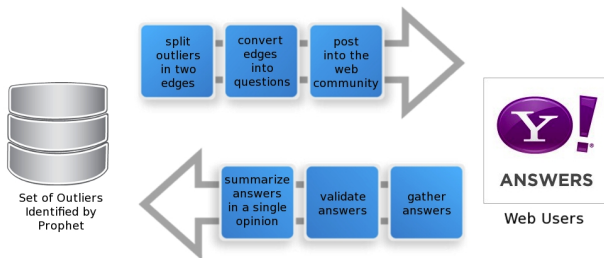
- Based on Active Learning and Interactive Learning
- Allow machines to convert knowledge into content understandable by humans
- Autonomously ask people to take part in the knowledge acquisition and labelling process



# Reaching web users assessment through SS-Crowd

The proposed approach can be summarized by the following steps:

- Converting KB's facts into human understandable sentences;
- Generating questions that will prompt users to decide whether the facts are correct or not;
- Receiving all the answers for an specific question;
- Combining the answers to produce a single result;
- Returning to *Prophet* that will use it as a parameter to create or not a new link in NELL's KB.





# Experiment with SS-Crowd

- Edges of an outlier identified by Prophet
  - TeamPlaysSport(Manchester United, basketball)
  - TeamWonTrophy(Manchester United, UEFA Champions League)
- Edges converted into human understandable questions:
  - Manchester United is a team that plays sport basketball
  - Manchester United is a team that won trophy UEFA Champions League:

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- Expectation:
  - At least one of the edges is wrong, confirming the health of outliers identification algorithm.

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# Experiments Set up

- We used NELL's KB at the 100th iteration → undirected graph 9,419 nodes and 24,132 edges.;
- We ran *Prophet* that found new rules and instances and misplace edges;
- all misplaced edges were sent to *SS-Crowd* to start the human assessment process;

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**Table :** Distribution of the relations considered in our tests

Relations	# of outliers	# of answers
AthletePlaysInLeague & Players	9	72
TeamPlaysSport & TeamPlaysInLeague	20	144
TeamPlaysSport & TeamWonTrophy	53	386

# Results

The rate of outliers with at least one wrong edge indicates the health of the anomalies detection algorithm;

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**Table :** Numbers for edges evaluated as suitable or not to the real world through the web community eyes.

Outliers	
at least one wrong edge	39 (47.56%)
both edges correct	40 (48.19%)
unresolved edges	3 (03.65%)

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  - Manchester United is a team that won trophy UEFA Champions League:
- Both relations are right!!

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- Edges converted into human understandable questions:
  - Manchester United is a team that plays sport basketball;
  - Manchester United is a team that won trophy UEFA Champions League:
- Both relations are right!!
- Manchester United is a basketball team and also a soccer team
- NELL was not successful to decide which one it should chose;

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# Conclusion

- The results obtained in the performed experiments have shown that the combination of *Prophet* and *SS-Crowd* allows a never-ending learning system - NELL - to identify which edges are really wrong and which edges needs more time (NELL iterations) to fill the gaps on information to be considered valid.
- The experiments show that *Prophet* has a great accuracy.
- Most of the combination of edges that produce a misplaced connection are related to a co-reference problem restricted to NELL and is not a misbehaviour of *Prophet* itself.
- The validation of a learning machine with *SS-Crowd* is a useful approach to help self-supervision and self-revision in NELL.

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