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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1. Introduction
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3. Proposed Work
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5. Conclusion
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 Rules

- **R12a**(sport, sportsleague):- players(sport, athlete), athleteplaysinleague(athlete, sportsleague), numberof(athlete) $\geq$ 10;

- **R12b**(sport, sportsleague):- sportteam(sport, sportsteam), teamplaysinleague(sportsteam, sportsleague), numberof(sportsteam) $\geq$ 10;

- **R12c**(sport, sportsleague):- sportusesstadium(sport, stadiumoreventvenue), stadiumhometoleague(stadiumoreventvenue, sportsleague), numberof(stadiumoreventvenue) $\geq$ 10

- **R12d**(sport, sportsleague):- players(sport, athlete), athleteplaysinleague(athlete, sportsleague), sportteam(sport, sportsteam), teamplaysinleague(sportsteam, sportsleague), sportusesstadium(sport, stadiumoreventvenue), stadiumhometoleague(stadiumoreventvenue, sportsleague);
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.
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 two rules are right but because of combination made by *Prophet* the relation predicted is wrong

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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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

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.

![Diagram](image)
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:
Experiment with SS-Crowd

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- Edges converted into human understandable questions:
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- Expectation:
  - At least one of the edges is wrong, confirming the health of outliers identification algorithm.
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;

<table>
<thead>
<tr>
<th>Relations</th>
<th># of outliers</th>
<th># of answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>AthletePlaysInLeague &amp; Players</td>
<td>9</td>
<td>72</td>
</tr>
<tr>
<td>TeamPlaysSport &amp; TeamPlaysInLeague</td>
<td>20</td>
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**Table**: Distribution of the relations considered in our tests

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Results

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

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<th>Numbers for edges evaluated as suitable or not to the real world through the web community eyes.</th>
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<tr>
<td>Outliers</td>
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<td>at least one wrong edge</td>
<td>39 (47.56%)</td>
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<td>40 (48.19%)</td>
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- Edges converted into human understandable questions:
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- Both relations are right!!
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  - TeamPlaysSport(Manchester United, basketball)
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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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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 need 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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