Guardian: Evaluating Trust in Online Social Networks with Graph Convolutional Networks

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Almost 4.57 billion people were active internet users as of April 2020.

— Statista
Social trust is the basis of online social networks.
Estimates of social trust help indicate to what extent a user could expect someone else to perform given actions, therefore has many applications, such as trust-based recommendations.
Network graph: an example
Can A trust E? And, to what extent?
Large-scale
Wait a second ...
Graph convolutional neural networks — an efficient variant of convolutional neural networks on graphs.
Representation learning with graph convolutional networks
The complexity of model parameters are independent of the input graph size.
Preliminaries: trust properties
Asymmetry: one user may trust someone else more than she is trusted back.

Trust properties
**Propagative nature**: trust may be passed from one user to another, creating chains of social trust that connects two users who are not connected.
Composable nature: trust needs to be aggregated if several chains of social trust exit.
An effective way of evaluating trust should be able to capture these trust properties simultaneously.
Guardian: an end-to-end learning framework for social trust evaluation.
Embedding layer

We use a pre-trained embedding layer that maps each user into a vector.
Two types of trust interactions: 

**popularity trust** and **engagement trust**
Popularity trust: the overall trust of a user endorsed by others (accumulated from the incoming links)
Engagement trust: the willingness of a user to trust others (accumulated from the outgoing links)
Two types of trust aggregation
Trust convolutional layer

To capture the **composable and asymmetric nature** of trust
Stack multiple trust convolutional layers

To capture the propagative nature of trust
Prediction layer
Our experimental results...
Datasets Used

Advogato and Pretty-Good-Privacy (PGP) adopt the concept of the “web of trust”, and both contain four different levels of trust.

<table>
<thead>
<tr>
<th>DATASET</th>
<th># OF NODES</th>
<th># OF EDGES</th>
<th>AVG. DEGREE</th>
<th>DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADVOGATO</td>
<td>6,541</td>
<td>51,127</td>
<td>19.2</td>
<td>4.82</td>
</tr>
<tr>
<td>PGP</td>
<td>38,546</td>
<td>317,979</td>
<td>16.5</td>
<td>7.7</td>
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</table>
# Accuracy

## Evaluation Accuracy on Advogato

<table>
<thead>
<tr>
<th>APPROACHES</th>
<th>F1-SCORE</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Guardian</strong></td>
<td>74.3%</td>
<td>0.082</td>
</tr>
<tr>
<td><strong>NEURALWALK</strong></td>
<td>74.0%</td>
<td>0.081</td>
</tr>
<tr>
<td><strong>OPINIONWALK</strong></td>
<td>64.3%</td>
<td>0.228</td>
</tr>
<tr>
<td><strong>MATRI</strong></td>
<td>65.6%</td>
<td>0.127</td>
</tr>
</tbody>
</table>
Accuracy

Evaluation Accuracy on PGP

<table>
<thead>
<tr>
<th>Approaches</th>
<th>F1-Score</th>
<th>MAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guardian</td>
<td>87.1%</td>
<td>0.083</td>
</tr>
<tr>
<td>NEURALWALK</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>OPINIONWALK</td>
<td>67.3%</td>
<td>0.249</td>
</tr>
<tr>
<td>Matri</td>
<td>68.3%</td>
<td>0.122</td>
</tr>
</tbody>
</table>
Efficiency

![Efficiency Graph](image)

- Guardian
- NeuralWalk
- OpinionWalk
- Matri

Wall-Clock Time (s)

- Advogato
- PGP
Scalability

Time vs. # of pairs
Scalability

Time vs. # of users
Guardian is an end-to-end learning framework, that can achieve the best possible performance for social trust evaluation in online social networks.
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