Joint point process models and recurrent neural networks for sequential recommendations and time prediction

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Introduction

Recurrent Neural Network (RNN):

- Feedback loops allow model to retain information of previous input.
- Typically fed sequence data with inter-item dependencies.
- Used to achieve state of the art results in many NLP and audio related problems.
- Recently shown promise in the field of session-based recommendation [1].

Point Process:

- Well-established concept from statistical theory.
- Probabilistic distribution of point in underlying mathematical space.
- Distributed according to probability distribution.

Our proposal:

- Joint model based on RNN and point process that performs recommendation and return time prediction.
- RNN is used to recommend next item based on previous choices.
- RNN is also used for inter-session modeling, which is used to assist both recommendation and time prediction.

Model

We propose a Temporal Hierarchical RNN (THRNN) based on the work done in [2]. The hierarchical RNN is extended with a point process and shares factors with one of the RNN layers. The point process is inspired by [3], and used to model time between sessions as opposed to choices.

Hierarchical RNN:

- Two highly coupled RNN layers.
- Intra-session RNN:
  - Fed with user choices and outputs item scores for recommendation.
  - The final output of full session is stored as a session representation.
- Inter-session RNN:
  - Fed with session representations along with session contexts.
  - Used to supply recommendation and time prediction with inter-session information.
  - Final output is used as initial hidden state in intra-session RNN and is used in the intensity function of the point process.

Temporal point process:

The parameterization of the intensity function of the point process is shown in Equation 1

\[ \lambda(t) = \exp(v_0 + h_t + w_y + (t-t_j) + b_h) \]  

- \( h_t \) is the final output/hidden state of the inter-session RNN.
- \( v_0, w_y, w_t, b_h \) are temporal modeling specific trained parameters.
- \( t_j \) is the time of the last session and \( t \) is the time variable.

The full conditional density distribution of the point process is shown in Equation 2.

\[ r(t) = \lambda(t) \exp \left( - \int_0^t \lambda(s) ds \right) \]  

Temporal tuning parameter

We introduce a tuning parameter in the temporal loss for controlling the long-/short-term focus of the model. The parameter appears as an exponent in every time term in the negative likelihood loss using the conditional density distribution (Equation 2).

\[ (t-t_j)^\alpha \]

Results:

- R@20
- MRR@20

<table>
<thead>
<tr>
<th>Model</th>
<th>R@20</th>
<th>MRR@20</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRU4EC</td>
<td>0.2476 ± 0.0002</td>
<td>0.0028 ± 0.0002</td>
</tr>
<tr>
<td>HRNN</td>
<td>0.2751 ± 0.0006</td>
<td>0.0104 ± 0.0004</td>
</tr>
<tr>
<td>THRNN</td>
<td>0.2795 ± 0.0006</td>
<td>0.0102 ± 0.0003</td>
</tr>
</tbody>
</table>

Table: Recall and MRR results on the Reddit dataset.

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References


Additional Information

- Code repo: https://github.com/BjornarVass/Recsys/
- This research project led to the publication [4].
- Authors with * are presenters at NorWai Innovate 2021.