JUMPER: Learning When to Make Classification Decisions in Reading

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Background

- Text Classification
- POS Tagging
- Machine Translation
- QA
- Document Summarization
- Chunking
- Dialogue Modeling
- NER

- 92.5 ACC on AG
- 97.1 ACC on WJS
- 40.5 BLEU on WMT EN2FR
- 83.9 ACC on SQuAD 1.0

...
How does the model make such a decision?
Motivation: reading text like human

During reading,

people obtain information from text orderly,

look for clues, \(\rightarrow\) Rationales

perform reasoning, \(\rightarrow\) Symbolic and distributed reasoning

and continue obtaining new information.

Understanding \(\rightarrow\) Sequential decision process
Paragraph....

1. What is the authorized level of injury? (10)
2. Is it an occupational injury? (Yes)
3. Did the incident happen during working hours? (Yes)
4. Did the labor contract end? (unknown)
When I was building the scaffolding,

1. What is the authorized level of injury? (10)
2. Is it an occupational injury? (Yes)
3. Did the incident happen during working hours? (Yes)
4. Did the labor contract end? (unknown)
When I was building the scaffolding, I was hit by a steel tube.

1. What is the authorized level of injury? (10)
2. Is it an occupational injury? (Yes)
3. Did the incident happen during working hours? (Yes)
4. Did the labor contract end? (unknown)
When I was building the scaffolding, I was hit by a steel tube, but my boss didn’t buy insurance for me. I was identified as ten-level disabled.

1. What is the authorized level of injury? (10)
2. Is it an occupational injury? (Yes)
3. Did the incident happen during working hours? (Yes)
4. Did the labor contract end? (unknown)
When I was building the scaffolding, I was hit by a steel tube, but my boss didn’t buy insurance for me. I was identified as ten-level disabled, and I need to rest for 4 months. How much money can I be compensated?

1. What is the authorized level of injury? (10)
2. Is it an occupational injury? (Yes)
3. Did the incident happen during working hours? (Yes)
4. Did the labor contract end? (unknown)
Generally, the goal is to transform some source sequence

\[ X = x_1, x_2, x_3, \ldots, x_N \]

into an integer.

Here, our goal is to transform the source sequence \( X \) into a sequence of decisions \( S \):

\[ S = s_1, s_2, s_3, \ldots, s_N \]

Which reflects the dynamic decision-making process in reading.
One-Jump Constraint

\[ \sum |s_t - s_{t-1}| = 1 \quad \forall t \in 1, 2, \ldots, T \]
One-jump constraint
Jumper: learning

Reward:

\[ R_{\text{final}}^{(j,i)} = 1 \{ s_{T_j}^{(j,i)} = t^{(j,i)} \} \]

for data point \( j \) and slot \( i \), where \( s_{T_j}^{(j,i)} \) is the symbolic state at the end of the paragraph and \( t^{(j,i)} \) is the groundtruth.

REINFORCE Algorithm:

\[
\nabla_\Theta J(\Theta) = \mathbb{E}_{\pi_\Theta} \left[ \sum_{t=1}^{T} \nabla_\Theta R_{t:T} \log \pi_\Theta(a_t | c_t) \right]
\]

\[
\approx \sum_{j=1}^{N} \sum_{i=1}^{I} \sum_{T_{\text{jump}}}^{T} \frac{1}{NT_j} R_{t:T_{\text{jump}}}^{(j,i)} \nabla_\Theta \log \pi_\Theta(a_t^{(j,i)} | c_t^{(j)})
\]
Jumper: learning when to jump

Fail to predict correctly

The ‘right’ jump position

Sentence \( t^* \)

May not have chance to predict

\( t^* + 1 \)

- sentence
- rationale
- may not exist
Experiments

Table 4

<table>
<thead>
<tr>
<th>Model</th>
<th>MR</th>
<th>AG</th>
<th>OI-Level</th>
<th>OI-InjIdn</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNN† [Kim, 2014]</td>
<td>81.00</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>fasttext† [Joulin et al., 2017]</td>
<td>–</td>
<td>92.50</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Bi-GRU</td>
<td>77.80</td>
<td>92.44</td>
<td>94.75</td>
<td>73.25</td>
</tr>
<tr>
<td>CNN</td>
<td>80.80</td>
<td>92.58</td>
<td>96.25</td>
<td>74.25</td>
</tr>
<tr>
<td>Self-Attentive</td>
<td>82.10</td>
<td>91.40</td>
<td>97.00</td>
<td>73.25</td>
</tr>
<tr>
<td>Hierarchical CNN-GRU</td>
<td>80.23</td>
<td>92.49</td>
<td>95.75</td>
<td>74.75</td>
</tr>
<tr>
<td>JUMPER</td>
<td>80.67</td>
<td>92.62</td>
<td>97.25</td>
<td>75.50</td>
</tr>
</tbody>
</table>

Table 3: Test accuracy (%) on MR, AG, and OI datasets. †Results quoted from previous papers.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>MR</th>
<th>AG</th>
<th>OI-Level</th>
<th>OI-InjIdn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg # of sub-sentences</td>
<td>2.17</td>
<td>3.46</td>
<td>4.88</td>
<td>4.88</td>
</tr>
<tr>
<td>Avg jumping position</td>
<td>1.46</td>
<td>2.04</td>
<td>3.23</td>
<td>2.87</td>
</tr>
<tr>
<td>Reduced %</td>
<td>32.7%</td>
<td>41.0%</td>
<td>33.8%</td>
<td>41.2%</td>
</tr>
</tbody>
</table>

Table 4
Experiments

<table>
<thead>
<tr>
<th>Model</th>
<th>CA</th>
<th>JA</th>
<th>OA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNN</td>
<td>96.25</td>
<td>94.81</td>
<td>91.25</td>
</tr>
<tr>
<td>Self-Attentive</td>
<td>97.00</td>
<td>98.45</td>
<td>95.50</td>
</tr>
<tr>
<td>Hierarchical CNN-RNN</td>
<td>96.00</td>
<td>98.18</td>
<td>94.25</td>
</tr>
<tr>
<td>JUMPER</td>
<td><strong>97.25</strong></td>
<td><strong>100</strong></td>
<td><strong>97.25</strong></td>
</tr>
</tbody>
</table>

Table 5: Performance of finding the key rationale in the OI-Level dataset, where information is often local. **CA**: Classification accuracy. **JA**: Jumping accuracy. **OA**: Overall accuracy.

Translation:

Had a business trip to Suzhou on 21 Oct last year,
Riding my colleague's bicycle and crashed to fence,
Comminuted fracture in leg,
I started work on 21 Sep,
and had the incident in Oct,
I don't want to work any more.
How much money should the company compensate?
The **authorized injury level is 9**!
Which department shall I appeal to for compensation?
Backtracking word-level clues

\[ \mathcal{D} = \text{top}_D \left( \frac{\partial \log(p_t(s_t))}{\partial \mathbf{c}^{(t-1)}} \odot (\mathbf{c}^{(t)} - \mathbf{c}^{(t-1)})^2 \right) \]

Expectation of the increase of \( \mathbf{c}^{(t-1)} \)

Real increase of \( \mathbf{c}^{(t-1)} \)

Matching rate of the two

\[ w_d = \text{argmax}\{c_1, \cdots, c_K\} \]
When rationales is scattered

MR:
As the characters get more depressed, the story gets more tiresome, especially as it continues to mount a conspicuous effort to be profound.

AG:
The US will offer an olive branch to Peter Mandelson, the European Union's new trade commissioner, next week by delaying any escalation of the dispute over subsidies to Airbus and Boeing, a US trade official said on Thursday.
Conclusion

• 1) Always take decisions at the ‘appropriate’ time.

• 2) Reducing total text reading by 30–40% and often finding the key rationale of prediction.

• 3) It achieves classification accuracy better than or comparable to state-of-the-art models in several benchmark and industrial datasets.
Question?
Decision-sharing mechanism
Decision-sharing mechanism
### Table 6: The average accuracy and $F_1$ on the OI dataset using the decision-sharing mechanism.

<table>
<thead>
<tr>
<th>Model</th>
<th>Accuracy</th>
<th>$F_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dev</td>
<td>test</td>
</tr>
<tr>
<td>Bi-GRU</td>
<td>90.62</td>
<td>90.18</td>
</tr>
<tr>
<td>CNN</td>
<td>92.41</td>
<td>91.64</td>
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<tr>
<td>Self-Attentive</td>
<td>92.12</td>
<td>91.85</td>
</tr>
<tr>
<td>Hierarchical CNN-GRU</td>
<td>91.56</td>
<td>91.30</td>
</tr>
<tr>
<td>JUMPER</td>
<td>92.43</td>
<td>92.42</td>
</tr>
<tr>
<td>JUMPER-sharing</td>
<td><strong>92.71</strong></td>
<td><strong>92.65</strong></td>
</tr>
</tbody>
</table>