Non-Monotonic Sequential Text Generation

Sean Welleck, Kianté Brantley, Hal Daumé III, Kyunghyun Cho
Sequential Text Generation

\[ Y = (y_1, y_2, \ldots, y_N) \]

(hi, how, are, you, ?)
Sequential Text Generation

Unconditional

Policy $\pi$ $\sim$ $Y$

(hi, how, are, you, ?)

(good, to, see, you, !)

• • •

(what, time, is, it, ?)
Sequential Text Generation

Conditional

元気ですか？ → Policy \( \pi \) → (how, are, you, ?)

Transformer, LSTM, …
Sequential Text Generation

Monotonic

how  are  you  ?

$\pi(a_1 \mid s_1)$  $\pi(a_2 \mid s_2)$  $\pi(a_3 \mid s_3)$  $\pi(a_4 \mid s_4)$

token  (how, are, X)
Sequential Text Generation

Non-Monotonic

\[ \pi(a_2 | s_2) \quad \pi(a_1 | s_1) \quad \pi(a_4 | s_4) \quad \pi(a_3 | s_3) \]

are how ? you

how are you ?
Binary Tree Generating Policy

..., how, are, you ?, the, ...

..., how, ..., [ ] [ ]

..., you ?, ...
Binary Tree Generating Policy

,..., how, are, you , ?, the, ...

..., how, ...

how

∅

∅

you

∅

∅

∅

∅

∅
Binary Tree Generating Policy

are

how

∅ ∅ you ∅ ∅ ∅

in-order traversal

how are you ?
Binary Tree Generating Policy
Imitation Learning

- Define an **oracle** \( \pi^*(a_t | s_t, X, Y) \)
- Sample sequences \((a_1, \ldots, a_T) \sim \pi^*\)
- Minimize cost \( \text{KL} \left[ \pi^*(\cdot | s_t), \pi_\theta(\cdot | s_t) \right] \)
**Oracles**

- **Oracle**: only puts mass on valid actions

\[ \pi^* \text{ uniform} \]
Oracles

- **Oracle**: only puts mass on valid actions

\[
\mathcal{L}_1 = \text{KL}(\pi^*_{\text{uniform}}, \pi^*_{\theta})
\]
Oracles

- **left-right**: only put mass on ‘left-most’ valid action
Coaching

- Weight correct actions by the learned policy
Coaching

- Weight valid actions by the learned policy

- Loss reinforces preferred orders

\[
KL(\pi^\text{coaching}, \pi_\theta)
\]
Results | Unconditional

Sentence: i do . i like lipton beverages .
Gen. Order: . i . do i like beverages lipton

Sentence: wow you sound like that .
Gen. Order: . you wow that like sound
# Results

<table>
<thead>
<tr>
<th>Oracle</th>
<th>% Novel</th>
<th>% Unique</th>
<th>Avg. Tokens</th>
<th>Avg. Span</th>
<th>BLEU</th>
</tr>
</thead>
<tbody>
<tr>
<td>left-right</td>
<td>17.8</td>
<td>97.0</td>
<td>11.9</td>
<td>1.0</td>
<td>47.0</td>
</tr>
<tr>
<td>uniform</td>
<td>98.3</td>
<td>99.9</td>
<td>13.0</td>
<td>1.43</td>
<td>40.0</td>
</tr>
<tr>
<td>annealed</td>
<td>93.1</td>
<td>98.2</td>
<td>10.6</td>
<td>1.31</td>
<td>56.2</td>
</tr>
<tr>
<td>Validation</td>
<td>97.0</td>
<td>100</td>
<td>12.1</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
## Results | Conditional

### Word Reordering

<table>
<thead>
<tr>
<th>Oracle</th>
<th>Validation</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Test</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BLEU</td>
<td>F1</td>
<td>EM</td>
<td>BLEU</td>
<td>F1</td>
<td>EM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>left-right</td>
<td>46.6</td>
<td>0.910</td>
<td>0.230</td>
<td>46.3</td>
<td>0.903</td>
<td>0.208</td>
<td></td>
<td></td>
</tr>
<tr>
<td>uniform</td>
<td>44.7</td>
<td>0.968</td>
<td>0.209</td>
<td>44.3</td>
<td>0.960</td>
<td>0.197</td>
<td></td>
<td></td>
</tr>
<tr>
<td>annealed</td>
<td>46.8</td>
<td>0.960</td>
<td>0.230</td>
<td>46.0</td>
<td>0.950</td>
<td>0.212</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Machine Translation

<table>
<thead>
<tr>
<th>Oracle</th>
<th>BLEU</th>
<th>Validation</th>
<th>Test</th>
<th>YiSi</th>
<th>Ribes</th>
<th>BLEU</th>
<th>Test</th>
<th>YiSi</th>
<th>Ribes</th>
</tr>
</thead>
<tbody>
<tr>
<td>left-right</td>
<td>32.30 (0.95)</td>
<td>31.96</td>
<td>69.41</td>
<td>84.80</td>
<td>28.00 (1.00)</td>
<td>30.10</td>
<td>65.22</td>
<td>82.29</td>
<td></td>
</tr>
<tr>
<td>uniform</td>
<td>24.50 (0.84)</td>
<td>27.98</td>
<td>66.40</td>
<td>82.66</td>
<td>21.40 (0.86)</td>
<td>26.40</td>
<td>62.41</td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td>annealed</td>
<td>26.80 (0.88)</td>
<td>29.67</td>
<td>67.88</td>
<td>83.61</td>
<td>23.30 (0.91)</td>
<td>27.96</td>
<td>63.38</td>
<td>80.91</td>
<td></td>
</tr>
<tr>
<td>+tree-encoding</td>
<td>28.00 (0.86)</td>
<td>30.15</td>
<td>68.43</td>
<td>84.36</td>
<td>24.30 (0.91)</td>
<td>28.59</td>
<td>63.87</td>
<td>81.64</td>
<td></td>
</tr>
<tr>
<td>+⟨end⟩-tuning</td>
<td>29.10 (0.99)</td>
<td>31.00</td>
<td>68.81</td>
<td>83.51</td>
<td>24.60 (1.00)</td>
<td>29.30</td>
<td>64.18</td>
<td>80.53</td>
<td></td>
</tr>
</tbody>
</table>
Results | Variable-Sized Text Infilling

**Left-Right**

\[ \pi((\text{Left} | \text{Right})) \sim \]

**Non-Monotonic**

\[ \pi((\text{Left} | \text{Middle} | \text{Right})) \sim \]
## Results | Variable-Sized Text Infilling

<table>
<thead>
<tr>
<th>Initial Tree</th>
<th>Samples</th>
</tr>
</thead>
</table>
| ![Tree Diagram](image) | - lasagna is my **favorite food** !  
- my **favorite food** is mac and cheese !  
- what is your **favorite food** ? pizza, i love it !  
- whats your **favorite food** ? mine is pizza !  
- seafood is my **favorite** . and mexican **food** !  
- what is yours ? |
• **Code & Pre-trained Models:**
  
  https://github.com/wellecks/nonmonotonic_text

• **Poster #45** (Pacific Ballroom)
• **Code & Pre-trained Models:**

  https://github.com/wellecks/nonmonotonic_text

• **Poster #45** *(Pacific Ballroom)*

  thank you!