### Overview

**Neural QA models**
- **Good performance**
- **Slow** (Not Scalable)
- **Sensitive to adversaries** [1]

**Sentence Selector**
- Train & Infer Speed
- Scalability
- Robustness

**QA model**
- **Minimum # of sentences required to answer question.**
- Most answerable questions only needs 1-2 sentences out of 5 (SQuAD) and 488 (TriviaQA).

### Method

**Sentence Selector**

\[ D^{enc} = \text{Encoder}(\text{Sentence, Question}) \]

\[ Q^{enc} = \text{Encoder}(\text{Question}) \]

\[ \text{score} = \text{FFN}(\text{Maxpool}(\text{Bilinear}(D^{enc}, Q^{enc}))) \]

**Selection Method**
- Top k: Fixed # of sentences
- Dyn: Dynamic # of sentences

**Enhancements for sentence selector**
- Transfer the weights of encoder from QA model
- Modify training data for sentence selector to select sentences only when QA model gets correct.
- Normalize scores from the same paragraph

**QA Model**
- DCN+ [2]
- S-Reader [3]

### QA Result & Analysis

#### QA Result with Full (Regular QA Model) & Minimal (Ours)

<table>
<thead>
<tr>
<th>Method</th>
<th>SQuAD w/ DCN+</th>
<th>SQuAD w/ S-Reader</th>
<th>NewsQA w/ S-Reader</th>
<th>SQuAD-Adv w/ DCN+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>83.1 1.0x</td>
<td>79.9 5.1x</td>
<td>62.3 6.9x</td>
<td>63.8 1.0x</td>
</tr>
<tr>
<td>Minimal (Top k)</td>
<td>79.2 5.1x</td>
<td>78.7 3.6x</td>
<td>63.2 5.3x</td>
<td>63.2 5.3x</td>
</tr>
<tr>
<td>Minimal (Dyn)</td>
<td>80.6 3.7x</td>
<td>79.8 3.6x</td>
<td>63.2 5.3x</td>
<td>63.2 5.3x</td>
</tr>
<tr>
<td>GNR</td>
<td>75.0</td>
<td>75.0</td>
<td></td>
<td>62.0</td>
</tr>
<tr>
<td>FastQA</td>
<td>78.5</td>
<td>78.5</td>
<td></td>
<td>56.1</td>
</tr>
</tbody>
</table>

On SQuAD & NewsQA, Minimal achieves comparable result with up to x7 speedup.

#### QA Result with Full (Regular QA Model) & Minimal (Ours)

<table>
<thead>
<tr>
<th>Method</th>
<th>TriviaQA (Wiki) w/ S-Reader</th>
<th>TriviaQA-Open w/ S-Reader</th>
<th>TriviaQA-Adv w/ DCN+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>59.6 1.0x</td>
<td>41.0 1.0x</td>
<td>52.6 1.0x</td>
</tr>
<tr>
<td>Minimal</td>
<td>59.5 13.8x</td>
<td>42.3 11.7x</td>
<td>59.7 6.1x</td>
</tr>
<tr>
<td>Previous SOTA</td>
<td>56.0</td>
<td>37.5</td>
<td>46.6</td>
</tr>
</tbody>
</table>

On TriviaQA (Wiki), SQuAD-Open & SQuAD-Adv, Minimal achieves SOTA with x6-x13 speedup.

### Examples, sentences ordered by score from our selector

1. **In 1873, Tesla returned to his birthtown, Smiljan. (.)**
   - **Question:** Where did Tesla return to in 1873?
   - **Answer:** Tesla had befriended, confirmed that Tesla rarely slept. Swzycey recalled one morning when Tesla called him at 3 a.m. “I was sleeping in my room (...) Suddenly, the telephone ring awakened me...”

2. **Kenneth Swezey, a journalist whom Tesla had befriended, confirmed that Tesla rarely slept. Swezey recalled one morning when Tesla called him at 3 a.m. “I was sleeping in my room (...) Suddenly, the telephone ring awakened me...”**
   - **Question:** What did Tesla Electric Light & Manufacturing do? When did Tesla call in the middle of the night? (.)
   - **Answer:** What did Tesla Electric Light & Manufacturing do? When did Tesla call in the middle of the night?

N/A (Need external knowledge)

- Writers whose papers are in the library are as diverse as Charles Dickens and Beatrix Potter. Illuminated manuscripts in the library dating from (...)
- The papers of which famous English Victorian author are collected in the library?

### Table

<table>
<thead>
<tr>
<th>Document</th>
<th># of sentences</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In 1873, Tesla returned to his birthtown, Smiljan. (.)</td>
<td>Where did Tesla return to in 1873?</td>
</tr>
<tr>
<td>2</td>
<td>(…) Tesla partnered with two businessmen in 1886, Robert Lane and Benjamin Vail, who agreed to finance an electric lighting company in Tesla’s name, Tesla Electric Light &amp; Manufacturing. The company installed electrical arc light based illumination systems designed by Tesla and (…)</td>
<td>What did Tesla Electric Light &amp; Manufacturing do?</td>
</tr>
<tr>
<td>3'</td>
<td>Kenneth Swezey, a journalist whom Tesla had befriended, confirmed that Tesla rarely slept. Swezey recalled one morning when Tesla called him at 3 a.m. “I was sleeping in my room (...) Suddenly, the telephone ring awakened me...”</td>
<td>Who did Tesla call in the middle of the night?</td>
</tr>
</tbody>
</table>

### Notes

1. Approximately **1,000** British soldiers were killed or injured.
2. The remaining **500** British troops, led by George Washington, retreated to Virginia.

Q: **How many casualties did British get?**

1. In January 1880, two of Tesla’s uncles put together enough money to help him leave **Czechoslovakia** for Prague where he was to study.
2. **Tedakatsu moved to the city of Chicago in 1881.**

Q: **What city did Tedakatsu move to in 1880?**

**Groundtruth.** Answer from Minimal (Dyn), Answer from Full. Minimal correctly answers questions by selecting the correct sentence.

1. However, in 1883-84 Germany began to build a colonial empire in Africa and the South Pacific, before losing interest in imperialism.
2. The establishment of the German colonial empire proceeded smoothly, starting with German New Guinea in 1884.

Q: **When did Germany found their first settlement?**

**Groundtruth.** Answer from Minimal (Dyn), Answer from Minimal (Top 1). Dyn selects 2 sentences and correctly answers the question.

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0. Check out more of our work at https://einstein.ai/research