**TOEFL Listening Comprehension Test**

### An Example Problem

**Story**

Basically a cloud either contributes to the cooling of earth’s surface or to its heating. Earth’s climate system is constantly trying to strike a balance between the cooling and warming effects of clouds .... we call this earth’s radiation budget ..... (audio story)

**Question**

According to the professor, what is earth’s radiation budget?

**Choices**

A. Average temperature difference between land mass and body of water
B. Balance of incoming solar energy and reflecting solar energy
C. Percentage of incoming solar energy that gets trapped in clouds
D. Portion of marine species that have been affected by global warming

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### Experimental Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Accuracy (%)</th>
<th>Manual</th>
<th>ASR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep-LSTM</td>
<td>32.4</td>
<td>34.3</td>
<td></td>
</tr>
<tr>
<td>E2E Memory Networks[1]</td>
<td>45.2</td>
<td>44.4</td>
<td></td>
</tr>
<tr>
<td>AMRN[2]</td>
<td>42.5</td>
<td>40.1</td>
<td></td>
</tr>
<tr>
<td>Tree-LSTM</td>
<td>46.5</td>
<td>44.9</td>
<td></td>
</tr>
<tr>
<td>proposed HAM</td>
<td>47.7</td>
<td>47.4</td>
<td></td>
</tr>
</tbody>
</table>

1. For manual, 1-hop sentence-level attention performed the best
2. For ASR, 2-hop phrase-level attention has the highest accuracy
3. Performance of ASR is just slightly lower than manual

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### Visualizing Attention

#### Hop 1 - Phrases with top 3 attention

1. incoming energy sunlight that is reflected off that surface back to space
2. there is not much reflection going on at all
3. they transmit incoming solar energy down to earth

#### Hop 2 - Phrases with top 3 attention

1. the amount of solar radiation energy from the sun absorbed by earth and the amount reflected back into space
2. increasing area of low thick clouds that reflect a large portion of solar energy back to space and cools the earth
3. process that could control the type of clouds

◊ The model selects key phrases related to the definition in hop1, and composes them to more high-level definition in hop2.

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### Source Code

The source code and TOEFL Listening Comprehension Test dataset is available at: [https://github.com/sunprinceS/Hierarchical-Attention-Model](https://github.com/sunprinceS/Hierarchical-Attention-Model)