


Time Reasoning



Ground Truth : 2012-11-06

| ID | Method | Results | Example F1 |
|---|--|--|------------|
| ① | CLIP | 2013-11-14. | 40% |
| ① + ② | Additional [CLS] +Location/Time Fine-tune | 2011-11-30. | 40% |
| ③ | Search Open-World Knowledge | <div style="display: flex; flex-direction: column; gap: 5px;"> <div>OWK1. The 2014 United States House of Representatives election in the United States Virgin Islands were held on Tuesday...</div> <div>OWK2. ...Hancock was elected to the Texas Senate in November 2012, having previously served three terms in the Texas House...</div> <div>OWK3. Indonesian law affecting Chinese-Indonesians were conducted through a series of laws, most of these laws are revoked...</div> <div>OWK4. ...Hancock was elected to the Texas Senate in November 2012, having previously served three terms in the Texas House...</div> <div>OWK5. The 2014 California gubernatorial election was held on November 4, 2014, to elect the Governor of California...</div> <div>OWK6. The 2014 California gubernatorial election was held on November 4, 2014, to elect the Governor of California...</div> </div> | / |
| ④ | Scoring Mechanism | <div style="display: flex; flex-direction: column; gap: 5px;"> <div>OWK1. x 0.28+ OWK2. x 0.27 + OWK3. x 0.21+ OWK4. x 0.31 + OWK5. x 0.09 + OWK6. x 0.13</div> </div> | |
| ⑤ | Time Reasoning | 2012-11-06. | 100% |
| Improvements [2013]-11-[14]. → [2011]-11-[30]. → [2012]-11-[06]. | | | 60% |



Ground Truth : 1978-06

| ID | Method | Results | Example F1 |
|--|--|---|------------|
| ① | CLIP | 1967-07-14. | 22.22 % |
| ① + ② | Additional [CLS] +Location/Time Fine-tune | 1969. | 28.57 % |
| ③ | Search Open-World Knowledge | <div style="display: flex; flex-direction: column; gap: 5px;"> <div>OWK1. The 1989 European Parliament election for the election of the delegation from the Netherlands was held on 15 June 1989.</div> <div>OWK2. The first elections for the European Parliament in Italy were held on 10 June 1979.</div> <div>OWK3. The 1980 National Convention of the U.S. Democratic Party nominated President Jimmy Carter and ...</div> <div>OWK4. The Italian presidential election of 1978 was held in Italy between 29 June and 8 July 1978..</div> <div>OWK5. The first elections for the European Parliament in Italy were held on 10 June 1979.</div> <div>OWK6. The Italian presidential election of 1978 was held in Italy between 29 June and 8 July 1978...</div> </div> | / |
| ④ | Scoring Mechanism | <div style="display: flex; flex-direction: column; gap: 5px;"> <div>OWK1. x 0.13+ OWK2. x 0.10 + OWK3. x 0.08+ OWK4. x 0.25 + OWK5. x 0.12 + OWK6. x 0.23</div> </div> | |
| ⑤ | Location Reasoning | 1978-06. | 100% |
| Improvements [1967]-[07]-[14]. → [1969]. → [1978]-[06]. | | | 77.78% |

Figure 3. We show the visualizations of 5 procedures of QR-CLIP. For each process, the reader can refer to Fig. 2

4.5. Limitation and Future Work

We are still in the early stages of investigating how to best use CLIP and the QR principle to explore open-world knowledge to support location and time reasoning. And the modules and techniques developed are simple but effective. In the future: 1) we will investigate more efficient and elegant implementations; 2) while addressing the limited computational resources, collect a larger OWK dataset as input candidates; 3) using multimodal OWKs to see if images from Instagram, Twitter, *etc.* could help with this task.

5. Conclusion

We designed a novel **QR-CLIP** model. It consists of two modules: 1) the **Quantity** module and 2) the **Relevance** module. Experiments show that it outperforms all previous SOTA on location and time reasoning by a wide margin. To show how our designed components affect the model, we conduct comprehensive ablation studies and verify that open-world knowledge is beneficial for solving our problem. We hope this paper will serve as a technical foundation for this study area and inspire more fascinating research.