Location Reasoning

Ground Truth : Baghdad, Al-Karkh Central Subdistrict , Al-Karkh District , Baghdad Governorate, Iraq, Asia.

ID	Method	Results	Example F1
0	CLIP	Qusayr, Miland, Al-Janudiyah Subdistrict, Jish Al-Shughur District, Idlib Governorate, Syria, Asia..	33.33%
1 + 2	Additional [CLS] +Location/Time Fine-tune	Ahvaz, Rah Ahan Square, amaniye, Ahwaz, Ahvaz County, Khuzestan Province, Iran, Asia.	40%
3	Search Open-World Knowledge	OWK1. Ayatollah ... an Iraqi-Iranian Shia scholar, ... returned to Iraq following the 2003 ... and administers humanitarian projects. OWK2. Ayatollah ... an Iraqi-Iranian Shia scholar, ... returned to Iraq following the 2003 ... and administers humanitarian projects. OWK3. Lieutenant General Qasem Soleimani is a freeway in Iran ... via Andimeshk and Ahvaz, ... from Ahvaz to Bandar... OWK4. Ayatollah ... an Iraqi-Iranian Shia scholar, ... returned to Iraq following the 2003 ... and administers humanitarian projects. OWK5. Khodabandeh County ... in Iran. The capital of the county is Qeydar... OWK6. Ayatollah ... an Iraqi-Iranian Shia scholar, ... returned to Iraq following the 2003 ... and administers humanitarian projects.	/
4	Scoring Mechanism	OWK1. x 0.56+ OWK2. x 0.47 + OWK3. x 0.05+ OWK4. x 0.40 + OWK5. x 0.09 + OWK6. x 0.43	
5	Location Reasoning	Baghdad, Al-Karkh Central Subdistrict , Al-Karkh District , Baghdad Governorate, Iraq, Asia	100%
Improvements		[Qusayr,...Syria,] Asia. → [Ahvaz, ... Khuzestan Province,] Iran, Asia. → [Baghdad ... Baghdad Governorate,] Iraq, Asia.	66.67%

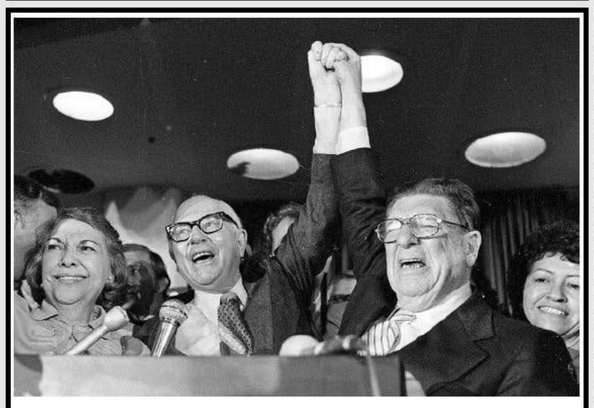
Ground Truth : Athens, Municipality of Athens, Regional Unit of Central Athens, Attica, Greece, Europe.

ID	Method	Results	Example F1
0	CLIP	Tripoli, Libya, Africa.	0%
1 + 2	Additional [CLS] +Location/Time Fine-tune	Corinaldo, Ancona, Marche, Italy, Europe.	33.33%
3	Search Open-World Knowledge	OWK1. Agioi Anargyroi-Kamatero is a municipality in the West Athens regional unit, Attica, Greece...is the town Agioi Anargyroi. OWK2. Athens A is a parliamentary constituency in Attica , ... when the Athens B constituency was split off, leaving Athens A... OWK3. Athens A is a parliamentary constituency in Attica , ... when the Athens B constituency was split off, leaving Athens A... OWK4. Agioi Anargyroi-Kamatero is a municipality in the West Athens regional unit, Attica, Greece...is the town Agioi Anargyroi. OWK5. Agioi Anargyroi-Kamatero is a municipality in the West Athens regional unit, Attica, Greece...is the town Agioi Anargyroi. OWK6. Athens A is a parliamentary constituency in Attica , ... when the Athens B constituency was split off, leaving Athens A...	/
4	Scoring Mechanism	OWK1. x 047+ OWK2. x 0.31 + OWK3. x 0.33+ OWK4. x 0.52 + OWK5. x 0.22 + OWK6. x 0.28	
5	Location Reasoning	Athens, Municipality of Athens, Regional Unit of Central Athens, Attica, Greece, Europe.	100%
Improvements		[Tripoli, Libya, Africa.] → [Corinaldo,...Marche, Italy,] Europe → [Athens, Municipality of Athens ...Greece,] Europe.	100%

Time Reasoning

Ground Truth : 2012-11-06

ID	Method	Results	Example F1
0	CLIP	2013-11-14.	40%
1 + 2	Additional [CLS] +Location/Time Fine-tune	2011-11-30.	40%
3	Search Open-World Knowledge	OWK1. The 2014 United States House of Representatives election in the United States Virgin Islands were held on Tuesday... OWK2. ...Hancock was elected to the Texas Senate in November 2012, having previously served three terms in the Texas House... OWK3. Indonesian law affecting Chinese-Indonesians were conducted through a series of laws, most of these laws are revoked... OWK4. ...Hancock was elected to the Texas Senate in November 2012, having previously served three terms in the Texas House... OWK5. The 2014 California gubernatorial election was held on November 4, 2014, to elect the Governor of California... OWK6. The 2014 California gubernatorial election was held on November 4, 2014, to elect the Governor of California...	/
4	Scoring Mechanism	OWK1. x 0.28+ OWK2. x 0.27 + OWK3. x 0.21+ OWK4. x 0.31 + OWK5. x 0.09 + OWK6. x 0.13	
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
0	CLIP	1967-07-14.	22.22 %
1 + 2	Additional [CLS] +Location/Time Fine-tune	1969.	28.57 %
3	Search Open-World Knowledge	OWK1. The 1989 European Parliament election for the election of the delegation from the Netherlands was held on 15 June 1989. OWK2. The first elections for the European Parliament in Italy were held on 10 June 1979. OWK3. The 1980 National Convention of the U.S. Democratic Party nominated President Jimmy Carter and ... OWK4. The Italian presidential election of 1978 was held in Italy between 29 June and 8 July 1978.. OWK5. The first elections for the European Parliament in Italy were held on 10 June 1979. OWK6. The Italian presidential election of 1978 was held in Italy between 29 June and 8 July 1978...	/
4	Scoring Mechanism	OWK1. x 0.13+ OWK2. x 0.10 + OWK3. x 0.08+ OWK4. x 0.25 + OWK5. x 0.12 + OWK6. x 0.23	
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.