

Using TimeML in Question Answering

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Introduction

Question answering (QA) refers to the process that, given a (typically large) textual corpus as input and a natural language question, returns one or more answers to the question, if any can be found in the input corpus. QA is the subject of the TREC QA evaluation [Voorhees & Tice 1999] and of the ARDA Aquaint program [<http://www.ic-arda.org/>]. A detailed roadmap for research in QA was published in 2000 [Harabagiu et al. 2000].

TimeML is an annotation scheme for marking up events and time expressions in textual documents as well as temporal links between events. Timebank is a corpus of 50 TimeML annotated documents (it will include 300 such documents by September, 2002).

Temporal questions come in many shapes. Only a small number of temporal questions do indeed start with the question word “When”. We distinguish between implicit and explicit temporal questions. Explicit temporal questions ask for a temporal expression (“When?”, “What time?”, “How often”, “In which century?”, etc.) while implicit temporal questions use temporal expressions to give non-temporal answers (e.g., “Who was president of X in 1990?” or “Did world steel output increase in the nineties?”).

Question corpus

The question corpus includes 50 questions (with 50 more questions to be ready by September, 2002). These questions are distributed across the different categories shown in the question creation tool.

The 50 questions will be chosen in such a way that all possible values of each individual parameter are accounted for. That doesn’t mean that all possible combinations of parameters have to be covered.

A tool was developed to annotate questions for the purpose of the corpus creation. This tool (Figure 1) can be used to specify properties of the questions such as answer type and volatility. It is available at <http://perun.si.umich.edu/~radev/mitre/protected/annotate-question.cgi>

To annotate questions in TimeML, one can use the Alembic Workbench (AWB) from MITRE. The same tool is also used to annotate full documents.

Figure 1 : Question annotation interface

Figure 2 presents the different parameters used to describe questions.

- ANS_TYPE: the type of the answer
- NB_TEMPEX: number of TEMPEX expressions in question
- INDEXICAL: is the question indexical
- NB_EVENTS: how many events are mentioned in the question
- POS_ANSWERS: how many possible answers can the question have
- EVENT_CLASSES: types of events
- VOLATILITY: how often does the answer change
- SUBORD_TYPE: subordination type
- REP_TYPE: does the question refer to a repetitive event
- NE_TYPE: what named entity type (if any) is the expected answer to the question

Feature	Possible values	Default
ANS_TYPE	Duration, Frequency, Point, Non-temporal, Point	Point
NB_TEMPEX	Zero, One, Two, Three or more	Zero
INDEXICAL	Yes, No	Yes
NB_EVENTS	Zero, One, Two, Three or more	Zero
POS_ANSWERS	many, a few, less than two, many	Many
EVENT_CLASSES	None, occurrence, perception, aspectual, intending, state, reporting	None
VOLATILITY	Longest term, Medium term, Short term, Ephemeral	Ephemeral
SUBORD_TYPE	None, Modal, Evidential, Negative-evidential, Factive	None
REP_TYPE	Recurrent, PointInTime, Period, MultipleTimes	PointInTime
NE_TYPE	Time, Location, Person, Number, Other	Time

Figure 2 : Question parameters

An example of an annotated question is shown in Figure 3.

```

<?xml version='1.0'?>
<!DOCTYPE DOCSENT SYSTEM './question.dtd'>

<TERQAS-QUESTION TQID="31">
  <QUESTION>
    Who was president of Iraq during the invasion of Kuwait?
  </QUESTION>
  <ANS_TYPE> Point </ANS_TYPE>
  <NB_TEMPEX> Zero </NB_TEMPEX>
  <INDEXICAL> Yes </INDEXICAL>
  <NB_EVENTS> Two </NB_EVENTS>
  <POS_ANSWERS> One </POS_ANSWERS>
  <EVENT_CLASSES> State </EVENT_CLASSES>
  <VOLATILITY> Medium term </VOLATILITY>
  <SUBORD_TYPE> None </SUBORD_TYPE>
  <REP_TYPE> PointInTime </REP_TYPE>
  <NE_TYPE> Person </NE_TYPE>
</TERQAS-QUESTION>

```

Figure 3 : Sample parameterized question

Sample questions

The question corpus currently contains 50 questions. Figure 4 lists five sample questions which are further shown in TimeML format in Figure 5.

```

When did the war between Iran and Iraq end?
When did John Sununu travel to a fundraiser for John Ashcroft?
How many Tutsis were killed by Hutus in Rwanda in 1994?
Who was Secretary of Defense during the Gulf War?
What was the largest U.S. military operation since Vietnam?

```

Figure 4 : Sample TimeBank questions

TimeML-annotated questions

We annotated the five questions using TimeML.

```

(Q1) When did the war between Iran and Iraq end?

<TIMEX3 tid="t1" type="DATE" value="QUERY">
When
</TIMEX3>
did the
<EVENT eid="e1" class="OCCURRENCE" tense="NONE" aspect="NONE">
war
</EVENT>
<MAKEINSTANCE eiid="ei1" eventID="e1"/>
between Iran and Iraq
<EVENT eid="e2" class="ASPECTUAL" tense="PAST" aspect="NONE">
end
</EVENT>

```

```
<MAKEINSTANCE eiid="ei2" eventID="e2"/>
?
<ALINK eventInstanceID="ei2" relatedToEvent="ei1" relType="TERMINATES"/>
<TLINK eventInstanceID="ei2" relatedToTime="t1" relType="IS_INCLUDED"/>
```

(Q2) When did John Sununu travel to a fundraiser for John Ashcroft?

```
<TIMEX3 tid="t1" type="DATE" value="QUERY">
When
</TIMEX3>
did John Sununu
<EVENT eid="e1" class="OCCURRENCE" tense="PAST" aspect="NONE">
travel
</EVENT>
<SIGNAL sid="s1">
to
</SIGNAL>
a
<EVENT eid="e2" class="OCCURRENCE" tense="NONE" aspect="NONE">
fundraiser
</EVENT>
for John Ashcroft?

<MAKEINSTANCE eiid="ei1" eventID="e1"/>
<MAKEINSTANCE eiid="ei2" eventID="e2"/>

<TLINK eventInstanceID="ei1" relatedToTime="t1" relType="IS_INCLUDED"/>
<SLINK eventInstanceID="ei1" subordinatedEventInstance="ei2" signalID="s1"
relType="MODAL"/>
<TLINK eventInstanceID="ei1" relatedToEvent="ei2" relType="BEFORE"/>
```

(Q3) How many Tutsis were killed by Hutus in Rwanda in 1994?

```
<Q qid="q1" type="QUANTITY">
How many
</Q>
Tutsis were
<EVENT eid="e1" class="OCCURRENCE" tense="PAST" aspect="NONE">
killed
</EVENT>
by Hutus in Rwanda
<SIGNAL sid="s1">
in
</SIGNAL>
<TIMEX3 tid="t1" type="DATE" value="1994">
1994
</TIMEX3>
?

<MAKEINSTANCE eiid="ei1" eventID="e1"/>

<TLINK eventInstanceID="ei1" relatedToTime="t1" relType="IS_INCLUDED"/>
```

<p>(Q4) Who was Secretary of Defense during the Gulf War?</p> <pre> <Q qid="q1" type="PERSON"> Who </Q> was <EVENT eid="e1" class="STATE" tense="NONE" aspect="NONE"> Secretary of Defense </EVENT> <MAKEINSTANCE eiid="ei1" eventID="e1"/> <SIGNAL sid="s1"> during </SIGNAL> the <EVENT eid="e2" class="OCCURRENCE" tense="NONE" aspect="NONE"> Gulf War </EVENT> <MAKEINSTANCE eiid="ei2" eventID="e2"/> <TLINK eventInstanceID="ei1" relatedToEvent="ei2" signalID="s1" relType="IS_INCLUDED"/> </pre>
<p>(Q5) What was the largest U.S. military operation since Vietnam?</p> <pre> <EVENT eid="e0" class="QUERY" tense="NONE" aspect="NONE"> What </EVENT> <MAKEINSTANCE eiid="ei0" eventID="e0"/> was the largest U.S. military <EVENT eid="e1" class="OCCURRENCE" tense="NONE" aspect="NONE"> operation </EVENT> <MAKEINSTANCE eiid="ei1" eventID="e1"/> <SIGNAL sid="s1"> since </SIGNAL> <EVENT eid="e2" class="OCCURRENCE" tense="NONE" aspect="NONE"> Vietnam </EVENT> <MAKEINSTANCE eiid="ei2" eventID="e2"/> <TLINK eventInstanceID="ei0" relatedToEvent="ei1" relType="IDENTITY"/> <TLINK eventInstanceID="ei1" relatedToEvent="ei2" signalID="s1" relType="AFTER"/> </pre>

Figure 5 : TimeML-annotated questions

Information Retrieval

We have provided a way to retrieve documents from the TimeBank corpus using *mg*¹, a popular search engine. Figure 6 and Figure 7 show the input and the output of MG-TERQAS.

<http://perun.si.umich.edu/~radev/mitre/protected/run-query.cgi>

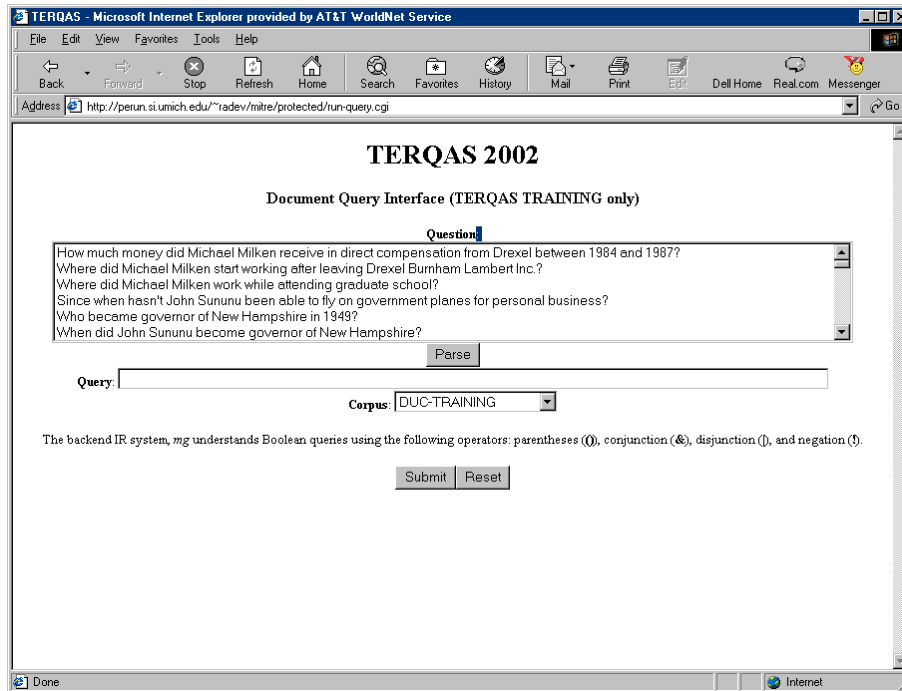
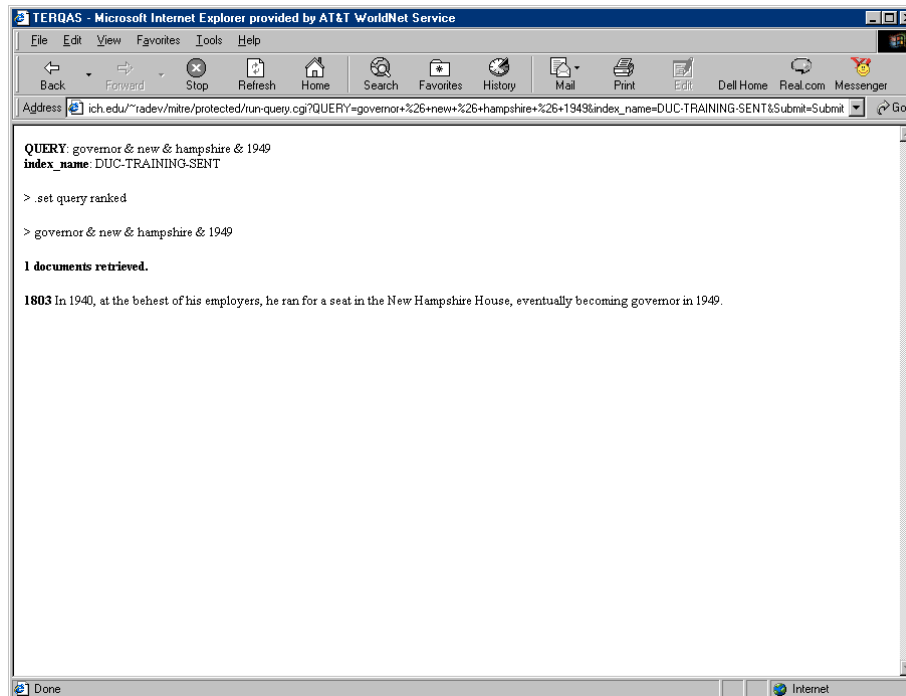


Figure 6 : Input to MG-TERQAS



¹ Developed by Tim Bell, Alistair Moffat, Ian Witten, and Justin Zobel (<http://www.mds.rmit.edu.au/mg/>)

Figure 7 : Output from MG-TERQAS

Plans for integration with an existing Q&A system

NSIR is a functional Q&A system developed at the University of Michigan [Radev & al. 2001, Radev & al. 2002] (http://perun.si.umich.edu/~radev/nsir/nsir_lrec.cgi). It can handle reasonably well temporal questions. We are currently investigating how TimeML and TimeBank can be used to improve the performance of NSIR or other similar Q&A systems.

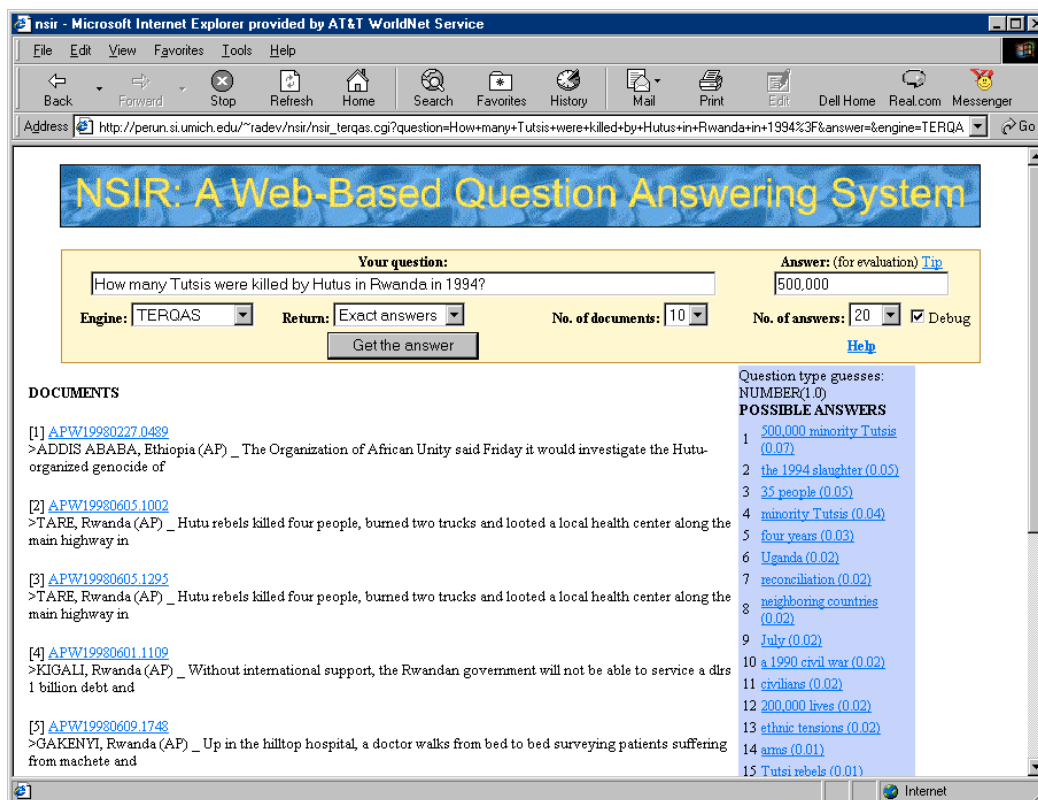


Figure 8 : NSIR's user interface

References

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Dragomir Radev, Weiguo Fan, Hong Qi, and Amardeep Grewal, “*Probabilistic Question Answering on the Web*”, Proceedings, 11th International WWW Conference (Honolulu, Hawaii, May 2002).

Andrea Setzer (2001) *Temporal Information in Newswire Articles: An Annotation Scheme and Corpus Study*, Doctoral Dissertation, University of Sheffield, Sheffield, UK.

Ellen Voorhees and Dawn Tice, *The TREC-8 Question Answering Track Evaluation*, Text Retrieval Conference TREC-8", Gaithersburg, MD, November 1999.

Appendix: question corpus

A.1. TimeML question corpus (version 0.2)

1. What did George Bush do after the U.N. Security Council ordered a global embargo on trade with Iraq in August 90?
2. What happened to world oil prices after the Iraqi "annexation" of Kuwait?
3. When did Iraq invade Kuwait?
4. When did Jordan close the port of Aqaba to Kuwait?
5. When did George Bush and John Sununu become close?
6. Who won the 1988 New Hampshire republican primary?
7. Through which cities did luggage on Pan Am Flight 103 travel?
8. During which decade did polygraph tests gain popularity?
9. When was the Defense Department allowed to ask personnel with access to sensitive classified information to take polygraph tests?
10. How long has Michael Milken been married to his wife Lori?
11. When did Michael Milken graduate from high school?
12. Where did George Bush meet with Jordan's King Hussein soon after the Iraqi invasion of Kuwait?
13. Did Hussein meet with Saddam before he (Hussein) met with Bush?
14. Did Iraq's cease fire with Iran occur before or after the invasion of Kuwait?
15. How long did Iraq fight with Iran?
16. Who was spokesman of the Soviet Embassy in Baghdad at the time of the invasion of Kuwait?
17. Which two nations met in Washington on August 14, 1990 to discuss a naval blockade against Iraq?
18. How long after the Pentagon put its warships in the Persian Gulf on alert did Iraq invade Kuwait?
19. How long after the Iraqi invasion of Kuwait did Iraq declare that Kuwait was annexed?
20. Since when hasn't John Sununu been able to fly on government planes for personal business?
21. Who became governor of New Hampshire in 1949?
22. When did John Sununu become governor of New Hampshire?
23. What political events took place in the fifties?
24. Who headed George Bush's 1988 campaign in Illinois?
25. How old was John Sununu in December 1991?
26. Who was president of Drew University in December 1991?
27. Which U.S. ship was attacked by Israeli forces during the 1967 war?
28. Did John Sununu resign before or after George Bush's ratings began to fall?
29. For how long is John Sununu expected to be presidential counselor with cabinet rank?
30. Where did Michael Milken study before going to the University of Pennsylvania?
31. How old was Michael Milken when he got married?
32. When did Michael Milken move his office from New York to Beverly Hills?
33. In what year did Michael Milken resign from Drexel Burnham Lambert Inc.?
34. In what decade were junk bonds promoted by Drexel Burnham Lambert Inc.?
35. How old was Michael Milken in January 1989?
36. What time of the day does Michael Milken typically wake up?
37. How much money did Michael Milken receive in direct compensation from Drexel between 1984 and 1987?
38. Where did Michael Milken start working after leaving Drexel Burnham Lambert Inc. ?
39. Where did Michael Milken work while attending graduate school?
40. When was Jorge Hernandez kidnapped?
41. The plane of which African president was shot down in April 1994?
42. How many people have been killed in the war between Kurdish guerrillas and government forces in Turkey from 1984 to 1998?
43. How old was Yigal Amir when he shot Yitzhak Rabin?
44. When was Rabin assassinated?
45. When did the war between Iran and Iraq end?
46. When did John Sununu travel to a fundraiser for John Ashcroft?

47. How many Tutsis were killed by Hutus in Rwanda in 1994?
48. Who was Secretary of Defense during the Gulf War?
49. What was the largest U.S. military operation since Vietnam?
50. When did the pope visit Cuba?

A.2. Other corpora containing temporal questions

Excite corpus (typos preserved)

what was important in 1985?
 what is the date of the superbowl in the year 2000?
 what were the effects of rock and roll on the soviet union?
 Where can I find research information of the Israeli Palistianian issues since 1991?
 Where can I find the history of the internet?
 what was the culture like in the 1920`s?
 what happened on all my chilren yesterday?
 WHat is the average life span of a human male?
 Where can I learn about the American Revolution topic the Boston Tea Party?
 When was it that the French Estates-General did not meet?
 Where can I find the 1999 Gorham Silver Snowflake?
 when are the holidays for 2000?
 In what year was the U.S submarine Nautilus launched?
 Where can I find weather information for New Jersey, Pennsylvania, Maryland,and Virginia for December 21, 1999?
 when was the telephone invented?
 What was the name of the ferry that capsized off Zeebrugge in 1987?
 Who was the second man on the moon?
 What important things happened in the year 1987?
 who was the 3rd u.s. president?
 Are the new 750Mhz & 800Mhz Intels out today, 12,20,1999?
 Where can I find a list of Nasdaq stocks with the greatest price appreciation in 1999?
 Where can I find the 1921 constitution of LOuisiana?
 Is Cat Stephens alive?
 Does the new millennium begin in 2000 or 2001?
 What was happening in the year 1000?
 who was man of the year in 1982 in the magazine time?
 I want to find pictures of presidents from the 1940-1949?
 When was the Great Depression?
 is it raining in New York?
 What year did the 18th ammendment come into effect?
 what high school was the 1999 national cheerleading champions?
 can You find the population of canada in 1999?
 who defeated George Foreman in the boxing championship in 1974?
 WHere can I find information on the 1900's?
 how often do all of the planets in our solar system line up in a row?
 What scandals happened during the period of 1870-1900?
 What were some popular snack foods from the 1970's?
 Where can i find the number one song in the country 13 years ago?
 Who was times man of the year in 1982?
 Where can I find some important events that happened in the 1930s?
 When is the 1999 Superbowl?
 what eleents led to a revitalization of western europe after 1100 a.d.?
 Is Northampton, MA, having a First Night festival for 2000?
 1982 man of the year?

Can you get me information during the 1900's?
Who defeated George Foreman in the Heavy Weight boxing championship of 1974?
What is the date of the 1999 Super Bowl?
Were can i learn about the whole middle ages which is from 500-1500?

Sample TREC8 questions

1 What was the monetary value of the Nobel Peace Prize in 1989?
4 How much did Mercury spend on advertising in 1993?
12 How much did Manchester United spend on players in 1993?
13 How much could you rent a Volkswagen bug for in 1966?
15 When was London's Docklands Light Railway constructed?
16 What two US biochemists won the Nobel Prize in medicine in 1992?
19 Who was the leader of the Branch Davidian Cult confronted by the FBI in Waco, Texas in 1993?
21 Who was the first American in space?
22 When did the Jurassic Period end?
23 When did Spain and Korea start ambassadorial relations?
24 When did Nixon visit China?
27 Where did the 6th annual meeting of Indonesia-Malaysia forest experts take place?
32 Who received the Will Rogers Award in 1989?
36 In 1990, what day of the week did Christmas fall on?
40 Who won the Nobel Peace Prize in 1991?
42 What was the target rate for M3 growth in 1992?
45 When did Lucelly Garcia, a former ambassador of Columbia to Honduras, die?
50 When was Dubai's first concrete house built?
59 Who was President of Costa Rica in 1994?
63 What nuclear-powered Russian submarine sank in the Norwegian Sea on April 7, 1989?
71 In what year did Joe DiMaggio compile his 56-game hitting streak?
76 In which year was New Zealand excluded from the ANZUS alliance?
78 Which large U.S. city had the highest murder rate for 1988?
89 At what age did Rossini stop writing opera?
92 Who released the Internet worm in the late 1980s?
96 What time of day did Emperor Hirohito die?