An Improved Natural Language Interface to a Complex Anatomical Knowledge Base

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Introduction:

The Foundational Model of Anatomy (FMA) is a large, complex knowledge base representing anatomical information (http://sig.biostr.washington.edu/projects/fm). We have developed a natural language interface to the FMA called GAPP (Fig. 1) This program takes English questions as input and answers them by generating corresponding queries to the FMA. Here we present a brief description of GAPP and several recent improvements from earlier versions. (http://sig.biostr.washington.edu/projects/gapp/).

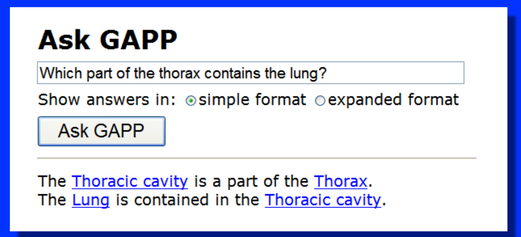

Figure 1: Question and results in latest version of GAPP.

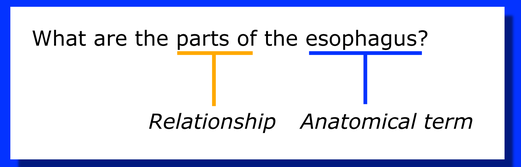

Figure 2: A natural language query. GAPP views questions as consisting of anatomical terms and relationships.

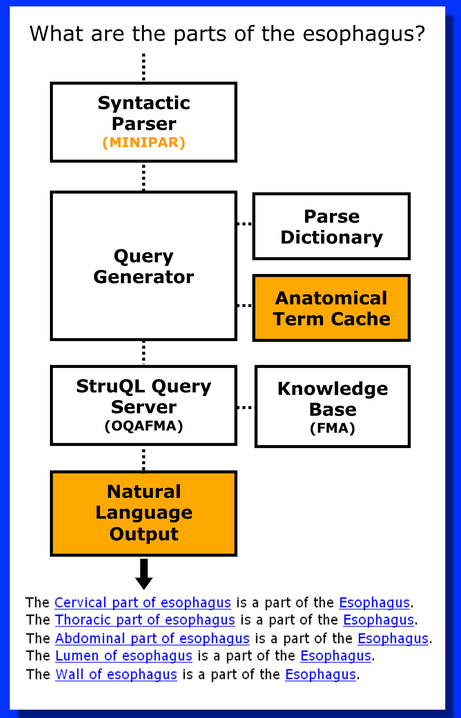

Figure 3: Architecture of GAPP, including syntactic parser, anatomical term cache, and post-processing of results for natural language output. Improved components are in orange.

Architecture:

To query the FMA, a user enters an English anatomy question (Fig. 2) First, a syntactic parser (Fig. 3) analyzes the syntactic structure of the question.

This parsed version of the question is passed to a query generator. The query generator attempts to find anatomical terms and relationships between them (Fig. 2).

To accomplish this, a parse dictionary (Fig. 3) is first used to match parts of the syntactic structure to relationships in the FMA. The parse dictionary also indicates the locations of potential anatomical terms in the question. An anatomical term cache (see below) is used to check whether terms exist in the FMA.

The query generator returns a query to the FMA in the StruQL database query language. Our StruQL query server to the FMA, called OQAFMA, passes the query to the FMA and gives results in XML.

The natural language output component reformats the XML results into English sentences.

Improvements:

New Syntactic Parser (Fig. 3)

This version of GAPP features a new syntactic parser, MINIPAR, which offers detailed syntactic representations, including the locations of traces in WH-movement. This feature is particularly important for a question-answering system, since most English questions involve WH-movement.

Anatomical Term Cache (Figs. 3,4)

Figure 4: The anatomical term cache maps anatomical terms to frame numbers in the FMA

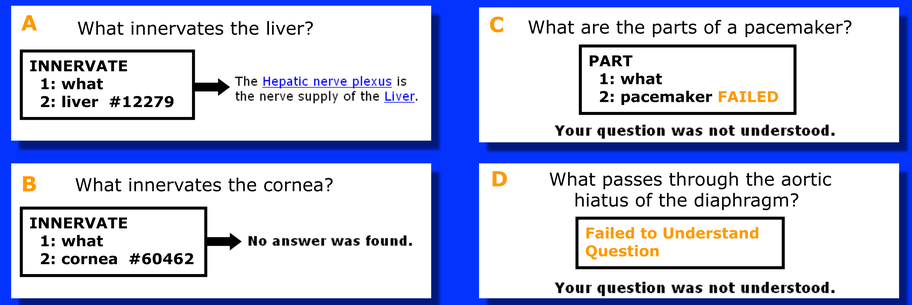

Figure 5: Diagnostic messages; A) Successful query and result. B) Well-formed query with no results. C) Term from query not found in FMA. D) Anatomical relationship not found in query.

The anatomical term cache is a hash table of the more than 110,000 anatomical terms in the FMA. Each term returns a frame number from the FMA, which is then used in the StruQL query in place of the anatomical term itself.

This component offers two major improvements. First, it eliminates a lengthy search through the FMA's namespace in the StruQL query, reducing average response time from 5-10 seconds to less than one second.

The addition of this term cache also allows GAPP to generate specific diagnostic messages for both successful and failed queries (Fig. 5) In a successful query, the anatomical entities and relationships are mapped correctly and a result is produced (Fig. 5A) Some other queries are well-formed, but return no results because the FMA is not yet complete (Fig. 5B)

In other queries the relationship is correctly extracted, but the term is not found in the FMA (Fig. 5C) Finally, sometimes GAPP fails to find an anatomical relationship in the input question. In these cases, GAPP simply reports that it completely failed to understand (Fig 5D.)

Natural Language Output (Figs 1,3,5)

Finally, results from GAPP now appear as English sentences. This is useful for queries that follow multiple relationships, such as "Where is the heart?" (Fig. 5) The results of this query are generated by the relationships "part", "contains", and "surrounds". Natural language output clearly differentiates each result. Natural language output also usefully organizes the results of nested queries (Fig. 1)

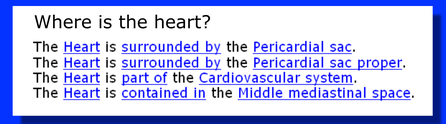

Figure 5: Natural language results for a multiple-relationship query.

Conclusions :

Our recent work on the GAPP question answering system has improved response time, user feedback, and the clarity of results. This will allow us to evaluate GAPP on a wider scale and should bring it closer to use as a tool to evaluate the development of the FMA.