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CS 4635: Project 1 Report
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Agent Architecture

Project 1 focuses on understanding input questions for expanding upon in later projects. The agent for this project was designed to perform two primary functions: determine the context (or topic) of the question and to choose the thematic object (or question object) of the question. Below is a block diagram of this process, along with a basic UML architecture of the agent and its knowledge base which will be described in more detail in the following sections.

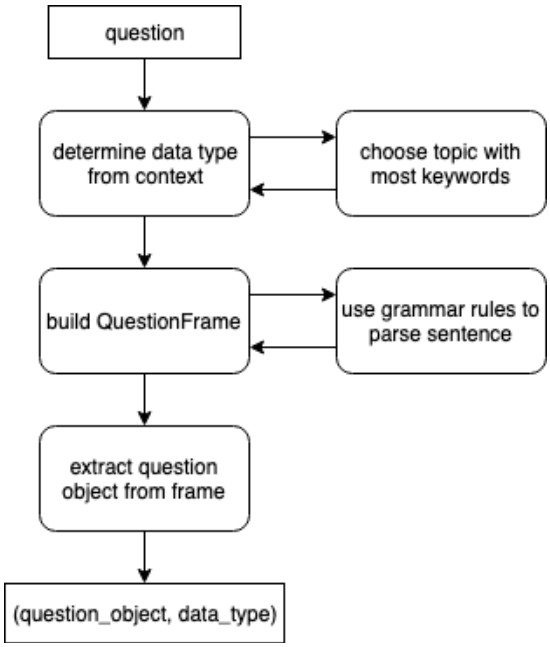

Figure 1. Question interpretation workflow.

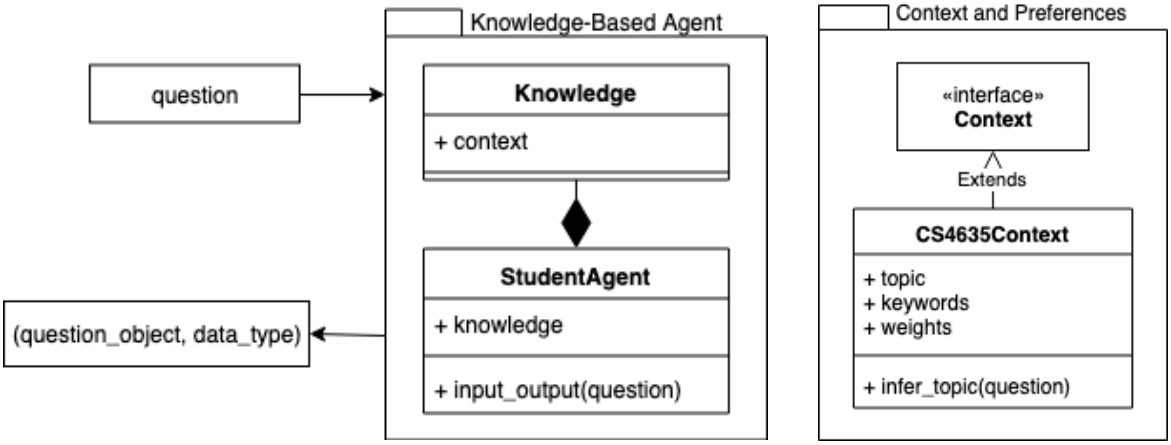

Figure 2. UML models of core design features.

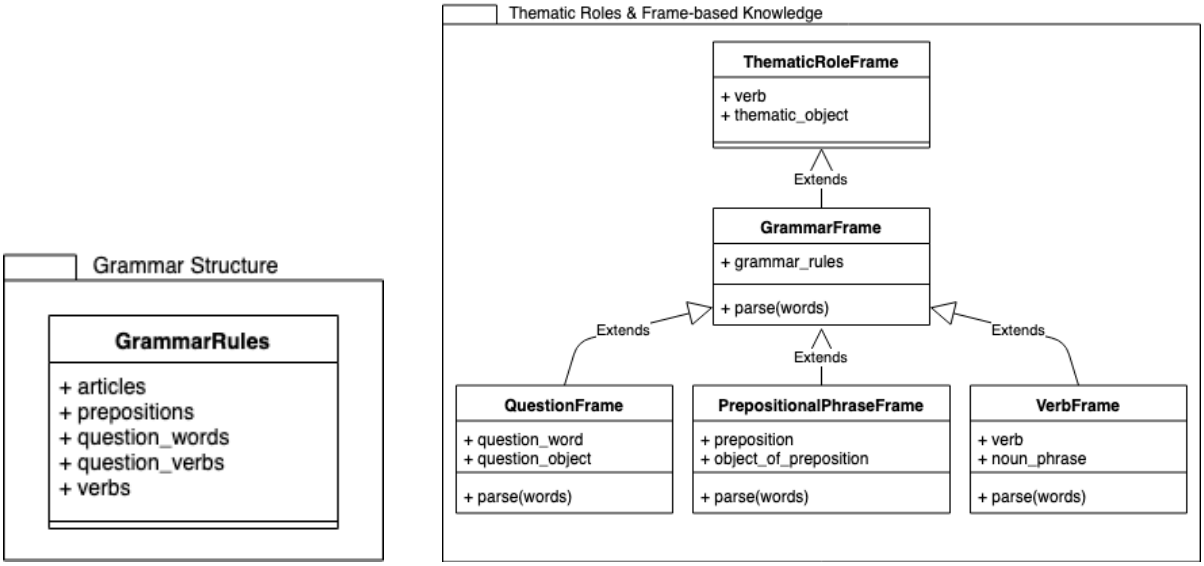

Figure 3. UML models of core design features (cont.).

Thematic Roles & Frame-Based Workflow

Inferring the Context

The agent's first task is to determine the context of the input question. The first step to designing this algorithm was reflecting on how a human might infer the topic of a sentence. Since this agent is designed to operate within a constrained environment with only five topics –– DUEDATE, RELEASEDATE, WEIGHT, PROCESS, and DURATION —– the topic of the sentence can be inferred by examining how many words in the sentence are related to each topic. The category with the most keywords must then be the topic of interest!

For each category, the agent was manually preloaded with common keywords relating to that topic (e.g. 'when', 'due' for DUEDATE). Upon receiving new input, the sentence is broken up into space-delimited words. For every word, the category containing that word as a keyword gets a point. The category with the most points is chosen as the topic of the question (here, the `_data_requested`). However, humans naturally know that some words may be more strongly associated to a different topic (e.g. 'when' may be used for both PROCESS and DUEDATE, but is more strongly associated with DUEDATE), so the agent was preloaded with preferences for certain keywords to deconflict between categories. When a preference keyword was encountered, that category would get two points for example. This preference weighting was designed as a tunable parameter to ensure that some keywords do not entirely determine the topic of the question. Thus, using a weighted keyword search with a constrained set of categories, the agent can infer the topic of the question with a high degree of accuracy.

Inferring the Thematic Object

The agent's next task is to determine the thematic object of the question. This is a difficult language processing task, but contextual clues, grammatical rules, thematic roles, and a frame-based knowledge representation provide sufficient constraints to appropriately solve this problem. The inputs to the agent are limited to short simple questions beginning with 'what', 'where', 'when', and 'how', which provides more structure for the agent to effectively

parse sentences. Having preloaded some grammatical constructs (such as articles, prepositions, question words, common verbs following the question word, and common verbs related to the context), the agent can build a `QuestionFrame` and fill in slots that will expose the thematic object. The 'object' slot of the `QuestionFrame` is then used as the agent's output (that is, `_question_object`).

A 'vocabulary' was manually preloaded into the agent that allows it to identify the fundamental structure of basic English. Several frames were defined that provide structure to the question (e.g. `VerbFrame`, `PrepositionalPhraseFrame`, and `QuestionFrame`). When the agent receives a new input, it attempts to break down the question into a format similar to the following (English First, 2019):

```
<question_word> <question_verb_phrase> [<prepositional_phrases> <standalone_verb_phrases> <standalone_noun_phrases>]
```

A `QuestionFrame` may have any number of standalone verb phrases and prepositional phrases, but there should only be one question word and question verb phrase. After parsing the question for verbs and prepositions, the thematic object is chosen using a predefined preference system as follows (Winston, 1992, Ch. 10, p. 214):

> The object of a question is…
>
> **strongly** associated with the question verb phrase ('is', 'are', 'do', 'does', etc.).
>
> **closely** associated with a standalone verb phrase ('submit', 'place', etc.).
>
> **somewhat** associated with a standalone noun phrase.
>
> **loosely** associated with a prepositional phrase excluding those beginning with 'by', 'for', 'from', 'with', or 'to'.

Once the question has been parsed and the object of the question has been decided, the agent will extract that object as the thematic object of the input and return it.

Human Cognition

Much of the time spent designing this agent centered around the question, "How do I know this?" To effectively design a human-like agent, it is necessary to introspect and understand how a human being might approach the problems of inferring the topic and object of a question, and how their innate preferences influence that decision. Take, for example, the question, "When is the project due?"

As a human, when I read the question, I determine the topic by looking at context clues. I know this question is about CS4635 because that's what this project is about. The word 'due' sticks out to indicate that the topic must relate to the submission, due date, or handing in of the object. Here, I implicitly performed a weighted keyword search and recognized that the word 'due' has a strong effect on setting the question's topic, here 'due date'.

To determine the object of the question, my eye is drawn immediately to the verb 'is'. Knowing grammar rules naturally made me inclined to start at the question word 'when' then think about what the common verbs that follow it are, here they are 'is', 'are', 'do', 'does', 'can'. I know that any prepositional phrases or extra verb phrases following the question verb are

auxiliary to the question, thus the object of the question is most likely the noun-phrase that is linked to the question verb, here 'the project'.

This agent is programmed with a basic knowledge of grammar rules, common verbs, contextual keywords, and built-in preferences that mimic those of the designer. This allows it to understand input questions in a manner similar to a human where the algorithms mirror those of human cognition. It is not feasible to preprogram the agent with a complete description of grammar rules and vocabulary which opens up the potential for learning. In later projects, it may be helpful to learn common idioms, contextual keywords and verbs, or other grammar rules to help the agent improve its understanding.

Testing

Test questions were generated based on the constraints provided in the instructions and with similar structure to the provided examples. The questions were given random objects to demonstrate that the agent is not hardcoded to seek out objects such as 'project' or 'assignment'. The questions consisted of multiple verb phrases and prepositional phrases to try to throw off the agent. Below is a table of 10 example questions used of the over 100 questions asked:

Number	Topic	Object	Question	Inferred Topic	Inferred Object	Understood?
1	PROCESS	survey	how do i complete the survery	PROCESS	survey	YES
2	WEIGHT	cat	how does my cat affect my grade	WEIGHT	cat	YES
3	RELEASEDATE	project 1	when should i check if project 1 is available	RELEASEDATE	project 1	YES
4	DUEDATE	dog	what day do i hand in my dog	DUEDATE	dog	YES
5	DURATION	paper	how much time do i have to work on my paper	DURATION	paper	YES
6	PROCESS	project 2	what site should i submit project 2 on the due date	DUEDATE	project 2	NO
7	DURATION	project	how many days after the release date can i work on the project	RELEASEDATE	many days after	NO
8	DUEDATE	final project	what time can i upload the final project	PROCESS	final project	NO
9	DUEDATE	project	when should my friend submit his project	DUEDATE	friend	NO
10	DUEDATE	paper	when does canvas say i need to submit the paper	DUEDATE	canvas	NO

Correctly Understanding

The agent was able to correctly understand these first 5 questions due to their directness and simplicity. These questions had clear cutoffs between topics and not so much confusion about the object that could be caused by many noun-phrases. Here, it may not have been necessary to use preferences to deconflict topics, but the internal knowledge helped.

Incorrectly Understanding

The agent was unable to correctly understand the latter 5 questions due to their ambiguity and complexity. These questions included keywords that belonged to multiple topics, and the use of weighted preferences had to be employed to attempt to deconflict. The use of uncommon verbs, keywords, prepositions, and other parts of speech can also confuse this agent as it was preprogrammed with a limited 'vocabulary'. It is difficult to include the entire Webster's Dictionary in the agent, and for a constrained problem such as this, it might not be necessary, although it can lead to an incorrect understanding.

References

Winston, P. H., (1992). *Artificial Intelligence Third Edition*. Retrieved from http://courses.csail.mit.edu/6.034f/ai3/ch10.pdf

English First, (2019). *English Grammar Guide*. Retrieved from http://www.ef.edu/english-resources/english-grammar/