Mini-Project 3 Journal

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1 AGENT IMPLEMENTATION

My agent solves the Sentence Reading Problem using a **rule-based system** that interprets a sentence-question pair and answers the question.

It utilizes the spaCy library to preprocess the vocabulary (i.e., the predefined 500 most common words), parsing text information such as verbs, nouns, pronouns, names, adjectives, adverbs, prepositions, colors, units, time words, question words, etc. This information is stored in my agent's working memory. As more test cases are exposed, the agent's working memory expands to include finer categories such as pronoun-subjects, pronoun-objects, and possessive pronouns to handle linguistic variety.

My agent follows a structure of a **production system**, applying **production rules**, which match patterns in the input pairs (i.e., a sentence and a related question), then extracts the answer from a frame-based representation. These production rules are expressed in a logical If-Then form and are grounded in **common-sense reasoning**, reflecting how humans interpret plain language. For example, simple production rules handle direct question types: if the question asks "where," the agent extracts and returns the location from the sentence. If the question asks "when," the agent identifies and returns the time expression. More sophisticated rules handle multi-argument sentences. In a complex sentence structure such as "She told her friend a story," the agent distinguishes between the indirect object (*friend*) and the direct object (*story*), selecting the correct one depending on the question type – returning the direct object if the question asks "what," and the indirect object if the question asks "who was."

Based on the interrogative words, a question is **classified** into five main types: *Who*, *What*, *Where*, *When*, and *How*. Each type contains subtypes. For example, *How* may indicate distances or durations ("how far," "how long"), quantities ("how much," "how many"), methods, etc.

Each sentence is represented as a **frame** containing slots such as subject, verb, object, time, and location. Each slot is filled with its corresponding element from the sentence (i.e., a filler).

Once the question type is identified, the corresponding production rules are activated to retrieve the relevant filler as the answer. If no rule applies, my agent returns an empty string as a fallback, which should not occur in well-formed test cases if the agent covers all patterns in the test case set.

2 AGENT PERFORMANCE

My agent passes 20 out of 20 test cases during the performance test, yielding correct outputs for all 20 sentence-question inputs. It receives full credit and does not struggle with any particular cases.

As explained in Section 1, my agent is rule-based. When it encounters a new pattern that it cannot initially solve, its production rules can be refined or expanded, and its working memory can be updated to accommodate the new linguistic structure. With exposure to more diverse cases, the agent's rule base, working memory, and frame representations improve over time. Through iterative refinements, my agent becomes capable of handling a broader range of sentence-question inputs and achieves high performance on the test cases.

3 AGENT EFFICIENCY

My agent performs efficiently by passing 20 out of 20 test cases within the allowed runtime and memory limits, receiving full credit.

My agent uses direct pattern matching by scanning the input word by word. The production rules are straightforward If-Then statements, which are deterministic and require no recursion, advanced searching, or backtracking.

Each sentence-question pair is tokenized and analyzed once, leading to a time complexity of $O(N)$, where N is the number of overall tokens. My agent checks a fixed number of production rules, and within each rule, it performs linear scans, so the worst-case time complexity remains $O(N)$. Membership checks (such as verifying whether a token is a noun) take constant lookup time, i.e., $O(1)$. Therefore, the total time complexity is $O(N)$. **As the sentence complexity grows, the runtime grows linearly with the number of input tokens.**

However, the rule-based system does not have the ability to generalize beyond its rule catalog. When my agent encounters an unseen sentence structure, manually adding new rules to its rule base is required to maintain performance.

4 AGENT OPTIMIZATION

My agent does the following things to arrive at answers efficiently.

First, it uses a predefined vocabulary and indexed categories, which are further divided into subgroups. As mentioned in Section 1, my agent categorizes pronouns into pronoun-subjects (e.g., *I*, *he*), pronoun-objects (e.g., *me*, *him*), and possessive pronouns (e.g., *my*, *his*). This structure allows fast and accurate lookups.

Second, my agent expands the production rule catalog to correctly interpret complex sentence structures such as "She told her friend a story," which contains a pronoun-subject (*she*), a possessive pronoun (*her*), an indirect object (*friend*), and a direct object (*story*). Specialized sub-rules are also added to handle expressions like "made of" or "made from."

Additionally, my agent utilizes frame-based representations to capture relationships among sentence components such as subjects, verbs, objects, time, and location, allowing flexible reasoning across different sentence structures and question types.

5 AGENT VS. HUMAN

My agent does not solve the problem the same way I do.

I can understand and answer each question almost instantly through natural language comprehension without consciously applying specific strategies. On the other hand, my agent follows a rigid sequence of If-Then rules. Whenever it encounters a keyword, the corresponding production rule is triggered to generate an answer for the question.

For cases within its knowledge base, my agent outperforms a human in efficiency. For unfamiliar cases that require generalization, my agent underperforms a human.

Locally, my agent answers 70 questions correctly in about 0.0032 seconds, much faster than human performance. However, when facing unfamiliar sentence structures or new question patterns, it fails immediately. As explained in Section 3, the rule-based agent has a poor generalization ability. As a human, I can generalize much better and adapt to new linguistic structures.

In most cases, people interpret questions similarly.

When the sentence structure is clear and no ambiguity exists, I feel that different people comprehend the sentence-question pair in the same way.

However, when the sentence-question pair has a complex structure or contains ambiguous expressions, different people may interpret it differently, which can lead to varying answers.