COURSEWORK 2

CSC-325 Artificial Intelligence

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Due: Thursday 22 April at 17:00. This is a hard deadline and set in relation to other submission deadlines.

Read and think through the whole coursework before starting to program.
Follow the instructions fully and accurately.

Submitting your coursework

A. Return your coursework in one Prolog file (.pl). Your filename must be in the following format:
CSC-325_2021_Coursework2_YOURSTUDENTNUMBER.pl
B. Submit the coursework file on the Canvas Assignments link.
C. The Prolog file should include:
   a. All your Prolog code, that is, the grammar rules and the lexicon.
   We should be able to execute and query your code to assess it;
   b. In comments, include the input query for each test sentence (below) along with the output.
D. While there may be different ways to write the grammar and lexicon, the output must be precise and fixed, as the results will be automatically checked. If the output does not match the intended output, you will lose 50% of the mark on that output.

Address the following in the coursework.

1. Write a DCG which parses input sentences and outputs a parse.
2. The DCG must parse sentences with the following features, some of which appeared earlier in lectures or labs, while others are explained further below:

   a. Transitive and intransitive verbs
   b. Common nouns
   c. Determiners (e.g., "a", "the", and "two")
   d. Subject/object singular/plural pronouns (e.g., "he", "him", "I", "we")
   e. Pronouns with grammatical person (e.g., "I", "you", "she")
   f. Singular/plural nouns (e.g., chair/chairs)
   g. Adjectives and adjectival phrases
   h. Prepositions and prepositional phrases
   i. Subject-verb agreement for person and number
   j. Determiner-common noun number agreement
   k. Animacy agreement between the subject and verb

3. The DCG should make use of separate grammar and lexicon. The lexicon must be included in your code and include all the words and word forms in The Lexicon below as well as what is needed for animacy.

4. The sample outputs (below) should be carefully studied and emulated by the parser. The categories, e.g., nbar, jp, adj, n, and parsing structure, e.g., nbar(jp(adj(tall), jp(adj(young), n(men)))), should appear n the output. Output that misses categories and parsing structures will be marked down 50%.

Demonstration of Work

To demonstrate that your code works as intended, your code should correctly recognise and give the right parse trees for the grammatical sentences in the list of test sentences (below) and fail for the ungrammatical sentences. In the list of test sentences below, an ungrammatical sentence is indicated with a * next to it, for example, "*the men sees the apples" is ungrammatical. We are not concerned with capitalisation or punctuation. For each sentence in the list of test sentences, query your parser and see that it correctly recognises or fails/false as well as outputs a correct parse. Copy the query and the output (parse or fails/false) into a commented section of your code. See the emphasised point about sample outputs below. Testing your parser with the test sentences is required. However, it would be wise to create further test sentences of your own. Generally, if issues or problems arise, report these in a discussion section.

Test sentences

1. the woman sees the apples
2. a woman knows him
3. *two woman hires a man
4. two women hire a man
5. she knows her
6. *she know the man
7. *us see the apple
8. we see the apple
9. i know a short man
10. *he hires they
11. two apples fall
12. the apple falls
13. the apples fall
14. i sleep
15. you sleep
16. she sleeps
17. *he sleep
18. *them sleep
19. *a men sleep
20. *the tall woman sees the red
21. the young tall man knows the old short woman
22. *a man tall knows the short woman
23. a man on a chair sees a woman in a room
24. *a man on a chair sees a woman a room in
25. the tall young woman in a room on the chair in a room in the room sees the red apples under the chair.

In addition to these sentences, your grammar should parse structures for animacy.

Structures for Animacy

Intuitively, we understand that people are animate (i.e., act under their own volition), while objects such as apples, chairs, and rooms are inanimate (i.e., do not act under their own volition, but are acted upon). We see that some verbs only allow animate subjects, while other verbs can take either animate or inanimate subjects. Add to your parser and lexicon aspects to correctly parse such sentences.

Test sentences (continued)

26. the woman sees the apples
27. a woman knows him
28. the man sleeps
29. *the room sleeps
30. *the apple sees the chair
31. *the rooms know the man
32. the apple falls
33. the man falls

Sample Outputs (this example highlights the categories and structures):

?- s(Tree,[she,knows,her],[]).
Tree = s(np(pro(she)), vp(v(knows), np(pro(her)))).

?- s(Tree, [the, woman, on, two, chairs, in, a, room, sees, two, tall, young, men], []).
Tree = s(np(det(the), nbar(n(woman)), pp(prep(on), np(det(two), nbar(n(chairs)), pp(prep(in), np(det(a), nbar(n(room)))))), vp(v(sees), np(det(two), nbar(jp(adj(tall), jp(adj(young), n(men)))))))

The output in this example should be carefully studied and emulated by the parser. The categories, e.g., nbar, jp, adj, n, and parsing structure, e.g., nbar(jp(adj(tall), jp(adj(young), n(men)))), should appear in the output. Output that misses categories and parsing structures will be marked down 50%.

Caveat: the grammar you are writing should recognize the relevant sentences (those above and many others) and fail on others. If you generate more sentences or provide further examples for recognition, you will quickly see that there are many odd or ungrammatical sentences that this grammar recognises. Writing a "real" grammar for a fragment of natural language must take into account a range of properties, e.g. ordering of prepositional phrases, pragmatics, etc., which we are not addressing in this exercise. Going "hard core" in the world of computational linguistic parsing and semantic representation means facing lots of hard, complex, and very interesting issues of natural language.

Extra recognition: if you are inclined to engage with further discussion, work on other examples, further extensions, or other languages, you are welcome to share it in your file in a discussion section. There is no additional mark per se. You will get remarks in return from the lecturer.

Marking Scheme

A total score of 100 broken down as follows:

- 34 marks for the code listing
- 66 marks total for all the correct parse trees (1-33), where 2 marks for each fully correct parse tree and 1 mark each for a partially correct parse tree.

Notes on grammatical constructions

Pronouns

Pronouns (e.g. he/him, I/we) have features such as number (singular/plural) and grammatical role (subject/object). In addition, pronouns have features such as grammatical person, e.g. first person "i", second person "you", third person "she". Grammatical person indicates a closer or more distant relationship between the speaker of the sentence and other persons: "I see the apple" represents the most personal statement (first person); "You see the apple" is between the speaker and a person who is immediately present; and "He sees the apple" is the most distant, as it can relate to a person who is not immediately present or somehow less ``relevant''. As the examples above show, there is subject-verb agreement for number, grammatical role, and grammatical person.

Structures for NPs with Adjectives and Prepositional Phrases

For our purposes, an adjective such as tall describes a property of a common noun such a man. The adjective precedes the noun. For example: the tall man sees the woman is grammatical; the man tall sees the woman is ungrammatical. You can have any number of adjectives, for example: the tall tall old man sees the woman; the tall tall old old man sees the woman.

For our purposes, a prepositional phrase modifies a noun, and it is made up of a preposition and a noun phrase. The preposition provides information about the relative locations of the nouns i.e., the noun that is modified and the noun within the prepositional phrase. The prepositional phrase follows the noun that it modifies: The man in the room sees a woman on a chair. We see the in relation between man and room. You can have any number of prepositional phrases, for example: the woman in a room on the chair in a room in the room sees the man.

As an adjective or prepositional phrase modifies a noun phrase, it can appear with the noun phrase in either the subject or the object position.

As a helpful hint about the grammar of adjectives and prepositional phrases in noun phrases, see the phrase tree for a sample sentence below. It indicates the grammatical structure of the categories and phrase structure for adjectives and prepositional phrases in noun phrases; though somewhat complicated, it shows the variety of structures. While the grammatical structure of jp and nbar are unfamiliar, we can take them as given. Use these categories and phrase structures for your grammar. Given such input (and similar), your parser should produce the same output :.

?- s(Tree, [the, woman, on, two, chairs, in, a, room, sees, two, tall, young, men], []).
Tree = s(np(det(the), nbar(n(woman)), pp(prep(on), np(det(two), nbar(n(chairs)), pp(prep(in), np(det(a), nbar(n(room)))))), vp(v(sees), np(det(two), nbar(jp(adj(tall), jp(adj(young), n(men)))))))

The Lexicon

The lexicon should include all the following words that appear, where the components of each lexical entry are as given. This is not the form that your code requires, but is a helpful hint.

Note: if you are going to add animacy, you need to see add it in the lexicon.

word, grammatical category (pronoun), number (singular/plural), grammatical person (1st, 2nd, or 3rd), and grammatical role (subject or object)

i,pro,singular,1,subject
you,pro,singular,2,subject
he,pro,singular,3,subject
she,pro,singular,3,subject
it,pro,singular,3,subject
we,pro,plural,1,subject
you,pro,plural,2,subject
they,pro,plural,3,subject
me,pro,singular,1,object
you,pro,singular,2,object
him,pro,singular,3,object
her,pro,singular,3,object
it,pro,singular,3,object
us,pro,plural,1,object
you,pro,plural,2,object
them,pro,plural,3,object

word, grammatical category (verb), number (singular/plural), grammatical person (1st, 2nd, 3rd)

know,tv,singular,1
know,tv,singular,2
knows,tv,singular,3
know,tv,plural,_
see,tv,singular,1
see,tv,singular,2
sees,tv,singular,3
see,tv,plural,_
hire,tv,singular,1
hire,tv,singular,2
hires,tv,singular,3
hire,tv,plural,_
fall,iv,singular,1
fall,iv,singular,2

falls,iv,singular,3
fall,iv,plural,_
sleep,iv,singular,1
sleep,iv,singular,2
sleeps,iv,singular,3
sleep,iv,plural,_

word, grammatical category (determiner), number

the,det,_
a,det,singular
two,det,plural

word, grammatical category (noun), number

man,n,singular
woman,n,singular
apple,n,singular
chair,n,singular
room,n,singular
men,n,plural
women,n,plural
apples,n,plural
chairs,n,plural
rooms,n,plural

word, grammatical category (preposition)

on,prep
in,prep
under,prep

word, grammatical category (adjective)

old,adj
young,adj
red,adj
short,adj
tall,adj