**Homework 3: Context Free Grammars**

**Part 1: Writing grammar rules**

1. Arthur rides the plodding horse near the castle.
   1. Misc17= Adj
   2. NP -> Det Adj NP

The first sentence to match up added an adjective to a noun. The CFG was not capable of handling this, so we first had to come up with a rule to create a Noun Phrase that included an adjective.

1. The Holy Grail is a sacred chalice.
   1. Misc 11 = Prop\_np (not people)
   2. NP -> Det Prop\_np

The Holy Grail is a proper noun, but it is not considered a regular proper noun since it does not refer to a person. To handle this, we needed to add a Determinant and Proper Noun combination to create a Noun Phrase since ‘The Holy Grail’ is the main part of the sentence.

1. Every coconut was carried to the hottest mountains.
   1. Misc17 = VerbP
   2. Misc19 = VerbPP
   3. Misc9 = AdjS
   4. Misc10 = PNoun
   5. NP -> Det AdjS PNoun
   6. Verb -> VerbP VerbPP TO
   7. VP -> Verb NP

Sentence three introduced four new objects to the equation. We created one three more logics to handle these new inputs. Some verbs and verb add-ons work as one in this case. ‘Was’ and ‘carried’ when together, work as one verb, so I created a new object to handle this case. The rest of the logics are very simple.

1. Sixty strangers are at the Round Table.
   1. Misc21 = PVerbT
   2. NP -> Det Prop\_np
   3. VP -> PVerbT PP
   4. NP -> Num PNoun

Here we just had to handle simple new objects that were added. The new verb type needed to be added to the verb phrase object as a rule.

1. Sir Lancelot might have spoken.
   1. Misc6 -> Modal
   2. Misc16 -> VerbB
   3. Verb -> VerbB VerbPP
   4. VP -> Modal Verb

A completely new type of object was added called the modal. The ‘might’ in the sentence adds an intent to the action of the verb. Therefore, it should be considered as part of a verb phrase.

1. Guinevere had been riding with Patsy for five weary nights.
   1. Misc18 -> VerbPresP
   2. AP -> Num Adj
   3. NP -> AP PNoun
   4. NP -> VerbPresP PP
   5. VP -> Verb NP PP

The AP object was created to handle Adjective Phrases. The AP is used to stop the creating of Noun Phrases when necessary. The ‘five weary nights’ part of the sentence has two noun modifiers following one another, so the AP object helped us handle that.

1. Sir Bedevere might have been suggesting this quest.
   1. VP -> Modal Verb NP

Sentence seven introduces a very complex verb phrase where the verb part contains three words. The model was added to the creation of a Verb Phrase.

1. The Britons migrate south frequently.
   1. Misc12 = PProper
   2. Misc 15 -> AdV
   3. NP -> PProper
   4. AdVP -> VerbB AdV AdV
   5. VP -> AdVP

Two new objects are introduced. The ‘Britons’ is a plural proper noun which can be handled by simple making it a Noun Phrase itself.

1. Arthur and Guinevere ride frequently near the castle.
   1. Misc2 -> CoConj
   2. AdVP -> VerbB AdBV
   3. VP <- AdVP PP
   4. CP-> Proper CoConj Proper
   5. NP -> CP

The use of a conjunction is introduced where two proper nouns are added. I went ahead and added a simple rule that creates a noun phrase for this specific case instead of adding NP CoConj NP where it would take any noun phrase and the conjunction and use them together. This would have caused confusion later on if the CoConj was used differently.

1. He suggests to grow fruit at home.
   1. Misc13 -> PerP
   2. Misc20 = SVerb
   3. PerP -> NP
   4. AdVP -> TO VerbB
   5. VP -> SVerb AdVP NP

First use of a personal pronoun. It acts very similar to a proper noun. The complicated part of this sentence is to handle the object ‘TO’. Since it adds to the action of the verb, I considered it to be an add-on to the verb, so I created a new object to handle this case called the AdVP (Add-ons to the verb).

1. Riding to Camelot is not hard.
   1. AP -> NOT Adj
   2. VP -> VerbT AP
   3. NP -> VerbPresP TO Prop\_np

Here we see the first use of a gerund phrase. The gerund phrase can be confused as a Verb Phrase, but it is actually a Noun Phrase. Therefore, we went ahead and created a rule to put the make it part of the object of the sentence.

1. Do coconuts speak?
   1. QUES -> DO
   2. S1 -> QUES NP VP Eos

This is the first time we see a question, and also the first time we see the object ‘DO’ being used. To handle questions, I created a separate object called ‘QUES’ which can identify when a sentence starts with question words like ‘do’, ‘does’, and all the ones that start with ‘Wh’. To finalize this CFG, we also have to identify this as a sentence. The previous sentences had a different noun verb structure, but questions are handled differently, so we created a new rule for sentences.

1. Why does England have a king?
   1. Misc25 = Wh
   2. QUES -> Wh DO
   3. VP -> PVerbT NP
   4. NP -> Prop\_np

Had to simple handle the ‘Wh’ objects like mentioned in sentence 12. Once that was completed, we just had to create a Verb Phrase and a Noun Phrase.

**CFG Output for Part 1:**

['Arthur', 'is', 'the', 'king', '.']

(START

(S1

(NP (Proper Arthur))

(VP (VerbT is) (NP (Det the) (NP (Noun king))))

(Eos .)))

['Arthur', 'rides', 'the', 'horse', 'near', 'the', 'castle', '.']

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP

(Det the)

(NP

(Noun horse)

(PP (Prep near) (NP (Det the) (NP (Noun castle)))))))

(Eos .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP (Det the) (NP (Noun horse)))

(PP (Prep near) (NP (Det the) (NP (Noun castle)))))

(Eos .)))

['Arthur', 'rides', 'the', 'plodding', 'horse', 'near', 'the', 'castle', '.']

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP (AP (Det the) (Adj plodding)) (Noun horse))

(PP (Prep near) (NP (Det the) (NP (Noun castle)))))

(Eos .)))

['the', 'Holy\_Grail', 'is', 'a', 'chalice', '.']

(START

(S1

(NP (Det the) (NP (Prop\_np Holy\_Grail)))

(VP (VerbT is) (NP (Det a) (NP (Noun chalice))))

(Eos .)))

(START

(S1

(NP (Det the) (Prop\_np Holy\_Grail))

(VP (VerbT is) (NP (Det a) (NP (Noun chalice))))

(Eos .)))

['the', 'sensational', 'Holy\_Grail', 'is', 'a', 'sacred', 'chalice', '.']

(START

(S1

(NP (AP (Det the) (Adj sensational)) (Prop\_np Holy\_Grail))

(VP (VerbT is) (NP (AP (Det a) (Adj sacred)) (Noun chalice)))

(Eos .)))

['every', 'coconut', 'was', 'carried', 'to', 'the', 'hottest', 'mountains', '.']

(START

(S1

(NP (Det every) (NP (Noun coconut)))

(VP

(Verb (VerbP was) (VerbPP carried) (TO to))

(NP (AP (Det the) (AdjS hottest)) (PNoun mountains)))

(Eos .)))

['sixty', 'strangers', 'are', 'at', 'the', 'Round\_Table', '.']

(START

(S1

(NP (Num sixty) (PNoun strangers))

(VP

(PVerbT are)

(PP (Prep at) (NP (Det the) (NP (Prop\_np Round\_Table)))))

(Eos .)))

(START

(S1

(NP (Num sixty) (PNoun strangers))

(VP

(PVerbT are)

(PP (Prep at) (NP (Det the) (Prop\_np Round\_Table))))

(Eos .)))

['Sir\_Lancelot', 'might', 'have', 'spoken', '.']

(START

(S1

(NP (Proper Sir\_Lancelot))

(VP (Modal might) (Verb (VerbB have) (VerbPP spoken)))

(Eos .)))

['Guinevere', 'had', 'been', 'riding', 'with', 'Patsy', 'for', 'five', 'weary', 'nights', '.']

(START

(S1

(NP (Proper Guinevere))

(VP

(Verb (VerbP had) (VerbPP been))

(NP (VerbPresP riding) (PP (Prep with) (NP (Proper Patsy))))

(PP (Prep for) (NP (AP (Num five) (Adj weary)) (PNoun nights))))

(Eos .)))

['Sir\_Bedevere', 'might', 'have', 'been', 'suggesting', 'this', 'quest', '.']

(START

(S1

(NP (Proper Sir\_Bedevere))

(VP

(Modal might)

(Verb (VerbB have) (VerbPP been))

(NP (VerbPresP suggesting) (NP (Det this) (NP (Noun quest)))))

(Eos .)))

['the', 'Britons', 'migrate', 'south', 'frequently', '.']

(START

(S1

(NP (Det the) (NP (PProper Britons)))

(VP (AdVP (VerbB migrate) (AdV south) (AdV frequently)))

(Eos .)))

['Arthur', 'and', 'Guinevere', 'ride', 'frequently', 'near', 'the', 'castle', '.']

(START

(S1

(NP (CP (Proper Arthur) (CoConj and) (Proper Guinevere)))

(VP

(AdVP (VerbB ride) (AdV frequently))

(PP (Prep near) (NP (Det the) (NP (Noun castle)))))

(Eos .)))

['he', 'suggests', 'to', 'grow', 'fruit', 'at', 'home', '.']

(START

(S1

(NP (PerP he))

(VP

(SVerb suggests)

(AdVP (TO to) (VerbB grow))

(NP (Noun fruit) (PP (Prep at) (NP (Noun home)))))

(Eos .)))

['riding', 'to', 'Camelot', 'is', 'not', 'hard', '.']

(START

(S1

(NP (VerbPresP riding) (TO to) (Prop\_np Camelot))

(VP (VerbT is) (AP (NOT not) (Adj hard)))

(Eos .)))

['do', 'coconuts', 'speak', '?']

(START

(S1

(QUES (DO do))

(NP (PNoun coconuts))

(VP (VerbB speak))

(Eos ?)))

['why', 'does', 'England', 'have', 'a', 'king', '?']

(START

(S1

(QUES (Wh why) (DO does))

(NP (Prop\_np England))

(VP (PVerbT have) (NP (Det a) (NP (Noun king))))

(Eos ?)))

**Part 2: Exemplar Sentences**

Part A): Make up a sentence that uses some of the same words in the sentences that you already parsed and is an actual English sentence, but cannot be parsed by those rules.

Sentence: “The Holy Grail and Arthur is a sensational story.”

My current solution solved the CFG by using very specific logic to the given sentences. I did not make a CFG that could be applied to any sentence in a book. The complexity of the different types of objects and their interactions can be described by many rules, and if you pick the most abstract of those rules, then many problems will follow as many more sentences can follow the rule.

Output:

['the', 'Holy\_Grail', 'and', 'Arthur', 'is', 'a', 'sensational', 'story', '.']

Part B): Make up a string of words that should not be an actual English sentence, but your grammar will parse it.

The current CFG rules only look for NP VP combination. It does not matter if the combination does not make sense. Here the action speak castle has no meaning what so ever, but since there is a noun after the verb, the CFG will consider it a Verb Phrase.

Output:

['Holy\_Grail', 'speak', 'castle', '.']

(START

(S1

(NP (Prop\_np Holy\_Grail))

(VP (PVerbT speak) (NP (Noun castle)))

(Eos .)))