**IST 664 – NLP Homework 3**

**Writing a CFG (Context-Free Grammar)**

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**Introduction & Background**

This homework was focused on Context Free Grammar and creating rules to be able to tag/parse different vocabulary. In the following report several sentences will be parsed, along the rules added to the CFG to do so and also a brief explanation of each parsing tree. The final section pertains to sentences unable to be parsed by the CFG rules along with a few sentences that make no logical sense but were able to be parsed.

**Analysis Process**

**Part 1**

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

(START

(S1

(NP (Proper Arthur))

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

(Eos .)))

(START

(S1

(NP (Proper Arthur))

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

(Eos .)))

**Explanation:** This sentence was able to be parsed with the initial CFG rules provided. The parse included tagging ‘Arthur’ as a Proper Noun in the Noun Phrase. The rest of the sentence is a Verb Phrase tagging ‘is’ as a 3rd person singular present verb, ‘the’ as a determinant and ‘king’ as a Noun.

**Rule Added:** None

['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) (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 .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

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

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

(Eos .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP (Det the) (Noun horse))

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

(Eos .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP (Det the) (Noun horse))

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

(Eos .)))

**Explanation:** This sentence was able to be parsed with the initial CFG rules provided. As shown above, this sentence was able to be parsed in many ways. The optimal way included tagging ‘Arthur’ as a Proper Noun in the Noun Phrase first. Then, the Verb Phrase “rides the horse near the castle” was parsed tagging ‘rides’ as a 3rd person singular present verb, ‘the’ as a Determinant, ‘horse’ as a Noun, ‘near’ as a preposition, ‘the’ again as a Determinant and finally ‘castle’ as a Noun.

**Rule Added:** None

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

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP

(Det the)

(adj plodding)

(NP

(Noun horse)

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

(Eos .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP

(Det the)

(adj plodding)

(NP

(Noun horse)

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

(Eos .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP (Det the) (adj plodding) (NP (Noun horse)))

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

(Eos .)))

(START

(S1

(NP (Proper Arthur))

(VP

(VerbT rides)

(NP (Det the) (adj plodding) (NP (Noun horse)))

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

(Eos .)))

**Explanation:** This sentence was parsed tagging ‘Arthur’ as a Proper Noun in the Noun Phrase first. Then, the Verb Phrase “rides the plodding horse near the castle” was parsed tagging ‘rides’ as a 3rd person singular present verb, ‘the’ as a Determinant, ‘plodding’ as an adjective, ‘horse’ as a Noun, ‘near’ as a preposition, ‘the’ again as a Determinant and finally ‘castle’ as a Noun.

**Rule Added:** *‘Det adj NP’* to Noun Phrases

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

(START

(S1

(NP (Det the) (NP (nnp Holy\_Grail)))

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

(Eos .)))

(START

(S1

(NP (Det the) (NP (nnp Holy\_Grail)))

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

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “The Holy Grail” with ‘the’ as a Determinant and ‘Holy Grail’ as Non-People Proper Noun. Then, the Verb Phrase “is a chalice” was parsed tagging ‘is’ as a 3rd person singular present verb, ‘a’ as a Determinant and finally ‘chalice’ as a Noun.

**Rule Added:** *‘nnp’* to Noun Phrases

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

(START

(S1

(NP (Det the) (adj sensational) (NP (nnp Holy\_Grail)))

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

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “The sensational Holy Grail” with ‘the’ as a Determinant, ‘sensational’ as an adjective and ‘Holy Grail’ as Non-People Proper Noun. Then, the Verb Phrase “is a sacred chalice” was parsed tagging ‘is’ as a 3rd person singular present verb, ‘a’ as a Determinant, ‘sacred’ as an adjective and finally ‘chalice’ as a Noun.

**Rule Added:** *‘nnp’* to Noun Phrases

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

(START

(S1

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

(VP

(vbd was)

(vbn carried)

(TO to)

(NP (Det the) (jjs hottest) (nns mountains)))

(Eos .)))

(START

(S1

(NP (Det every) (Noun coconut))

(VP

(vbd was)

(vbn carried)

(TO to)

(NP (Det the) (jjs hottest) (nns mountains)))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “Every coconut” with ‘every’ as a Determinant and ‘coconut’ as a Noun. Then, the Verb Phrase “was carried to the hottest mountains” was parsed tagging ‘was’ as a Past Tense Verb, ‘carried’ as a Past Participle Verb, ‘to’ defined as TO, and finally by the NP tagging ‘the’ as an Determinant, ‘hottest’ as an Superlative Adjective and ‘mountains’ as a Plural Noun.

**Rule Added:** *‘vbd vbn TO NP’* to Verb Phrases and *‘Det jjs nns‘* to Noun Phrases

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

(START

(S1

(NP (cd sixty) (nns strangers))

(VP

(vbzp are)

(PP (Prep at) (NP (Det the) (NP (nnp Round\_Table)))))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “Sixty strangers” with ‘sixty’ as a Number and ‘strangers’ as a Plural Noun. Then, the Verb Phrase “are at the Round Table” was parsed tagging ‘are’ as a 3rd Person Plural Present Verb, the Prepositional Phrase tagging ‘at’ as a Preposition, and a Noun Phrase tagging ‘the’ as a Determinant and ‘Round Table’ as a Non-People Proper Noun.

**Rule Added:** *‘vbzp PP’* to Verb Phrases and *‘cd nns’* to Noun Phrases

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

(START

(S1

(NP (Proper Sir\_Lancelot))

(VP (md might) (vbzp have) (vbn spoken))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Proper Noun ‘Sir Lancelot’ in the Noun Phrase to start. Then, the Verb Phrase “might have spoken” was parsed tagging ‘might’ as a Modal, ‘have’ as a 3rd Person Plural Present Verb and ‘spoken’ as a Past Participle Verb.

**Rule Added:** *‘md vbzp vbn’* to Verb Phrases

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

(START

(S1

(NP (Proper Guinevere))

(VP

(vbd had)

(vbn been)

(vbg riding)

(PP

(Prep with)

(NP

(Proper Patsy)

(PP (Prep for) (NP (cd five) (adj weary) (nns nights))))))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Proper Noun ‘Guinevere’ in a Noun Phrase to start. Then, the Verb Phrase “had been riding with Patsy for five weary nights” was parsed tagging ‘had’ as a Past Tense Verb, ‘been’ as a Past Participle Verb and ‘riding’ as a Present Participle Verb. The next part of the Verb Phrase included the Prepositional Phrase tagging ‘with’ as a Preposition, the Noun Phrase tagging ‘Patsy’ as a Proper Noun, the Prepositional Phrase tagging ‘for’ as a Preposition, and the Noun Phrase tagging ‘five’ as a Number, ‘weary’ as an adjective and ‘nights’ as a Plural Noun.

**Rule Added:** *‘vbd vbn vbg PP’* to Verb Phrases. *‘Proper PP’* and *‘cd adj nns’* to Noun Phrases.

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

(START

(S1

(NP (Proper Sir\_Bedevere))

(VP

(md might)

(vbzp have)

(vbn been)

(vbg suggesting)

(NP (Det this) (NP (Noun quest))))

(Eos .)))

(START

(S1

(NP (Proper Sir\_Bedevere))

(VP

(md might)

(vbzp have)

(vbn been)

(vbg suggesting)

(NP (Det this) (Noun quest)))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Proper Noun ‘Sir Bedevere’ in a Noun Phrase to start. Then, the Verb Phrase “might have been suggesting this quest” was parsed tagging ‘might’ as a Modal, ‘have’ as a 3rd Person Plural Present Verb, ‘been’ as a Past Participle Verb and ‘suggesting’ as a Present Participle Verb. The next part of the Verb Phrase included a Noun Phrase tagging ‘this’ as a Determinant and ‘quest’ as a Noun.

**Rule Added:** *‘md vbzp vbn vbg NP’* to Verb Phrases

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

(START

(S1

(NP (Det the) (nnps Britons))

(VP (vbzp migrate) (rb south) (rb frequently))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “The Britons” with ‘the’ as a Determinant and ‘Britons’ as a Plural Proper Noun. Then, the Verb Phrase “migrate south frequently” was parsed tagging ‘migrate’ as a 3rd Person Plural Present Verb, and ‘south’ and ‘frequently’ as Adverbs.

**Rule Added:** *‘vbzp rb rb’* to Verb Phrases and *‘Det nnps‘* to Noun Phrases

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

(START

(S1

(NP (Proper Arthur) (cc and) (Proper Guinevere))

(VP

(vbzp ride)

(rb frequently)

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

(Eos .)))

(START

(S1

(NP (Proper Arthur) (cc and) (Proper Guinevere))

(VP

(vbzp ride)

(rb frequently)

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

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “Arthur and Guinevere” with ‘Arthur’ as a Proper Noun, ‘and’ as a coordinating conjunction and ‘Guinevere’ as a Proper Noun. Then, the Verb Phrase “ride frequently near the castle” was parsed tagging ‘ride’ as a 3rd Person Plural Present Verb, ‘frequently’ as an Adverb, the Prepositional Phrase tagging ‘near’ as a Preposition, and the Noun Phrase tagging ‘the’ as a Determinant and ‘castle’ as a Noun.

**Rule Added:** *‘Proper cc Proper’* and *‘Det Noun’* to Noun Phrases

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

(START

(S1

(NP (prp he))

(VP

(vbz suggests)

(TO to)

(vbzp grow)

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

(Eos .)))

**Explanation:** This sentence was parsed tagging the Personal Pronoun ‘he’ in a Noun Phrase to start. Then, the Verb Phrase “suggests to grow fruit at home” was parsed tagging ‘suggests’ as a 3rd Person Singular Verb, ‘to’ defined as TO, ‘grow’ as a 3rd Person Plural Present Verb, the Noun Phrase tagging ‘fruit’ as a Noun, ‘at’ as a Preposition and ‘home’ as a Noun.

**Rule Added:** *‘vbzp NP’* to Verb Phrases and *‘prp’* to Noun Phrases

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

(START

(S1

(VP

(vbg riding)

(TO to)

(NP (nnp Camelot))

(VP (VerbT is) (NOT not) (NP (adj hard))))

(Eos .)))

**Explanation:** This entire sentence was parsed as a Verb Phrase. The tagging included ‘riding’ as a Present Participle Verb, ‘to’ defined as TO, the Noun Phrase tagging ‘Camelot’ as a Non-People Proper Noun, ‘is’ as a 3rd Person Singular Present Verb, ‘not’ defined as NOT, and the Noun Phrase tagging ‘hard’ as an adjective.

**Rule Added:** *‘VP Eos’* to S1. *‘vbg TO NP VP’* and *‘VerbT NOT NP’* to Verb Phrases. *‘adj’* to Noun Phrases.

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

(START (S1 (NP (DO do) (nns coconuts)) (VP (vbzp speak)) (Eos ?)))

**Explanation:** This entire sentence was parsed as a Noun Phrase. The tagging included ‘do’ defined as Do/Does, ‘coconuts’ as a Plural Noun, and a Verb Phrase tagging ‘speak’ as a 3rd Person Plural Present Verb.

**Rule Added:** *‘vbzp’* to Verb Phrases and *‘DO nns’* to Noun Phrases

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

(START

(S1

(NP (wrb why) (DO does) (nnp England))

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

(Eos ?)))

(START

(S1

(NP (wrb why) (DO does) (nnp England))

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

(Eos ?)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “Why does England” with ‘why’ as a Wh-Adverb, ‘does’ defined as Do/Does and ‘England’ as a Non-People Proper Noun. Then, the Verb Phrase “have a king” was parsed tagging ‘have’ as a 3rd Person Plural Present Verb, a Noun Phrase tagging ‘a’ as a Determinant and ‘king’ as a Noun.

**Rule Added:** *‘vbzp NP’* to Verb Phrases and *‘wrb DO nnp’* to Noun Phrases

**2 Challenge Sentences**

['either', 'Arthur', 'knows', 'or', 'Patsy', 'does', '.']

(START

(S1

(NP (cc either) (Proper Arthur))

(VP (vbz knows) (NP (cc or) (Proper Patsy) (DO does)))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Noun Phrase “either Arthur” with ‘either’ as a Coordinating Conjunction and ‘Arthur’ as a Proper Noun. Then, the Verb Phrase “knows or Patsy does” was parsed tagging ‘knows’ as a 3rd Person Singular Verb and a Noun Phrase tagging ‘or’ as a Coordinating Conjunction, ‘Patsy’ as a Proper Noun, and ‘does’ defined as Do/Does.

**Rule Added:** *‘vbz NP’* to Verb Phrases. *‘cc Proper’* and *‘cc Proper Do’* to Noun Phrases

['he', 'knows', 'what', 'they', 'are', 'covering', 'with', 'that', 'story', '.']

(START

(S1

(NP (prp he))

(VP

(vbz knows)

(wdt what)

(NP (prp they))

(VP

(vbzp are)

(vbg covering)

(PP (Prep with) (NP (Det that) (NP (Noun story))))))

(Eos .)))

(START

(S1

(NP (prp he))

(VP

(vbz knows)

(wdt what)

(NP (prp they))

(VP

(vbzp are)

(vbg covering)

(PP (Prep with) (NP (Det that) (Noun story)))))

(Eos .)))

(START

(S1

(NP (prp he))

(VP

(vbz knows)

(wdt what)

(NP (prp they))

(VP

(vbzp are)

(vbg covering)

(PP (Prep with) (NP (IN that) (Noun story)))))

(Eos .)))

**Explanation:** This sentence was parsed tagging the Personal Pronoun ‘he’ in a Noun Phrase to start. Then, the Verb Phrase “knows what they are covering with that story” was parsed tagging ‘knows’ as a 3rd Person Singular Verb, ‘what’ as a Wh-Determiner, a Noun Phrase tagging ‘they’ as a Personal Pronoun, a Verb Phrase tagging ‘are’ as a 3rd Person Plural Present Verb, ‘covering’ as a Present Participle Verb, a Prepositional Phrase tagging ‘with’ as Preposition, and a Noun Phrase tagging ‘that’ defined as IN and ‘story’ as a Noun.

**Rule Added:** *‘vbz wdt NP VP’ and ‘vbzp vbq PP’* to Verb Phrases. *‘IN Noun’* to Noun Phrases

**Part 2**

**2 sentences created with similar words that could not be parsed**

['Sir\_Lancelot', 'carried', 'the', 'coconut', 'they', 'spoke', 'of', '.']

**Explanation:** This sentence could not be parsed because a new rule including ‘vbd NP VP’ would need to be added to the rules in order to handle Past Tense Verb ‘carried’. This is where the parsing gets caught up and cannot continue.

['Arthur', 'should', 'know', 'of', 'the', 'bloodiest', 'nights', '.']

**Explanation:** This sentence could not be parsed because a new rule including ‘md vbzp NP VP’ would need to be added to the rules to handle the “should know of bloodiest nights”. This is where the parsing gets caught up and cannot continue.

**2 sentences that made no sense but were able to be parsed**

['Arthur', 'either', 'Guinevere', 'is', 'not', 'swallow', '.']

(START

(S1

(NP (Proper Arthur) (cc either) (Proper Guinevere))

(VP (VerbT is) (NOT not) (NP (Noun swallow)))

(Eos .)))

**Explanation:** Although this sentence does not make sense, it was able to be parsed by tagging the Noun Phrase “Arthur either Guinevere” with ‘Arthur’ as a Proper Noun, ‘either’ as a Coordinating Conjunction and ‘Guinevere’ as a Proper Noun. Then, the Verb Phrase “is not swallow” was parsed tagging ‘is’ as a 3rd Person Singular Present Verb, ‘not’ defined as NOT, and the Noun Phrase tagging ‘swallow’ as a Noun. Overgeneralization was the issue here. The ‘*Proper cc Proper’* rule needs to be refined in order to eliminate the error. Further refinement to the ‘*VerbT NOT NP’* rule also needs to be done.

['castle', 'knows', 'sixty', 'halves', '.']

(START

(S1

(NP (Noun castle))

(VP (vbz knows) (NP (cd sixty) (nns halves)))

(Eos .)))

**Explanation:** Although this sentence does not make sense, it was able to be parsed by tagging the Noun ‘castle’ in a Noun Phrase to start. Then, the Verb Phrase “knows sixty halves” was parsed tagging ‘knows’ as a 3rd Person Singular Verb, a Noun Phrase tagging ‘sixty’ as a Number and ‘halves’ as a Plural Noun. Overgeneralization was the issue here. The ‘*vbz NP’* rule needs to be refined in order to eliminate this overgeneralization error.