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CS 6320.002

HOMEWORK 2

PROBLEM 1: CKY PARSER

The Hw2_CKYparser.py program is executed separately for each of the 4 sentences.
Initially CFG is inputted from the grammar file and this is converted to CNF by the program and written to the same grammar file. After this, CNF Grammar produced is cross-checked with the one manually derived. Then the CKY algorithm is run on the CNF Grammar hereafter and the output is produced.

Sentence 1:
Sales of the company to return to normalcy.

CFG:
Root → S
S → NP1 PUNC
INFVP → TO VP
VP → VB PP
NP → Det NN INFVP
NP1 → NNS PP
PP → IN NP
PP → TO NN

Lexicon:
Det → 'the'
IN →'of'
NNS → 'Sales'
NN → 'company' | 'normalcy'
VB → 'return'
TO → 'to'
PUNC → '.'

CNF Grammar
Root → NP1 PUNC // Substitute single non-terminal S with its rule for Root
S → NP1 PUNC
INFVP → TO VP
VP → VB PP
NP → X1 INFVP //new variable X1 to make NP rule in the form A → B C
NP1 → NNS PP
PP → IN NP
PP → TO NN
X1 → Det NN

Sentence 2:
The new products and services contributed to increase revenue.

CFG:
Root → S
S → NP VP
NP → NP CC NNS
NP → DT JJ NNS
VP → VBD VP
VP → TO VP
VP → VB NN

Lexicon:
DT → 'The'
TO → 'to'
VBD → 'contributed'
VB → 'increase'
NNS → 'products' | 'services'
NN → 'revenue'
CC → 'and'
JJ → 'new'

CNF Grammar:
Root → NP VP // Substitute single non-terminal S with its rule for Root
S → NP VP // new variable X1 to make NP rule in the form A → B C
NP → X1 NNS // new variable X2 to make NP rule in the form A → B C
NP → X2 NNS
VP → VBD VP
VP → TO VP
VP → VB NN
X1 → NP CC
X2 → DT JJ

Sentence 3:
Dow falls as recession indicator flashed red and economical worries continue through the month.

CFG:
Root → S
S → NP VP
NP → NNP
NP → NN NN
NP → JJ NNS
NP → DT NN
ADJP → JJ
VP → VBD ADJP
VP → VBZ SB
VP → VBP PP

SB → SB CC S
SB → IN S
PP → IN NP

Lexicon:
DT → 'the'
CC → 'and'
NNP → 'Dow'
NN → 'recession' | 'indicator' | 'month'
NNS → 'worries'
JJ → 'red' | 'economical'
VBZ → 'falls'
VBD → 'flashed'
VBP → 'continue'
IN → 'as' | 'through'

CNF Grammar:
Root → NP VP // Substitute single non-terminal S with its rule for Root
S → NP VP
NP → 'Dow' // Converting single non-terminal NNP to the lexicon value for NP rule
NP → NN NN
NP → JJ NNS
NP → DT NN
ADJP → 'economical' // Converting single non-terminal JJ to its lexicon value for ADJP rule
ADJP → 'red' // Converting single non-terminal JJ to its lexicon value for ADJP rule
VP → VBD ADJP
VP → VBZ SB
VP → VBP PP
SB → X1 S // new variable X1 to make SB rule in the form A → B C
SB → IN S
X1 → SB CC
PP → IN NP

Sentence 4:
Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.

CFG:
Root → S
S → NP VP
NP → NN NN
NP → JJ JJ NN
NP → NP PP
NP → NNP CD
NP → DT CD NNP NNP NNP NNP
NP → DT JJ NN
VP → VP CC VP

VP → VBZ NP PP PP
VP → MD ADVP VP
VP → VB NP
ADVP → RB
PP → IN NP

Lexicon:
DT → 'the' | 'a'
RB → 'only'
MD → 'could'
VBZ → 'lands'
VB → 'clinch'
CC → 'but'
JJ → 'historic' | 'quadruple' | 'senior' | ‘international' | 'silver'
NNP → 'World' | 'Figure' | 'Skating' | 'Championships' | 'Day'
NN → 'figure' | 'skater' | 'jump' | 'competition' | 'medal'
CD → '3' | '2019'
IN → 'in' | 'at' | 'on'

CNF Grammar:
Root → NP VP
S → NP VP
NP → NN NN
NP → NNP CD
NP → NP PP
NP → X1 NN // new variable X1 to make NP rule in the form A → B C
X1 → JJ JJ
NP → X10 NNP // new variable X10 to make NP rule in the form A → B C
X10 → X9 NNP //new variable X9 to make NP rule in the form A → B C
X9 → X7 NNP //new variable X7 to make NP rule in the form A → B C
X7 → X2 NNP //new variable X2 to make NP rule in the form A → B C
X2 → DT CD
NP → X3 NN // new variable X3 to make NP rule in the form A → B C
X3 → DT JJ
PP → IN NP
VP → VB NP
VP → X4 VP // new variable X4 to make VP rule in the form A → B C
X4 → VP CC
VP → X6 VP // new variable X6 to make VP rule in the form A → B C
X6 → MD ADVP
VP → X8 PP // new variable X8 to make VP rule in the form A → B C
X8 → X5 PP //new variable X5 to make VP rule in the form A → B C
X5 → VBZ NP
ADVP → 'only' // Converting single non-terminal RB to its lexicon value for ADJP rule

All the outputs for all the sentences are in the output folder.
The output as bracketed parse are in the output.txt files and the parse trees are in the T.txt file.

CKY Parse Output:

Sentence 1: Sales of the company to return to normalcy.
Number of parses: 1

[S [NP1 [NNS Sales] [PP [IN of] [NP [X1 [Det the] [NN company]] [INFVP [TO to] [VP [VB return] [PP [TO to] [NN normalcy]]]]]]] [PUNC .]]

Sentence 2: The new products and services contributed to the increase revenue.
Number of parses: 1

[S [NP [X1 [NP [X2 [DT The] [JJ new]] [NNS products]] [CC and]] [NNS services]] [VP [VBD contributed] [VP [TO to] [VP [VB increase] [NN revenue]]]]]

Sentence 3: Dow falls as recession indicator flashed red and economical worries continue through the month.
Number of parses: 1

[S [NP Dow] [VP [VBZ falls] [SB [X1 [SB [IN as] [S [NP [NN recession] [NN indicator]] [VP [VBD flashed] [ADJP red]]]] [CC and]] [S [NP [JJ economical] [NNS worries]] [VP [VBP continue] [PP [IN through] [NP [DT the] [NN month]]]]]]]]

Sentence 4: Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.
Number of parses: 3

[S [NP [NN figure] [NN skater]] [VP [X4 [VP [X8 [X5 [VBZ lands] [NP [X1 [JJ historic] [JJ quadruple]] [NN jump]]] [PP [IN in] [NP [X1 [JJ senior] [JJ international]] [NN competition]]]] [PP [IN at] [NP [NP [X10 [X9 [X7 [X2 [DT the] [CD 2019]] [NNP World]] [NNP Figure]] [NNP Skating]] [NNP Championships]] [PP [IN on] [NP [NNP Day] [CD 3]]]]] [CC but]] [VP [X6 [MD could] [ADVP only]] [VP [VB clinch] [NP [X3 [DT a] [JJ silver]] [NN medal]]]]]]

[S [NP [NN figure] [NN skater]] [VP [X4 [VP [X8 [X5 [VBZ lands] [NP [X1 [JJ historic] [JJ quadruple]] [NN jump]]] [PP [IN in] [NP [NP [X1 [JJ senior] [JJ international]] [NN competition]] [PP [IN at] [NP [X10 [X9 [X7 [X2 [DT the] [CD 2019]] [NNP World]] [NNP Figure]] [NNP Skating]] [NNP Championships]]]]] [PP [IN on] [NP [NNP Day] [CD 3]]]] [CC but]] [VP [X6 [MD could] [ADVP only]] [VP [VB clinch] [NP [X3 [DT a] [JJ silver]] [NN medal]]]]]]

[S [NP [NN figure] [NN skater]] [VP [X4 [VP [X8 [X5 [VBZ lands] [NP [NP [X1 [JJ historic] [JJ quadruple]] [NN jump]] [PP [IN in] [NP [X1 [JJ senior] [JJ international]] [NN competition]]]]] [PP [IN at] [NP [X10 [X9 [X7 [X2 [DT the] [CD 2019]] [NNP World]] [NNP Figure]] [NNP Skating]] [NNP Championships]]]] [PP [IN on] [NP [NNP Day] [CD 3]]]] [CC but]] [VP [X6 [MD could] [ADVP only]] [VP [VB clinch] [NP [X3 [DT a] [JJ silver]] [NN medal]]]]]]

PROBLEM 2: STATISTICAL PARSING

1. Executed the Constituency Parser with a Self-Attentive Encoder (Kitaev & Klein, 2018) on all the 4 sentences: (Includes Extra-credit)

S1: Sales of the company to return to normalcy.

```
(S
  (NP (NP (NNS Sales)) (PP (IN of) (NP (DT the) (NN company))))
  (VP (TO to) (VP (VB return) (PP (TO to) (NP (NN normalcy)))))
  (. .))
```

Difference to CKY parse for S1 in Problem 1:

Both parses are the same. This happened because the CNF grammar rules are written including the correct POS Tags of each term and because the rules are very strict to the parse tree drawn manually for this sentence before writing its CFG and CNF rather than being generalized.

S2: The new products and services contributed to increase revenue.

```
(S
  (NP (DT The) (JJ new) (NNS products) (CC and) (NNS services))
  (VP
    (VBD contributed)
    (S (VP (TO to) (VP (VB increase) (NP (NN revenue))))))
  (. .))
```

Difference to CKY parse for S2 in Problem 1:

Both parses are similar. The CKY parse contains few extra symbols for the rules as derived from CFG to CNF. This happened because the CNF grammar rules are written based on the parse tree drawn manually for this sentence and because the CFG and CNF is written manually. Only missed the parse for punctuation in the sentence.

S3: Dow falls as recession indicator flashed red and economical worries continue through the month.

```
(S
  (NP (NNP Dow))
  (VP
    (VBZ falls)
    (SBAR
      (SBAR
        (IN as)
        (S
          (NP (NN recession) (NN indicator))
          (VP (VBD flashed) (ADJP (JJ red)))))
      (CC and)
      (S
        (NP (JJ economical) (NNS worries))
```

(VP (VB continue) (PP (IN through) (NP (DT the) (NN month)))))))
(. .))

Difference to CKY parse for S3 in Problem 1:
Both parses are same. The CKY parse contains few extra symbols for the rules as derived from CFG to CNF. This happened because the CNF grammar rules are written based on the parse tree drawn manually for this sentence and because the CFG and CNF is written manually. Only missed the parse for punctuation in the sentence.

S4: Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.

```
(S
  (NP (NN Figure) (NN skater))
  (VP
    (VP
      (VBZ lands)
      (NP (JJ historic) (JJ quadruple) (NN jump))
      (PP
        (IN in)
        (NP (JJ senior) (JJ international) (NN competition)))
      (PP
        (IN at)
        (NP
          (DT the)
          (CD 2019)
          (NNP World)
          (NNP Figure)
          (NNP Skating)
          (NNPS Championships)))
      (PP (IN on) (NP (NN Day) (CD 3))))
    (CC but)
    (VP
      (MD could)
      (ADVP (RB only))
      (VP (VB clinch) (NP (DT a) (NN silver) (NN medal)))))
  (. .))
```

Difference to CKY parse for S4 in Problem 1:
CKY Parser in Problem 1 gives 3 parses for the S4 according to the CNF grammar rules written. The first CKY parse and the neural parse for S4 match. The CKY parse contains few extra symbols for the rules as derived from CFG to CNF. This happened because the CNF grammar rules are written based on the parse tree drawn manually for this sentence and because the CFG and CNF is written manually. Because of this, the grammar rules although strict are not restrictive only for the 1st parse tree which is why 2 other parses are developed from the written grammar. This is because there are many intermediate new CNF rules developed to preserve the CNF rule and this could lead to different parse trees. But the neural parser only gives the accurate parse.

3. Manually recognize all the Noun and Verb Phrases and indicate NP pre/post-modifiers as well as heads of NP and VP:

For more than 30 years, Mauro Morandi has been the sole inhabitant of a beautiful island in the Mediterranean Sea. For the past few weeks his hermit's hut has been an aptly isolated location from which to watch the global coronavirus crisis unfold

For more than 30 years, Mauro Morandi has been the sole inhabitant of a beautiful island in the Mediterranean Sea.

NP: more than 30 years
Head: years
Pre-modifier: more than 30 (comparative adjective cardinal)

NP: Mauro Morandi (proper noun)
Head: Mauro Morandi

NP: a beautiful island
Head: island
Pre-modifier: a beautiful (Determiner adjective)

NP: the sole inhabitant
Head: inhabitant
Pre-modifier: the sole (Determiner adjective)

NP: the sole inhabitant of a beautiful island
Head: inhabitant
Premodifier: the sole (Determiner adjective)
Post-modifier: of a beautiful island (prepositional phrase)

NP: the Mediterranean Sea
Head: Mediterranean Sea
Pre-modifier: the (Determiner)

VP: been the sole inhabitant of a beautiful island in the Mediterranean Sea
Head: been (VBN)

VP: has been the sole inhabitant of a beautiful island in the Mediterranean Sea
Head: has (VBZ)

For the past few weeks his hermit's hut has been an aptly isolated location from which to watch the global coronavirus crisis unfold.

NP: the past few weeks
Head: weeks
Pre-modifier: the past few (Determiner adjective quantifier)

NP: his (pronoun)

NP: hermit's hut
Head: hermit's hut

NP: the global coronavirus crisis
Head: coronavirus crisis
Pre-modifier: the global (Determiner adjective)

NP: an aptly isolated location
Head: location
Pre-modifier: an aptly isolated (Determiner adjective adjective)

NP: an aptly isolated location from which to watch the global coronavirus crisis unfold
Head: location
Pre-modifier: an aptly isolated (Determiner adjective adjective)
Post-modifier: from which to watch the global coronavirus crisis unfold (Prepositional phrase)

VP: to watch the global coronavirus crisis unfold
Head: watch (VB)

VP: been an aptly isolated location from which to watch the global coronavirus crisis unfold
Head: been (VBN)

VP: has been an aptly isolated location from which to watch the global coronavirus crisis unfold
Head: has (VBZ)

PROBLEM 3: SEMANTIC ROLE LABELLING

1. Manual Semantic Role Labelling using ProbBank FrameSets

S1: Sales of the company to return to normalcy.

Predicate: return

Meaning: come back
Roles:
- Arg1-PPT: entity in motion
- Arg2-EXT: (extent -- rare)
- Arg3-DIR: start point
- Arg4-GOL: end point
- Argm-LOC: medium

[Sales of the company]Arg1 to return to normalcy.

S2: The new products and services contributed to increase revenue.

Predicate: contributed

Meaning: contribute
Roles:
- Arg0-PAG: giver (vnrole: 13.2-1-1-agent)
- Arg1-PPT: thing given (vnrole: 13.2-1-1-theme)
- Arg2-GOL: entity given to (vnrole: 13.2-1-1-recipient)

[The new products and services]Arg0 contributed to [increase revenue] Arg1

S3: Dow falls as recession indicator flashed red and economical worries continue through the month.

Predicate: falls

Meaning: move downwards
Roles:
- Arg1-PPT: Logical subject, patient, thing falling (vnrole: 51.1-theme, 45.6-1-patient)
- Arg2-EXT: EXT, amount fallen (vnrole: 45.6-1-extent)
- Arg3-DIR: start point
- Arg4-GOL: end point, end state of arg1
- Argm-LOC: medium

[Dow]Arg1 falls as recession indicator flashed red and economical worries continue through the month.

Predicate: flashed

Meaning: shine, show quickly, shine or show quickly
Roles:
- Arg0-PAG: shower, agent (vnrole: 43.1-agent, 40.3.2-agent)
- Arg1-PPT: thing shining (vnrole: 43.1-theme, 40.3.2-patient)
- Arg2-LOC: location, such as screen (vnrole: 43.1-location, 40.3.2-recipient)

Dow falls as [recession indicator]Arg1 flashed red and economical worries continue through the month.

Predicate: continue

Roles:
- Arg0-PAG: causer of continuation (vnrole: 55.3-agent, 55.6-agent)
- Arg1-PPT: thing continuing (vnrole: 55.3-theme, 55.6-theme, 55.3-theme, 55.6-theme)

Dow falls as recession indicator flashed red and [economical worries]Arg1 continue through the month.

S4: Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.

Predicate: lands

Meaning: bring to land, from water or air, or metaphorical extension: (cause to) end up in a location
Roles:
Arg0-PAG: bringer, captain, pilot, agent (vnrole: 9.10-1-Agent)
Arg1-PPT: thing landing (vnrole: 9.10-1-Theme)

[Figure skater]Arg0 lands [historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3]Arg1 but could only clinch a silver medal.

Predicate: clinch

Meaning: make into a sure thing
Roles:
Arg0-PAG: causer of sureness
Arg1-PPT: sure thing

[Figure skater]Arg0 lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch [a silver medal]Arg1.

Extra-credit Dependency Parse Using Stanford Dependency Parser

S1: Sales of the company to return to normalcy.

Parse:
```
(ROOT
  (NP
    (NP (NNS Sales))
    (PP (IN of)
      (NP (DT the) (NN company)
        (S
          (VP (TO to)
            (VP (VB return)
              (PP (TO to)
                (NP (NN normalcy))))))))
    (. .)))
```

Universal dependencies:

```
root(ROOT-0, Sales-1)
case(company-4, of-2)
det(company-4, the-3)
nmod(Sales-1, company-4)
mark(return-6, to-5)
```

acl(company-4, return-6)
case(normalcy-8, to-7)
nmod(return-6, normalcy-8)

S2: The new products and services contributed to increase revenue.

Parse:
```
(ROOT
  (S
    (NP
      (NP (DT The) (JJ new) (NNS products))
      (CC and)
      (NP (NNS services)))
    (VP (VBD contributed)
      (S
        (VP (TO to)
          (VP (VB increase)
            (NP (NN revenue))))))
    (. .)))
```

Universal dependencies:

det(products-3, The-1)
amod(products-3, new-2)
nsubj(contributed-6, products-3)
cc(products-3, and-4)
conj(products-3, services-5)
root(ROOT-0, contributed-6)
mark(increase-8, to-7)
xcomp(contributed-6, increase-8)
dobj(increase-8, revenue-9)

S3: Dow falls as recession indicator flashed red and economical worries continue through the month.

Parse:
```
(ROOT
  (S
    (NP (NNP Dow))
    (VP (VBZ falls)
      (SBAR (IN as)
        (S
          (NP (NN recession) (NN indicator))
          (VP (VBD flashed)
            (SBAR
              (S
                (NP (JJ red)
```

```
            (CC and)
            (JJ economical) (NNS worries))
          (VP (VBP continue)
            (PP (IN through)
              (NP (DT the) (NN month))))))))))
  (. .)))
```

Universal dependencies:

```
nsubj(falls-2, Dow-1)
root(ROOT-0, falls-2)
mark(flashed-6, as-3)
compound(indicator-5, recession-4)
nsubj(flashed-6, indicator-5)
advcl(falls-2, flashed-6)
amod(worries-10, red-7)
cc(red-7, and-8)
conj(red-7, economical-9)
nsubj(continue-11, worries-10)
ccomp(flashed-6, continue-11)
case(month-14, through-12)
det(month-14, the-13)
nmod(continue-11, month-14)
```

S4: Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.

Parse:

```
(ROOT
  (S
    (NP (NNP Figure) (NNP skater))
    (VP
      (VP (VBD lands)
        (NP (JJ historic) (NN quadruple) (NN jump))
        (PP (IN in)
          (NP
            (NP (JJ senior) (JJ international) (NN competition))
            (PP (IN at)
              (NP(DT the)(CD 2019)(NNP World)(NNP Figure)(NNP Skating)(NNP Championships))))
        (PP (IN on)
          (NP (NNP Day) (CD 3))))
      (CC but)
      (VP (MD could)
        (ADVP (RB only))
        (VP (VB clinch)
          (NP (DT a) (JJ silver) (NN medal)))))
    (. .)))
```

Universal dependencies:

compound(skater-2, Figure-1)
nsubj(lands-3, skater-2)
root(ROOT-0, lands-3)
amod(jump-6, historic-4)
compound(jump-6, quadruple-5)
dobj(lands-3, jump-6)
case(competition-10, in-7)
amod(competition-10, senior-8)
amod(competition-10, international-9)
nmod(lands-3, competition-10)
case(Championships-17, at-11)
det(Championships-17, the-12)
nummod(Championships-17, 2019-13)
compound(Championships-17, World-14)
compound(Championships-17, Figure-15)
compound(Championships-17, Skating-16)
nmod(competition-10, Championships-17)
case(Day-19, on-18)
nmod(lands-3, Day-19)
nummod(Day-19, 3-20)
cc(lands-3, but-21)
aux(clinch-24, could-22)
advmod(clinch-24, only-23)
conj(lands-3, clinch-24)
det(medal-27, a-25)
amod(medal-27, silver-26)
dobj(clinch-24, medal-27)

2. Automatic Semantic Role Labelling using Neural SRL (includes extra-credit)

S1: Sales of the company to return to normalcy.

{"doc_key": "S0", "sent_offset": 0, "predicted_srl": [[0, 1, 3, "ARG1"], [0, 4, 7, "ARGM-PRP"], [5, 0, 3, "ARG1"], [5, 6, 7, "ARG4"]], "srl": [[]], "sentences": [["Sales", "of", "the", "company", "to", "return", "to", "normalcy", "."]]}

S2: The new products and services contributed to increase revenue.

{"doc_key": "S0", "sent_offset": 0, "predicted_srl": [[4, 1, 1, "ARGM-TMP"], [5, 0, 4, "ARG0"], [5, 6, 8, "ARG2"], [7, 0, 4, "ARG0"], [7, 8, 8, "ARG1"]], "srl": [[]], "sentences": [["The", "new", "products", "and", "services", "contributed", "to", "increase", "revenue", "."]]}

S3: Dow falls as recession indicator flashed red and economical worries continue through the month.

{"doc_key": "S0", "sent_offset": 0, "predicted_srl": [[1, 0, 0, "ARG1"], [1, 2, 13, "ARGM-TMP"], [10, 8, 9, "ARG1"], [10, 11, 13, "ARGM-TMP"], [5, 3, 4, "ARG0"], [5, 6, 6, "ARG1"]], "srl": [[]], "sentences": [["Dow", "falls", "as", "recession", "indicator", "flashed", "red", "and", "economical", "worries", "continue", "through", "the", "month", "."]]}

S4: Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.

{"doc_key": "S0", "sent_offset": 0, "predicted_srl": [[2, 0, 1, "ARG0"], [2, 3, 5, "ARG1"], [2, 6, 9, "ARGM-LOC"], [2, 10, 16, "ARGM-LOC"], [2, 17, 19, "ARGM-TMP"], [5, 3, 3, "ARGM-ADJ"], [5, 4, 4, "ARGM-MNR"], [23, 0, 1, "ARG0"], [23, 21, 21, "ARGM-MOD"], [23, 22, 22, "ARGM-ADV"], [23, 24, 26, "ARG1"]], "srl": [[]], "sentences": [["Figure", "skate", "lands", "historic", "quadruple", "jump", "in", "senior", "international", "competition", "at", "the", "2019", "World", "Figure", "Skating", "Championships", "on", "Day", "3", "but", "could", "only", "clinch", "a", "silver", "medal", "."]]}

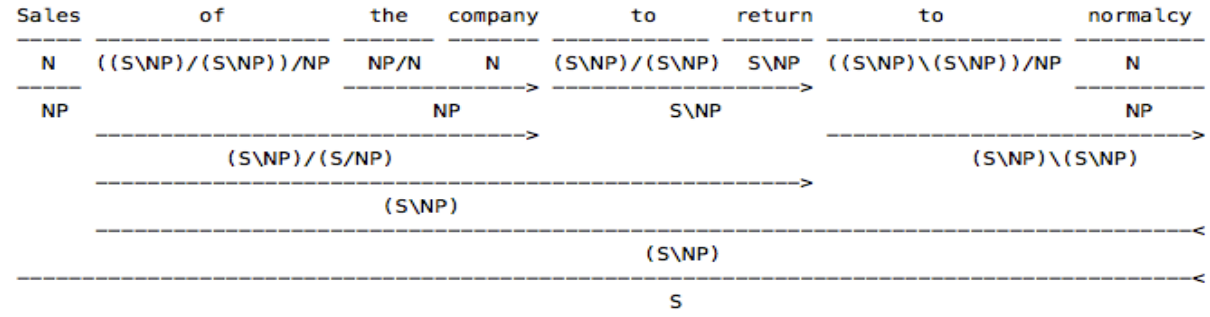
3. Differences between manual and automatic SRL for all sentences (Includes extra-credit).

The manual SRL and the automatic SRL match perfectly with each other. The automatic SRL is more complexly annotated than the manual one since the manual one is done by hand.

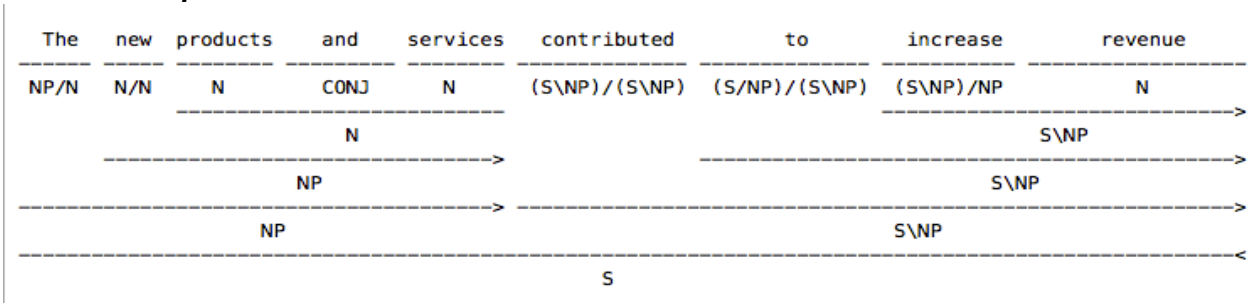
Extra-credit Problem

1. Manual Semantic Parsing using Framenet.

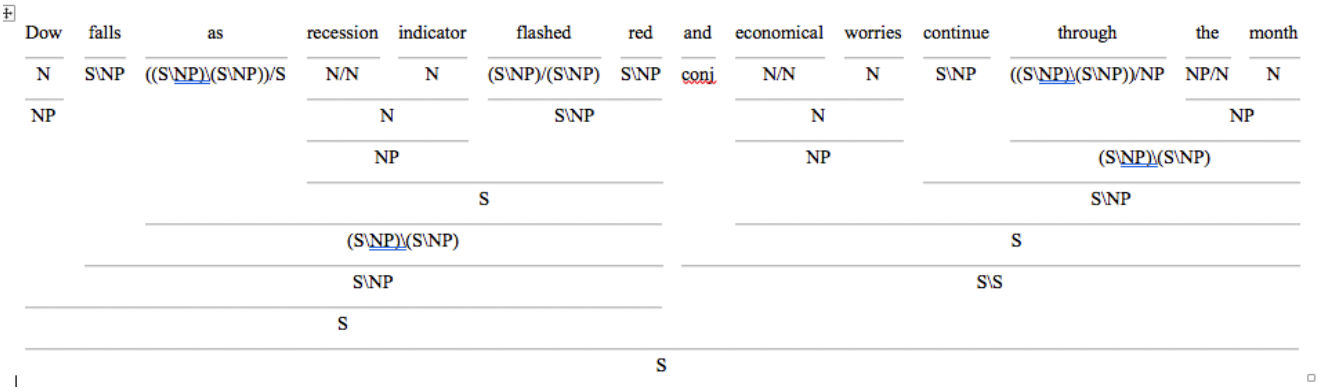
S1: Sales of the company to return to normalcy.



S2: The new products and services contributed to increase revenue.



S3: Dow falls as recession indicator flashed red and economical worries continue through the month.



S4: Figure skater lands historic quadruple jump in senior international competition at the 2019 World Figure Skating Championships on Day 3 but could only clinch a silver medal.