# NPL_coursework_2

March 18, 2018

## 1 Coursework 2: Natural Language Processing

The aim of this task is to learn the Formal grammars and parsing.

***NOTE***: Based on chapters 11, 12, 13, 14 of Jurefsky and Martin* https://web.stanford.edu/~jurafsky/slp3/11.pdf

```
In [1]: import nltk
        from nltk import tree
        from nltk.corpus import treebank
        from nltk import Nonterminal
        from nltk import induce_pcfg
        import matplotlib.pyplot as plt
        import matplotlib.image as mpimg
        from nltk import tokenize
        from nltk.grammar import toy_pcfg1
        from nltk.parse import pchart
        from nltk.parse import ViterbiParser
```

```
In [2]: def loadData(path):
            with open(path,'r') as f:
                data = f.read().split('\n')
            return data

        def getTreeData(data):
            return map(lambda s: tree.Tree.fromstring(s), data)
```

```
In [3]: # Main script
        print("loading data..")
        data = loadData('parseTrees.txt')
        print("generating trees..")
        treeData = getTreeData(data)
        print("done!")
```

```
loading data..
generating trees..
done!
```

## 2 Task 1

** Rules from the page 3** * Det  the * Noun  flight * Nominal  Noun | Nominal Noun
** Rules from the page 4** * S  NP VP * VP  Verb NP * VP  Verb PP * PP  Preposition NP
** Rules from the page 5** * Noun  flights | morning * Proper-Noun  Baltimore | United | American * Determiner  the | that * Preposition  from | to | near * NP  Proper-Noun * VP  Verb NP | Verb PP * PP  Preposition NP
**Rules from the page 9** * Det  NP
**Added rules:** * S -> NP | PP | NP N | N N | NP S * VP -> N PP * NP -> Det V

```
In [4]: list1 = ["Baltimore", "to Baltimore", "near Baltimore", "the flight", "Americans flights
                 "one flight", "any flight", "any morning flight from Baltimore", "Uniteds flight
                 "any flight leaving from Baltimore", "any flight that serves lunch", "Uniteds pi
```

```
In [5]: grammar1 = nltk.CFG.fromstring("""
        S ->  NP | PP | N N | NP S
        VP -> V NP | N PP | V PP
        PP -> P NP
        Nom -> N | Nom N
        PN -> "Baltimore" | "Americans" | "Uniteds"
        NP -> PN | Det N | Det V
        Det -> "that" | "the" | "that" | "one" | "any" | NP
        N -> "flight" | "flights" | "morning" | "lunch" | "pilots"
        V -> "serves" | "leaving" | "protests"
        P -> "to" | "near" | "from"
        """)
```

```
In [6]: # CYK algorithm
        parser1 = nltk.ChartParser(grammar1)
        for i in list1:
            print( "\033[1m" + i + "\033[0;0m")
            for tree in parser1.parse(i.split()):
                print(tree)
            print("\n")
```

```
Baltimore
(S (NP (PN Baltimore)))



to Baltimore
(S (PP (P to) (NP (PN Baltimore))))



near Baltimore
(S (PP (P near) (NP (PN Baltimore))))



the flight
(S (NP (Det the) (N flight)))
```

```
Americans flights
(S (NP (Det (NP (PN Americans))) (N flights)))


morning flight
(S (N morning) (N flight))


one flight
(S (NP (Det one) (N flight)))


any flight
(S (NP (Det any) (N flight)))


any morning flight from Baltimore
(S
  (NP (Det (NP (Det any) (N morning))) (N flight))
  (S (PP (P from) (NP (PN Baltimore)))))


Uniteds flight to Baltimore
(S
  (NP (Det (NP (PN Uniteds))) (N flight))
  (S (PP (P to) (NP (PN Baltimore)))))


any flight leaving from Baltimore
(S
  (NP (Det (NP (Det any) (N flight))) (V leaving))
  (S (PP (P from) (NP (PN Baltimore)))))


any flight that serves lunch
(S
  (NP (Det any) (N flight))
  (S (NP (Det (NP (Det that) (V serves))) (N lunch))))


Uniteds pilots protests
(S (NP (Det (NP (Det (NP (PN Uniteds))) (N pilots))) (V protests)))
```

## 3 Task 2

** Rules from the page 3** * NP  ProperNoun * P  Det Nominal * Det  a * Det  the * Noun  flight
** Rules from the page 4** * S  NP VP
** Rules from the page 5** * NP  Pronoun * Pronoun  I * Proper-Noun  Baltimore | American * Verb  like | need | fly * Preposition  from | to | on * Conjunction  and
** Rules from the page 7** * S  Aux NP VP
** Rules from the page 21** * VP  VP PP
**Added rules:** * S -> Wh-NP Aux NP PP PP | RB NP * NP -> V Det * PN -> PN Conj PN * VP -> V NP | V PP | P VP | V VP * PP -> P NP * Det -> NP

```
In [7]: list2 = ["Do American Airlines have a flight between Baltimore and Denver?",
                  "I would like to fly on American airlines.",
                  "Please repeat that.", "I need to fly between Philadelphia and Atlanta.",
                  "What is the fare from Atlanta to Denver?", "We flew to Baltimore and Denver."]
```

```
In [8]: # The word "please" is udentified as an adverb, according to Merriam-Webster dictionary,
        # despite Jurefsky and Martin mentioned it as a politeness markers in the 10th chapter
        # https://www.merriam-webster.com/dictionary/please?show=1&t=1319640457

        grammar2 = nltk.CFG.fromstring("""
        S -> Aux NP VP | Wh-NP Aux NP PP PP | NP VP | RB NP
        NP -> PN | Det N | Pronoun | V Det
        PN -> PN Conj PN
        VP -> V NP | VP PP | V PP | P VP | V VP
        PP -> P NP

        Aux -> "Do" | "is"
        Det -> "a" | "that" | "the"| NP
        Pronoun -> "I" | "We"
        PN -> "American" | "Baltimore" | "Denver" | "Philadelphia" | "Atlanta"
        N -> "Airlines" | "flight" | "airlines" | "fare"
        V -> "have" | "would" | "like" | "fly" | "repeat" | "need" | "flew"
        P -> "between" | "on" | "from" | "to"
        Conj -> "and"
        RB -> "Please"
        Wh-NP -> "What"
        """)
```

```
In [9]: import re
        parser2 = nltk.ChartParser(grammar2)

        for i in list2:
            print( "\033[1m" + i + "\033[0;0m")
            a = re.sub(r'[^\w\s]','', i)
            for tree in parser2.parse(a.split()):
                print(tree)
            print("\n")
```

```
Do American Airlines have a flight between Baltimore and Denver?
(S
  (Aux Do)
  (NP (Det (NP (PN American))) (N Airlines))
  (VP
    (VP (V have) (NP (Det a) (N flight)))
    (PP (P between) (NP (PN (PN Baltimore) (Conj and) (PN Denver))))))


I would like to fly on American airlines.
(S
  (NP (Pronoun I))
  (VP
    (V would)
    (VP
      (V like)
      (VP
        (P to)
        (VP
          (V fly)
          (PP (P on) (NP (Det (NP (PN American))) (N airlines))))))))


Please repeat that.
(S (RB Please) (NP (V repeat) (Det that)))


I need to fly between Philadelphia and Atlanta.
(S
  (NP (Pronoun I))
  (VP
    (V need)
    (VP
      (P to)
      (VP
        (V fly)
        (PP
          (P between)
          (NP (PN (PN Philadelphia) (Conj and) (PN Atlanta))))))))


What is the fare from Atlanta to Denver?
(S
  (Wh-NP What)
  (Aux is)
  (NP (Det the) (N fare))
  (PP (P from) (NP (PN Atlanta)))
  (PP (P to) (NP (PN Denver))))
```

```
We flew to Baltimore and Denver.
(S
  (NP (Pronoun We))
  (VP
    (V flew)
    (PP (P to) (NP (PN (PN Baltimore) (Conj and) (PN Denver))))))
```

## 4 Task 3

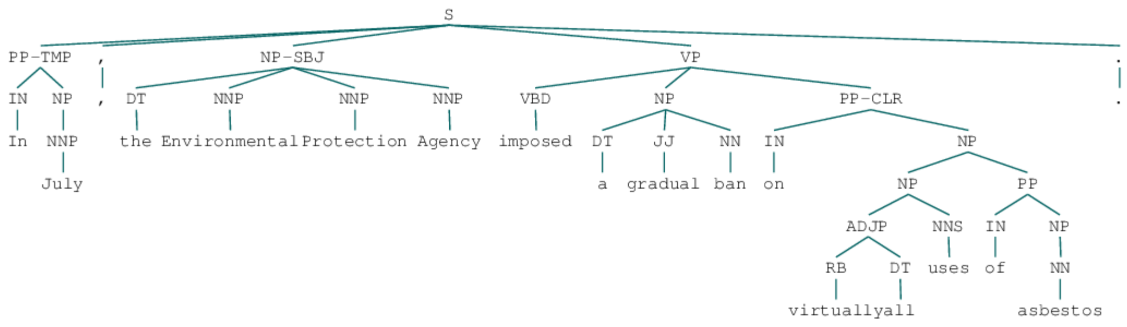
```
To download Penn Treebank, need to execute
nltk.download()
and install Penn Treebank corpora manually
```

```
In [10]: # here we load in the sentences
         sentence22 = treebank.parsed_sents('wsj_0003.mrg')[21]
         sentence7 = treebank.parsed_sents('wsj_0003.mrg')[6]
         sentence13 = treebank.parsed_sents('wsj_0004.mrg')[12]
```

```
In [11]: print(sentence22)
         sentence22
```

```
(S
  (PP-TMP (IN In) (NP (NNP July)))
  (, ,)
  (NP-SBJ (DT the) (NNP Environmental) (NNP Protection) (NNP Agency))
  (VP
    (VBD imposed)
    (NP (DT a) (JJ gradual) (NN ban))
    (PP-CLR
      (IN on)
      (NP
        (NP (ADJP (RB virtually) (DT all)) (NNS uses))
        (PP (IN of) (NP (NN asbestos))))))
  (. .))
```

```
Out[11]:
```



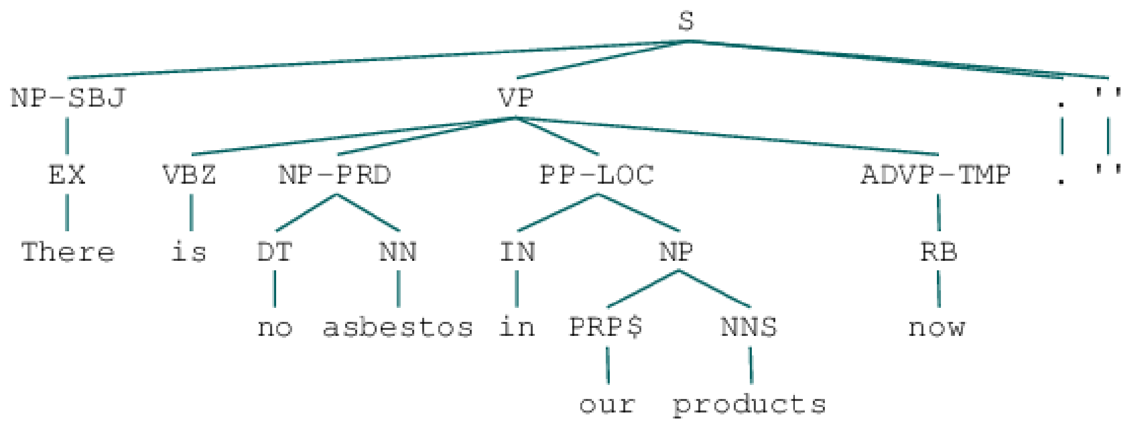
```
In [12]: tbank_productions = []

         # Extract the rules (productions) for the sentence
         for sent in sentence22:
             for production in sent.productions():
                 tbank_productions.append(production)

         tbank_productions
```

```
Out[12]: [PP-TMP -> IN NP,
          IN -> 'In',
          NP -> NNP,
          NNP -> 'July',
          , -> ',',
          NP-SBJ -> DT NNP NNP NNP,
          DT -> 'the',
          NNP -> 'Environmental',
          NNP -> 'Protection',
          NNP -> 'Agency',
          VP -> VBD NP PP-CLR,
          VBD -> 'imposed',
          NP -> DT JJ NN,
          DT -> 'a',
          JJ -> 'gradual',
          NN -> 'ban',
          PP-CLR -> IN NP,
          IN -> 'on',
          NP -> NP PP,
          NP -> ADJP NNS,
          ADJP -> RB DT,
          RB -> 'virtually',
          DT -> 'all',
          NNS -> 'uses',
          PP -> IN NP,
          IN -> 'of',
          NP -> NN,
          NN -> 'asbestos',
          . -> '.']
```

```
In [13]: print(sentence7)
         sentence7
```

```
(S
  (NP-SBJ (EX There))
  (VP
    (VBZ is)
    (NP-PRD (DT no) (NN asbestos))
    (PP-LOC (IN in) (NP (PRP$ our) (NNS products)))
    (ADVP-TMP (RB now)))
  (. .)
  ('' ''))
```

Out[13]:



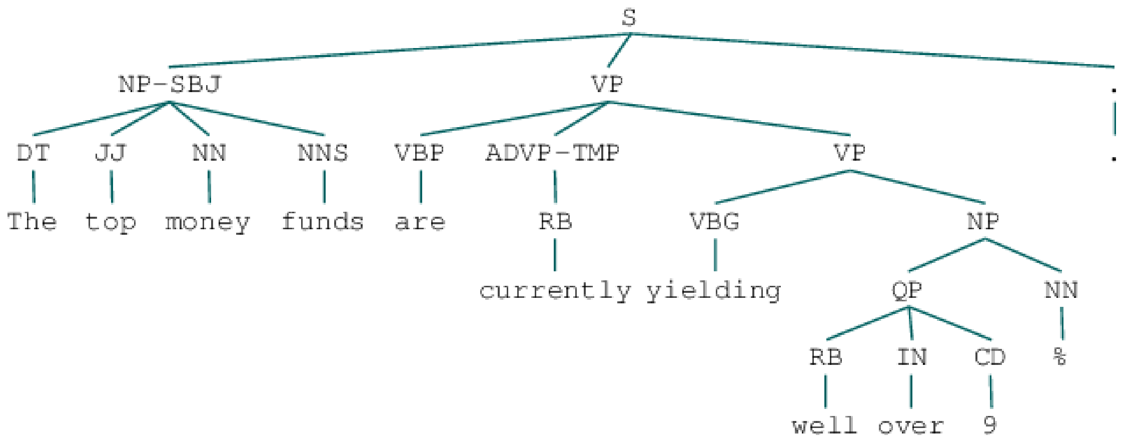
```
In [14]: tbank_productions = []

         # Extract the rules (productions) for the sentence
         for sent in sentence7:
             for production in sent.productions():
                 tbank_productions.append(production)

         tbank_productions
```

```
Out[14]: [NP-SBJ -> EX,
          EX -> 'There',
          VP -> VBZ NP-PRD PP-LOC ADVP-TMP,
          VBZ -> 'is',
          NP-PRD -> DT NN,
          DT -> 'no',
          NN -> 'asbestos',
          PP-LOC -> IN NP,
          IN -> 'in',
          NP -> PRP$ NNS,
          PRP$ -> 'our',
          NNS -> 'products',
          ADVP-TMP -> RB,
          RB -> 'now',
          . -> '.',
          '' -> "''"]
```

```
In [15]: print(sentence13)
         sentence13
```

```
(S
  (NP-SBJ (DT The) (JJ top) (NN money) (NNS funds))
  (VP
    (VBP are)
    (ADVP-TMP (RB currently))
    (VP (VBG yielding) (NP (QP (RB well) (IN over) (CD 9)) (NN %))))
  (. .))
```

Out[15]:



```
In [16]: tbank_productions = []

         # Extract the rules (productions) for the sentence
         for sent in sentence13:
             for production in sent.productions():
                tbank_productions.append(production)

        tbank_productions

Out[16]: [NP-SBJ -> DT JJ NN NNS,
          DT -> 'The',
          JJ -> 'top',
          NN -> 'money',
          NNS -> 'funds',
          VP -> VBP ADVP-TMP VP,
          VBP -> 'are',
          ADVP-TMP -> RB,
          RB -> 'currently',
          VP -> VBG NP,
          VBG -> 'yielding',
          NP -> QP NN,
          QP -> RB IN CD,
          RB -> 'well',
          IN -> 'over',
          CD -> '9',
          NN -> '%',
          . -> '.']
```

## 5 Task 4

a) Initial sentence: "List me the seats on the flight to Denver"

1) List me the seats on the flight to Denver. Please mention all available seats on the flight to Denver. Direct meaning.
2) List me the seats... on the flight to Denver. Please send me the list of seats, I have a flight to Denver right now.
3) List me, the seats on the flight to Denver. Write me, seats are already on the flight.
4) List me the seats on the flight to Denver. Send me the list while you are on the flight.

b) Replacing grammar_script.py with the rules

```
In [17]: sentence = ['List', 'me', 'the', 'seats', 'on', 'the', 'flight', 'to', 'Denver']
         # here we define a grammar
         # IVP stands for imperative verb phrase
         # IVerb stands for imperative verb
         # S -> NP VP
         grammar3 = nltk.CFG.fromstring("""
         S -> IVP
         IVP -> IVerb NP PP PP
         NP -> Det Det N | PN | Det N
         PP -> P NP
         PN -> "Denver"
         Det -> 'me' | 'the'
         N -> 'seats' | 'flight'
         IVerb -> 'List'
         P -> 'on' | 'to'
         """)
```

```
In [18]: parser3 = nltk.ChartParser(grammar3)
         for tree in parser3.parse(sentence):
             print(tree)
```

```
(S
  (IVP
    (IVerb List)
    (NP (Det me) (Det the) (N seats))
    (PP (P on) (NP (Det the) (N flight)))
    (PP (P to) (NP (PN Denver)))))
```

Lets find all possible parses of the above sentence.

```
In [19]: grammar4 = nltk.CFG.fromstring("""
         S -> VP PP PP | V NP
         PP -> P NP | P N P
         VP -> V NP | N PP
         NP -> 'Denver' | Det N | Det NP | N P | NP NP
         Det -> 'me' | 'the'
         N -> 'seats' | 'flight'
         V -> 'List'
         P -> 'on' | 'to'
         """)
```

```
In [20]: parser4 = nltk.ChartParser(grammar4)
         for tree in parser4.parse(sentence):
             print(tree)
```

```
(S
  (V List)
  (NP
    (Det me)
    (NP
      (Det the)
      (NP
        (NP
          (NP (N seats) (P on))
          (NP (Det the) (NP (N flight) (P to))))
        (NP Denver)))))
(S
  (V List)
  (NP
    (Det me)
    (NP
      (Det the)
      (NP
        (NP (N seats) (P on))
        (NP (NP (Det the) (NP (N flight) (P to))) (NP Denver))))))
(S
  (V List)
  (NP
    (Det me)
    (NP
      (Det the)
      (NP
        (NP (N seats) (P on))
        (NP (Det the) (NP (NP (N flight) (P to)) (NP Denver)))))))
(S
  (V List)
  (NP
    (Det me)
    (NP
      (NP
        (NP (Det the) (NP (N seats) (P on)))
        (NP (Det the) (NP (N flight) (P to))))
      (NP Denver))))
(S
  (V List)
  (NP
    (Det me)
    (NP
      (NP
        (Det the)
        (NP
          (NP (N seats) (P on))
          (NP (Det the) (NP (N flight) (P to)))))
      (NP Denver))))
(S
  (V List)
  (NP
    (Det me)
    (NP
      (NP (Det the) (NP (N seats) (P on)))
      (NP (NP (Det the) (NP (N flight) (P to))) (NP Denver)))))
(S
  (V List)
  (NP
    (Det me)
    (NP
      (NP (Det the) (NP (N seats) (P on)))
      (NP (Det the) (NP (NP (N flight) (P to)) (NP Denver))))))
(S
  (V List)
  (NP
    (NP
      (NP (Det me) (NP (Det the) (NP (N seats) (P on))))
      (NP (Det the) (NP (N flight) (P to))))
    (NP Denver)))
(S
  (V List)
  (NP
    (NP
      (Det me)
      (NP
        (NP (Det the) (NP (N seats) (P on)))
        (NP (Det the) (NP (N flight) (P to)))))
    (NP Denver)))
(S
  (V List)
  (NP
    (NP
      (Det me)
      (NP
        (Det the)
        (NP
          (NP (N seats) (P on))
          (NP (Det the) (NP (N flight) (P to))))))
    (NP Denver)))
(S
  (V List)
  (NP
    (NP (Det me) (NP (Det the) (NP (N seats) (P on))))
    (NP (NP (Det the) (NP (N flight) (P to))) (NP Denver))))
(S
  (V List)
  (NP
    (NP (Det me) (NP (Det the) (NP (N seats) (P on))))
    (NP (Det the) (NP (NP (N flight) (P to)) (NP Denver)))))
(S
  (VP (V List) (NP (Det me) (NP (Det the) (N seats))))
  (PP (P on) (NP (Det the) (N flight)))
  (PP (P to) (NP Denver)))
```

Repeating the fist grammar, adding the new rule: NP -> NP PP No new parses appeared

```
In [21]: # c)
         grammar5 = nltk.CFG.fromstring("""
         S -> IVP
         IVP -> IVerb NP PP PP
         NP -> Det Det N | PN | Det N | NP PP
         PP -> P NP

         PN -> "Denver"
         Det -> 'me' | 'the'
         N -> 'seats' | 'flight'
         IVerb -> 'List'
         P -> 'on' | 'to'
         """)
```

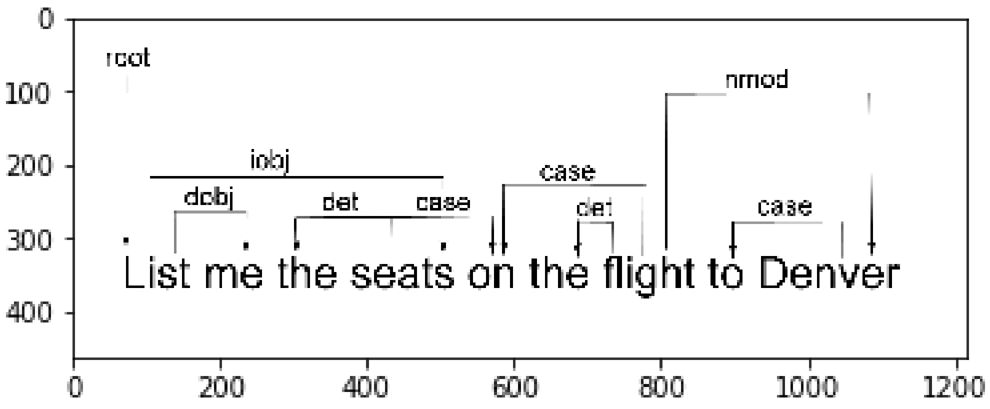
```
In [22]: parser5 = nltk.ChartParser(grammar5)
         for tree in parser5.parse(sentence):
             print(tree)
```

```
(S
  (IVP
    (IVerb List)
    (NP (Det me) (Det the) (N seats))
    (PP (P on) (NP (Det the) (N flight)))
    (PP (P to) (NP (PN Denver)))))
```

No new parses appeared

e) Transform CFG tree to dependency tree. (S (IVP (IVerb List) (NP (Det me) (Det the) (N seats)) (PP (P on) (NP (Det the) (N flight))) (PP (P to) (NP (PN Denver)))))

```
In [23]: plt.imshow(mpimg.imread('sentence.png'))
         plt.show()
```


root
iobj
dobj
det
case
case
det
nmod
case
List me the seats on the flight to Denver
0
100
200
300
400
0
200
400
600
800
1000
1200