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Practical No. 3

Theory

LL(1) Parsing:
Here the 1st **L** represents that the scanning of the Input will be done from Left to Right manner and the second **L** shows that in this parsing technique we are going to use Left most Derivation Tree. And finally, the **1** represents the number of look-ahead, which means how many symbols are you going to see when you want to make a decision.

Algorithm to construct LL(1) Parsing Table:
Step 1: First check for left recursion in the grammar, if there is left recursion in the grammar remove that and go to step 2.
Step 2: Calculate First() and Follow() for all non-terminals.

1. **First():** If there is a variable, and from that variable, if we try to drive all the strings then the beginning Terminal Symbol is called the First.
2. Follow(): What is the Terminal Symbol which follows a variable in the process of derivation.

Step 3: For each production A –> α. (A tends to alpha)

1. Find First(α) and for each terminal in First(α), make entry A –> α in the table.
2. If First(α) contains ε (epsilon) as terminal than, find the Follow(A) and for each terminal in Follow(A), make entry A –> α in the table.
3. If the First(α) contains ε and Follow(A) contains $ as terminal, then make entry A –> α in the table for the $. To construct the parsing table, we have two functions:

In the table, rows will contain the Non-Terminals and the column will contain the Terminal Symbols. All the **Null Productions** of the Grammars will go under the Follow elements and the remaining productions will lie under the elements of the First set.

Practicals

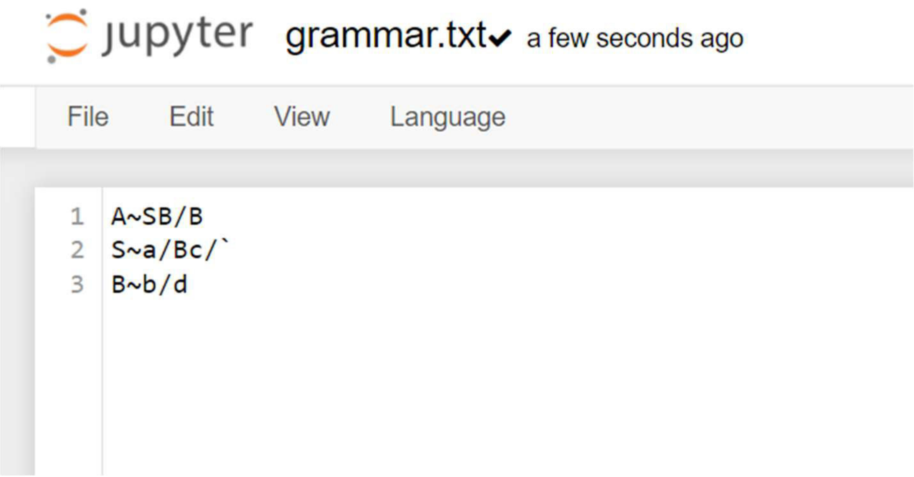
Aim:
A. Write a program to find FIRST for any grammar. All the following rules of FIRST must be implemented.
B. Further, write a program to find Follow for the given grammar.
C. Construct the LL(1) parsing table using the FIRST and FOLLOW values computed above.

Program:

```
from collections import OrderedDict

# ` symbol represents EPSILON

def EnterGrammar():
    d = OrderedDict()
    f = open("grammar.txt", "r")

    print('Grammar\n'+f.read())

    f.seek(0)
    for line in f:
        k = ""
        for c in line:
            if c != "~" and k == "":
                d[c] = []
                k = c
            elif c != "~" and c != "\n":
                d[k].append(c)

    f.seek(0)
    nonterminal = []
    terminal = []
    for line in f:
        for c in line:
            if c not in d.keys() and c!= "~" and c!= "\n" and c!= "`" and c!= "/" and c not in terminal:
                terminal.append(c)
            if c>='A' and c<='Z' and c not in nonterminal:
                nonterminal.append(c)

    return d,nonterminal,terminal


def Calculate_First(rule, index):
    first = ""
    v = rule[index]
    j = 1
    for i in range(len(v)):
        if v[i] == "/":
            j = 1
        elif j == 1:
            if v[i] not in rule.keys():
                if v[i] not in first and v[i] != "/":
                    first = first + v[i]
                    j = 0
            else:
                a = list(Calculate_First(rule, v[i]))
                while "`" in a and i+1 < len(v) and v[i+1] != "/":
                    a.remove("`")
                    if v[i+1] not in rule.keys():
                        a.append(v[i+1])
                    else:
                        a = list(set().union(a, Calculate_First(rule, v[i+1])))
                        i += 1
                a.extend(first)
                first = "".join(list(set(a)))
                j = 0
    return first


def Calculate_Follow(rule, n, start_symbol):
    follow = ""
    if n == start_symbol:
        follow += "$"
    for k, v in rule.items():
        for i in range(len(v)):
            if v[i] == n:
                if i == len(v) - 1:
                    follow += Calculate_Follow(rule, k, start_symbol)
                elif i + 1 < len(v) and v[i + 1] not in rule.keys() and v[i+1] != "/" and v[i+1] not in
follow:
                    follow += v[i + 1]
                elif i + 1 < len(v) and v[i+1] != "/" and v[i+1] not in follow:
                    a = []
                    for j in first[v[i + 1]]:
                        a.append(j)
                    if "`" in a:
                        a.remove("`")
                        a.append(Calculate_Follow(d, v[i+1], start_symbol))
                    follow += "".join(list(set("".join(a))))
                elif k == start_symbol:
                    follow += "$"
    return follow


def parsingTable(rule,nonterminals,terminals,first,follow):
    terminals.append('$')
    #make table
    parse_table = [ ["_"]*(len(terminals) + 1) for i in range(len(nonterminals) + 1) ]
    for i in range(len(parse_table)):
```

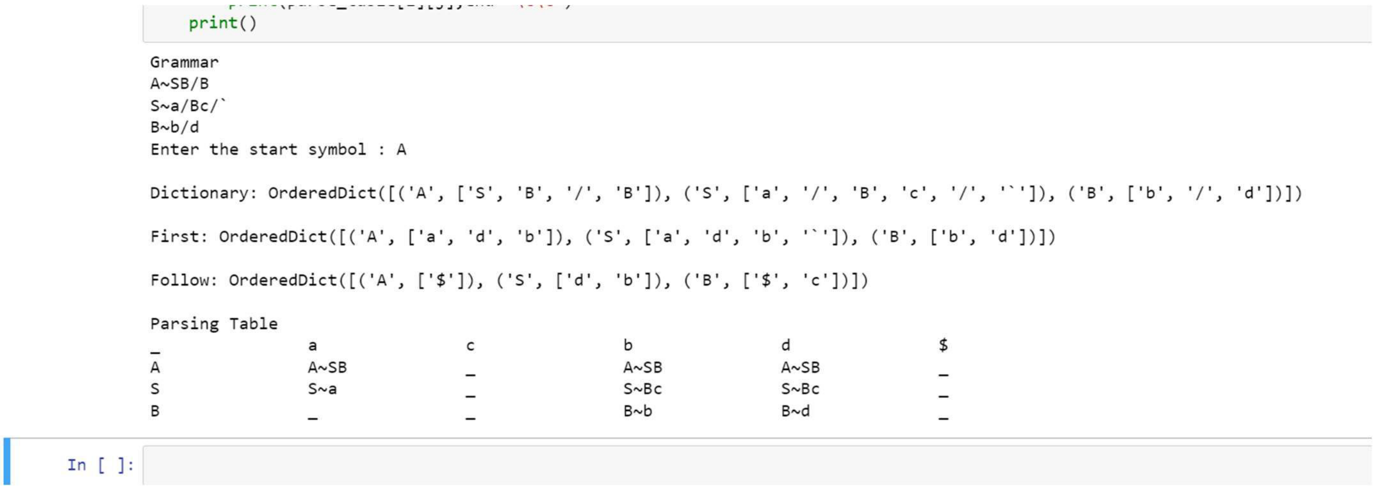
```
    for j in range(len(parse_table[0])):
        if i == 0 and j != 0:
            parse_table[i][j] = terminals[j-1]
        if i != 0 and j == 0:
            parse_table[i][j] = nonterminals[i-1]

#fill table
for i in range(1,len(parse_table)):
    for j in range(1,len(parse_table[0])):
        if parse_table[0][j] in first[parse_table[i][0]]:
            key = parse_table[i][0]
            for k,v in rule.items():
                if k == key:
                    val = v

            c = 0
            flag = 0
            while c < len(val) and flag == 0:
                if val[c] in nonterminals:
                    if parse_table[0][j] in first[val[c]]:
                        rhs = ''
                        for k in range(c, len(val)):
                            if val[k] == '/':
                                break
                            rhs += val[k]

                        ans = parse_table[i][0] + '~' + rhs
                        parse_table[i][j] = ans
                        flag = 1

                elif val[c] == parse_table[0][j]:
                    rhs = ''
                    for k in range(c,len(val)):
                        if val[k] == '/':
                            break
                        rhs += val[k]

                    ans = parse_table[i][0] + '~' + rhs
                    parse_table[i][j] = ans
                    flag = 1

                else:
                    while val[c] != '/' and c < len(val):
                        c += 1
                    if c < len(val):
                        c += 1
            elif parse_table[0][j] in follow[parse_table[i][0]] and '`' in first[parse_table[i][0]]:
                parse_table[i][j] = parse_table[i][0] + '~`'

            elif parse_table[0][j] in follow[parse_table[i][0]]:
                parse_table[i][j] = '_'

            else:
                pass

    return parse_table

rule,nonterminals,terminals = EnterGrammar()
start_symbol = input("Enter the start symbol : ")
print()
print("Dictionary:",rule)
print()

first = OrderedDict()
for k, v in rule.items():
    first[k] = []
    first[k].extend(Calculate_First(rule, k))
print("First:",first)
print()

follow = OrderedDict()
for k, v in rule.items():
    follow[k] = []
    follow[k].extend(Calculate_Follow(rule, k, start_symbol))
    follow[k] = list(set(follow[k]))
print("Follow:", follow)
print()

parse_table = parsingTable(rule,nonterminals,terminals,first,follow)
print("Parsing Table")
for i in range(len(parse_table)):
    for j in range(len(parse_table[0])):
        print(parse_table[i][j],end="\t\t")
    print()
```

Input:



```
A~SB/B
S~a/Bc/`
B~b/d
```

Output:



```
    print()
```

```
Grammar
A~SB/B
S~a/Bc/`
B~b/d
Enter the start symbol : A

Dictionary: OrderedDict([('A', ['S', 'B', '/', 'B']), ('S', ['a', '/', 'B', 'c', '/', '`']), ('B', ['b', '/', 'd'])])

First: OrderedDict([('A', ['a', 'd', 'b']), ('S', ['a', 'd', 'b', '`']), ('B', ['b', 'd'])])

Follow: OrderedDict([('A', ['$']), ('S', ['d', 'b']), ('B', ['$', 'c'])])

Parsing Table
_               a               c               b               d               $
A               A~SB            _               A~SB            A~SB            _
S               S~a             _               S~Bc            S~Bc            _
B               _               _               B~b             B~d             _
```

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$A \rightarrow SB | B$
$S \rightarrow a | Bc | \varepsilon$
$B \rightarrow b | d$

First -

$\text{First}(a) = \{a\}$
$\text{first}(b) = \{b\}$
$\text{first}(c) = \{c\}$
$\text{first}(d) = \{d\}$
$\text{first}(\varepsilon) = \{\varepsilon\}$

$\text{First}(B) = \text{first}(b) \cup \text{first}(d) = \{b\} \cup \{d\} = \{b, d\}$

$$\begin{aligned}\text{first}(S) &= \text{first}(a) \cup \text{first}(Bc) \cup \text{first}(\varepsilon) \\ &= \{a\} \cup \text{first}(B) \cup \{\varepsilon\} \\ &= \{a\} \cup \{b, d\} \cup \{\varepsilon\} \\ &= \{a, b, d, \varepsilon\}\end{aligned}$$

$$\begin{aligned}\text{first}(A) &= \text{first}(SB) \cup \text{first}(B) \\ &= \text{first}(S) - \{\varepsilon\} \cup \text{first}(B) \cup \text{first}(B) \\ &= \{a, b, d, \varepsilon\} - \{\varepsilon\} \cup \{b, d\} \cup \{b, d\} \\ &= \{a, b, d\} \cup \{b, d\} \cup \{b, d\} \\ &= \{a, b, d\}\end{aligned}$$

Follow -

follow (A) = $\{\$\}$

follow (s) = first(B)

$= \{b, d\}$

follow (B) = first(ε) $- \{\varepsilon\} \cup$ follow(A) $\cup$ first(c)

$= \{\varepsilon\} - \{\varepsilon\} \cup \{\$\} \cup \{c\}$

$= \{c, \$\}$

Parsing Table -

	a	b	c	d	$
A	A→SB	A→SB|B		A→SB|B	
S	S→a	S→Bc|ε		S→Bc|ε	
B		B→b		B→d	