Theory of Computation Final Project Presentation

December 2020
Ina Patrice Gonzales

TABLE OF CONTENTS

ABOUT THE PROJECT

What is a Pushdown Automata?

Def: a pushdown automata is an finite state machine that uses a stack data structure

What is a Deterministic Pushdown Automata?

Def: a deterministic pushdown automata accepts the deterministic context - free languages; there will be at most one transition from any state based on the input given

Project Goals

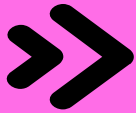**Implement a Pushdown Automata**

Context Free Language
$L = \{a^n b^n \mid n >= 0\}$

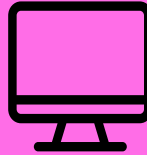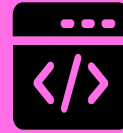**Deterministic & One Look Ahead**

Brief Overview of Program

INPUT

Eight sets of strings:
$a^2b^2\$$ ... $a^{10}b^{10}\$$

Program is a DPDA that will compute the transitions for the given string.

PROGRAM

OUTPUT

Output is a table with: step, state, unread input, top of stack, delta rule used, and R rule used

The Code (function declarations)

HEADER FILES

validString()

printStack()

DPDA()

formatTable()

pushToStack()

RULES

```cpp
// headers
#include <iostream>
#include <stack>
#include <string>
#include <iomanip>

using namespace std;

// initialize variables for program
// stacks used for DPDA
stack <char> inputStack;
stack <char> checkStack;

// function declaration

// returns true if string is valid
bool validString (string str);

// prints a stack
void printStack (stack <char> anyStack);

// pushes a string into a stack
void pushToStack (string str, stack <char> &anyStack);

// transition rules
void rule1 (string &state, string &rule, string &rUsed);
void rule2 (string &state, string &rule, string &rUsed);
void rule3 (string &state, string &rule, string &rUsed);
void rule4 (string &state, string &rule, string &rUsed);
void rule5 (string &state, string &rule, string &rUsed);
void rule6 (string &state, string &rule, string &rUsed);
void rule7 (string &state, string &rule, string &rUsed);
void rule8 (string &state, string &rule, string &rUsed);

// uses the given rules to analyze the given input
void DPDA (stack <char> &inputStack, stack <char> &checkStack, string &state, int &step, string &rule, string &rUsed);

// formats the information from the DPDA() into a table
void formatTable (int step, string state,stack <char> inputStack, stack <char> checkStack, string rule, string rUsed);
```
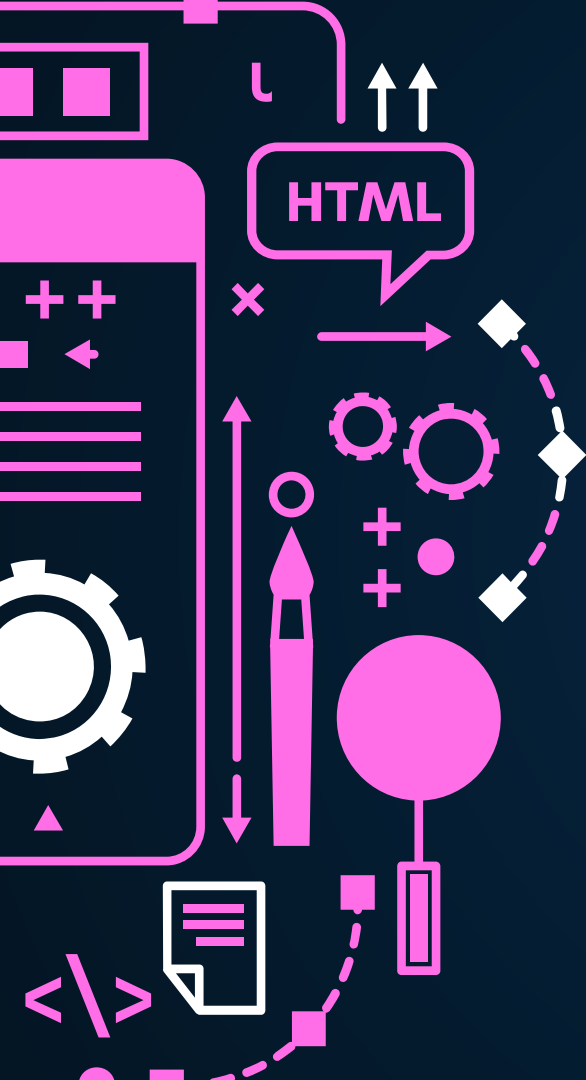
The Code (main function)

```cpp
51
52      // main function of program
53      int main(){
54          string dashes = "=========================================================================================================";
55          // user inputs a string to be checked by the DPDA program
56          string inputString;
57          cout << dashes << endl << "Hello! Welcome to Ina's Theory of Computation Final Project!" << endl << dashes << endl;
58          cout << "To begin, please enter a string like this one --> (ex: aabb$) below!" << endl;
59          cout << "Note: This string should fit the language of L(G) = {a^nb^n | N >= 0}." << endl << dashes << endl;;
60          cout << "Your Input: ";
61          cin >> inputString;
62
63          cout << dashes << endl;
64
65          // if the input is not valid (ex: "absdf$" or "aab$"), it will print an error message and program will quit
66          if (validString(inputString) == false) {
67              cout << "Input Status: INVALID" << endl << dashes << endl;
68              cout << "DPDA Status: REJECTED" << endl;
69              cout << "** DPDA does not recognize that string. **" << endl << dashes << endl;
70          }
71          // if the input is valid (ex: "aabb$" or "aaabbb$"), the program will continue running
72          else{
73              cout << "Input Status: VALID" << endl;
74              cout << dashes << endl << "DPDA Status: ACCEPTED!" << endl;
75              cout << "** DPDA recognizes that string. **" << endl << dashes << endl;
76              // pushes the valid input into a stack to be used by the DPDA function
77              pushToStack(inputString,inputStack);
78
79              // step 0 of the DPDA
80              string state = "p";
81              string rule = "-";
82              string rUsed = " ";
83              int step = 0;
84
85              // calling the rest of the program to execute the DPDA
86              DPDA(inputStack,checkStack,state,step,rule,rUsed);
87          }
88
89          cout << dashes << endl << "I hope you enjoyed my program! Goodbye!" << endl << dashes << endl;
90          return 0;
91      }
```

The Code

(transition rules)

```
177  // transition rules
178
179  void rule1(string &state, string &rule, string &rUsed){
180      rule = "1";
181      state = "q";
182      rUsed = "";
183      checkStack.push('S');
184  }
185
186  void rule2(string &state, string&rule, string &rUsed){
187      rule = "2";
188      state = "qa";
189      rUsed = "";
190      inputStack.pop();
191  }
192
193  void rule3(string &state, string&rule, string&rUsed){
194      rule = "3";
195      state = "q";
196      rUsed = "";
197      checkStack.pop();
198  }
199
200  void rule4(string &state, string &rule, string &rUsed){
201      rule = "4";
202      state = "qb";
203      rUsed = "";
204      inputStack.pop();
205  }
```

```cpp
238     // uses the transition rules to analyze the given input
239     void DPDA (stack <char> &inputStack, stack <char> &checkStack, string &state, int &step, string &rule, string &rUsed){
240         do {
241             if (step == 0){
242                 rule = "-";
243                 formatTable(step, state,inputStack,checkStack,rule, rUsed);
244                 step++;
245             }
246             else {
247                 if (state == "p"){
248                     rule1(state, rule, rUsed);
249                     formatTable(step, state,inputStack,checkStack,rule, rUsed);
250                     step++;
251                 }
252
253                 if (state == "q"){
254                     if (inputStack.top() == '$'){
255                         rule6(state, rule, rUsed);
256                         formatTable(step, state,inputStack,checkStack,rule, rUsed);
257                         step++;
258                     }
259                     else if (inputStack.top() == 'b'){
260                         rule4(state, rule, rUsed);
261                         formatTable(step, state,inputStack,checkStack,rule, rUsed);
262                         step++;
263                     }
264                     else {
265                         rule2(state, rule, rUsed);
266                         formatTable(step, state,inputStack,checkStack,rule, rUsed);
267                         step++;
268                     }
269                 }
```

Outputs (VALID)

```
Inas-MBP-2:Desktop inagonzales$ ./a.out
=================================================================================
Hello! Welcome to Ina's Theory of Computation Final Project!
=================================================================================
To begin, please enter a string like this one --> (ex: aabb$) below!
Note: This string should fit the language of L(G) = {a^nb^n | N >= 0}.
=================================================================================
Your Input: aabb$
=================================================================================
Input Status: VALID
=================================================================================
DPDA Status: ACCEPTED!
** DPDA recognizes that string. **
=================================================================================
STEP        STATE                   UNREAD INPUT            STACK           RULE        R USED
0           p                       aabb$                                   -
1           q                       aabb$                   S               1
2           qa                      abb$                    S               2
3           qa                      abb$                    aSb             7           S -> aSb
4           q                       abb$                    Sb              3
5           qa                      bb$                     Sb              2
6           qa                      bb$                     aSbb            7           S -> aSb
7           q                       bb$                     Sbb             3
8           qb                      b$                      Sbb             4
9           qb                      b$                      bb              8           S -> e
10          q                       b$                      b               5
11          qb                      $                       b               4
12          q                       $                                       5
13          q$                                                              6
=================================================================================
I hope you enjoyed my program! Goodbye!
=================================================================================
Inas-MBP-2:Desktop inagonzales$
```

Input: aabb$

Outputs (VALID)

Input: aaabbb$

```
[Inas-MBP-2:Desktop inagonzales$ ./a.out
=================================================================================
Hello! Welcome to Ina's Theory of Computation Final Project!
=================================================================================
To begin, please enter a string like this one --> (ex: aabb$) below!
Note: This string should fit the language of L(G) = {a^nb^n | N >= 0}.
=================================================================================
Your Input: aaabbb$
=================================================================================
Input Status: VALID
=================================================================================
DPDA Status: ACCEPTED!
** DPDA recognizes that string. **
=================================================================================
STEP       STATE           UNREAD INPUT          STACK         RULE       R USED
0          p               aaabbb$                             -
1          q               aaabbb$               S             1
2          qa              aabbb$                S             2
3          qa              aabbb$                aSb           7          S -> aSb
4          q               aabbb$                Sb            3
5          qa              abbb$                 Sb            2
6          qa              abbb$                 aSbb          7          S -> aSb
7          q               abbb$                 Sbb           3
8          qa              bbb$                  Sbb           2
9          qa              bbb$                  aSbbb         7          S -> aSb
10         q               bbb$                  Sbbb          3
11         qb              bb$                   Sbbb          4
12         qb              bb$                   bbb           8          S -> e
13         q               bb$                   bb            5
14         qb              b$                    bb            4
15         q               b$                    b             5
16         qb              $                     b             4
17         q               $                                   5
18         q$                                                  6
=================================================================================
I hope you enjoyed my program! Goodbye!
=================================================================================
Inas-MBP-2:Desktop inagonzales$
```

Outputs (INVALID)

```
[Inas-MBP-2:Desktop inagonzales$ ./a.out
==========================================================================
Hello! Welcome to Ina's Theory of Computation Final Project!
==========================================================================
To begin, please enter a string like this one --> (ex: aabb$) below!
Note: This string should fit the language of L(G) = {a^nb^n | N >= 0}.
==========================================================================
Your Input: aab$
==========================================================================
Input Status: INVALID
==========================================================================
DPDA Status: REJECTED
** DPDA does not recognize that string. **
==========================================================================
==========================================================================
I hope you enjoyed my program! Goodbye!
==========================================================================
Inas-MBP-2:Desktop inagonzales$
```

Input: aab$

```
[Inas-MBP-2:Desktop inagonzales$ ./a.out
==========================================================================
Hello! Welcome to Ina's Theory of Computation Final Project!
==========================================================================
To begin, please enter a string like this one --> (ex: aabb$) below!
Note: This string should fit the language of L(G) = {a^nb^n | N >= 0}.
==========================================================================
Your Input: bbb$
==========================================================================
Input Status: INVALID
==========================================================================
DPDA Status: REJECTED
** DPDA does not recognize that string. **
==========================================================================
==========================================================================
I hope you enjoyed my program! Goodbye!
==========================================================================
Inas-MBP-2:Desktop inagonzales$
```

Input: bbb$

Project Stages

Not understanding how the stack actually works

Coding in C++ (call by reference)

Understanding what a DPDA does

Final Project Done!

Trying to code in Python

Making sure the program worked