0

UMassAmherst

Overview

- Regular Expressions
- State Machines

1

Objective

- Understand how pattern matching can be performed with regular expressions
- Learn how state machines can be used to implement regular expressions

UMassAmherst

Regular Expressions

- Method to describe patterns of text
  - Character-by-character processing
  - Special operators
    - | (alternatives)
    - . (arbitrary character)
    - * (zero or more repetitions)
    - + (one or more repetitions)
    - () (precedence)
    - …

UMassAmherst

Regular Expressions

- Examples
  - abcd
    - abcd matches; aabcd does not match
  - a*bcd
    - aabcd matches; bcd matches; cd does not match
  - (ab|bb)cd

    abcd matches; bbcd matches; abbbcd does not match
  - (ab|bb)*cd

    abbbcd matches; bbabcd matches; cd matches; ababcd matches; abbb does not match

UMassAmherst

Use of Regular Expressions

- Compiler
  - Interpreting characters in program
  - Regular expressions for numbers, keywords, etc.
  - Example tool: flex
- Networking
  - Checking network traffic for attacks
  - Regular expressions for attack patterns
  - Example tool: snort database

UMassAmherst

More Examples for Regular Expressions

- Examining command lines
- Parsing user input
- Parsing various text files
- Examining web server logs
- Examining test results
- Finding text in emails
- Reading configuration files

6

UMassAmherst

More Examples for Regular Expressions

- ^[a-zA-Z"-'\s]{1,40}$

7

UMassAmherst

Limits of Regular Expressions

- Regular expression match patterns from "regular language"
- Regular expression cannot describe patterns from more complex language
  - What can you not describe with a regular expression?

UMassAmherst

Limits of Regular Expressions

- Regular expression match patterns from "regular language"
- Regular expression cannot describe patterns from more complex language
  - Context-free grammars
    - Equal number of opening and closing parentheses
  - Context-sensitive grammars
    - Grammatically correct English language

UMassAmherst

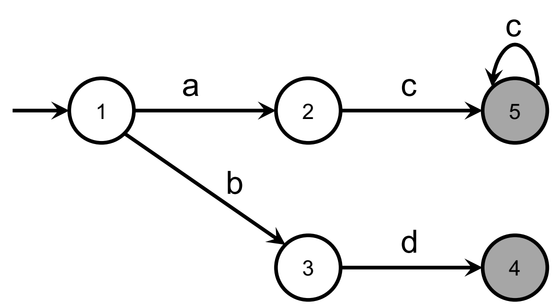
State Machine

- Regular expression can be matched with a state machine (or finite automaton)
- State machine is special case of directed graph
  - Nodes represent state
  - Edges represent transitions (based on input)
- State machines can be constructed for any kind of regular expression

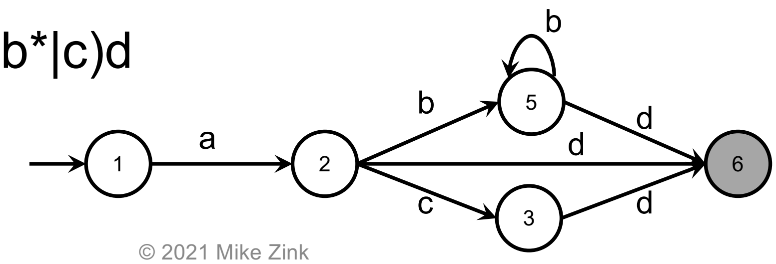
UMassAmherst

State Machine Examples

- Example 1: ac+|bd



- Example 2: a(b*|c)d



Deterministic vs Non-Deterministic

- What is the problem with (ab)*ac?

UMassAmherst

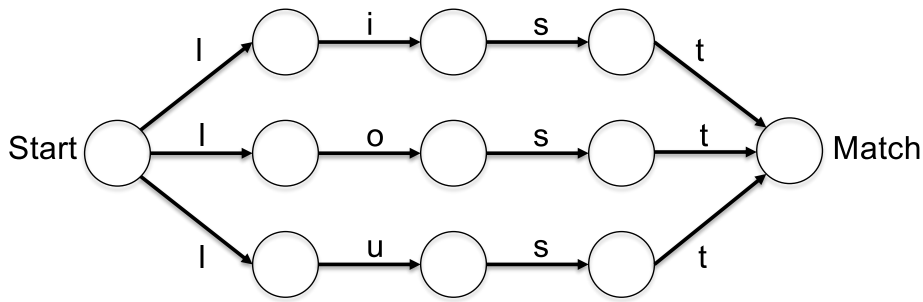
Deterministic vs Non-Deterministic

- What is the problem with (ab)*ac?
  - Non-deterministic transition on a
- Non-deterministic state machines
  - A bit more complex to implement
  - We do not consider them here
  - There exist algorithms to convert from NFA to DFA

UMassAmherst

Deterministic vs Non-Deterministic

- list/lost/lust

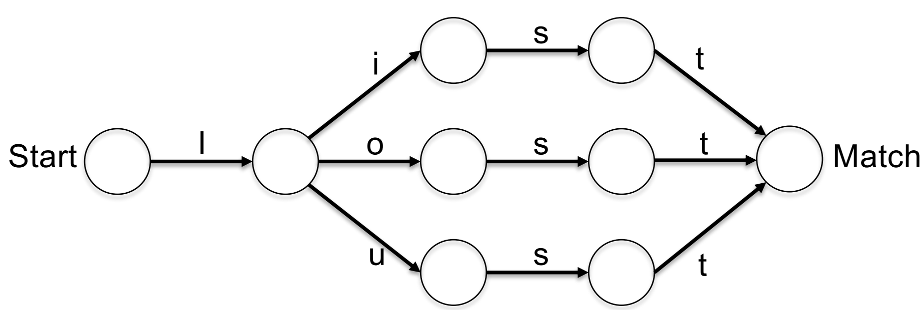


14

UMassAmherst

Deterministic vs Non-Deterministic

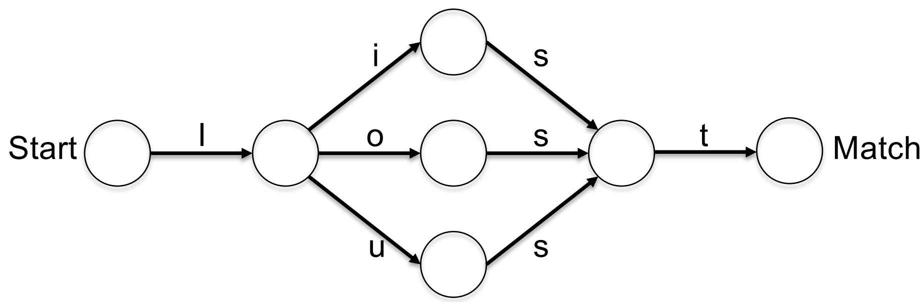
- list/lost/lust



15

Deterministic vs Non-Deterministic

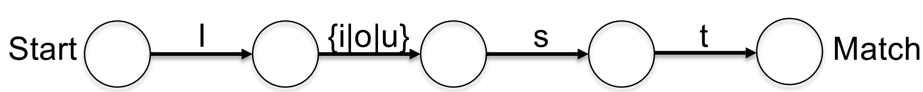
- list/lost/lust



UMassAmherst

Deterministic vs Non-Deterministic

- list/lost/lust



UMassAmherst

Implementing a State Machine

- Vertex with multiple outgoing edges
  - Need class to represent edge
  - Need linked list to store edges
- Matching operation
  - Start at start node
  - Follow edge that matches character
  - At end, check if accepting state
  - If no edge or no accepting state, then no match

UMassAmherst

Edge Class

```
class Edge:
    def __init__(self, c, dest):
        self.destination = dest
        self.character = c
```


UMassAmherst

Vertex Class

```
class Vertex:
    def __init__(self, n):
       self.number = n
       self.edgeList = []
       self.isAcceptingState = None

    def setAcceptingState(self):
        self.isAcceptingState = True

    def addEdge(self,e):
        self.edgeList.append(e)

    def followEdge(self,c):
        for i in self.edgeList:
          if i.character == c:
              return i.destination
       return None
```


UMassAmherst

Matching Method

```
class DFA:
    def __init__(self,s):
       self.start = s

    def match(self,s):
        self.characters = list(s)
        self.current = self.start

        print("trying to match "+s+": ")

        for i in self.characters:
          if self.current == None:
              print("no match")
              return
          print(self.current.number ," ")
            self.current = self.current.followEdge(i)

        if self.current == None:
          print("no match")
          return

        print(self.current.number);
        if self.current.isAcceptingState:
          print("match")
       else:
          print("no match")
       return
```

UMassAmherst

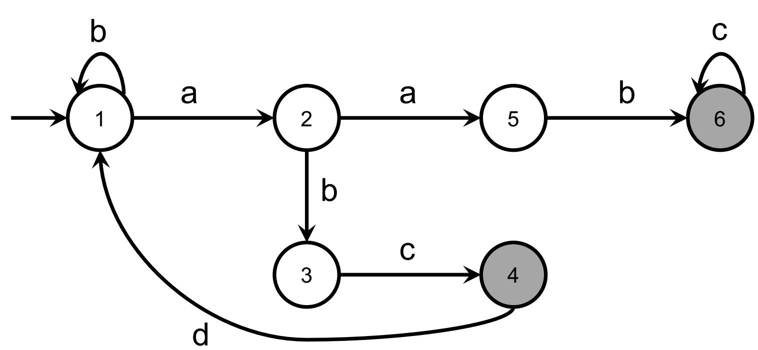
Creating DFA and Patter Matching

```
v1 = Vertex(1)
v2 = Vertex(2)
v3 = Vertex(3)
v4 = Vertex(4)
v5 = Vertex(5)
v6 = Vertex(6)
v4.setAcceptingState()
v6.setAcceptingState()

v1.addEdge(Edge("a",v2))
v1.addEdge(Edge("b",v1))
v2.addEdge(Edge("b",v3))
v2.addEdge(Edge("a",v5))
v3.addEdge(Edge("c",v4))
v5.addEdge(Edge("b",v6))
v6.addEdge(Edge("c",v6))
v4.addEdge(Edge("d",v1))

stateMachine = DFA(v1)
stateMachine.match("abc")
stateMachine.match("bbabc")
stateMachine.match("baab")
stateMachine.match("baabcc")
stateMachine.match("abcdbbbabc")
stateMachine.match("abcd")
stateMachine.match("e")
```


UMassAmherst

Matching Example

- Graph:
- Matching:
  - abc
  - bbabc
  - baab
  - baabcc
  - abcdbbbabc
  - abcd
  - e



Next Steps

- Next lecture and on Thursday
- Project 2 due on 11/11

UMassAmherst
The Commonwealth's Flagship Campus

