CSE 322
Exam Reviews

Basic Concepts

• Formal Languages
  – Alphabet ($\Sigma$)
  – String ($\Sigma^*$)
  – Length ($|x|$)
  – Empty String ($\epsilon$)
  – Empty Language ($\emptyset$)

• Language/String Operations
  – “Regular” Operations:
    • Union ($\cup$)
    • Concatenation ($\cdot$)
    • (Kleene) Star ($^*$)
  – Other:
    • Intersection
    • Complement
    • Reversal
    • Shuffle
    • ...

Finite Defns of Infinite Languages

• English, mathematical
• DFAs
  – States
  – Start states
  – Accept states
  – Transitions ($\delta$ function)
  – M accepts $w \in \Sigma^*$
  – M recognizes $L \subseteq \Sigma^*$
• Nondeterminism
• NFAs
  – Transitions ($\delta$ relation)
  • Missing out-edges
  • Multiple out-edges
  • $\epsilon$-moves
  – N accepts $w \in \Sigma^*$
  – N recognizes $L \subseteq \Sigma^*$
• Regular Expressions
  – $\emptyset$, $\epsilon$, $a \in \Sigma$, $\cup$, $\cdot$, $^*$, $( )$
• GNFAs

Key Results, Constructions, Methods

• L is regular iff it is:
  – Recognized by a DFA
  – Recognized by a NFA
  – Recognized by a GNFA
  – Defined by a Regular Expr
Proofs:
- GNFA $\rightarrow$ Reg Expr
  (Kleene/Floyd/Warshall: $R_s R_s^* R_b$)
- Reg Expr $\rightarrow$ NFA
  (join NFAs w/ $\epsilon$-moves)
- NFA $\rightarrow$ DFA
  (subset construction)
- DFA $\rightarrow$ GNFA
  (special case)

• The class of regular languages is closed under:
  – Regular ops: union, concatenation, star
  – Also: intersection, complementation, ($\&$ reversal, prefix, no-prefix, …)
• NOT closed under $\subseteq$, $\supseteq$
• Also: Cross-product construction (union, …)
## Applications

- "globbing"
  - `lpr *.txt`

- pattern-match searching:
  - `grep "Ruzzo.*terrific" *.txt`

- **Compilers**:
  - `Id ::= letter ( letter|digit )*`
  - `Int ::= digit digit*`
  - `Float ::= d d* . d* ( \varepsilon | E d d* )`
  - (but not, e.g. expressions with nested, balanced parens, or variable names matched to declarations)

- Finite state models of circuits, control systems, network protocols, API's, etc., etc.