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ECE471-571 – Pattern Recognition

Lecture 18: Syntactic Pattern Recognition

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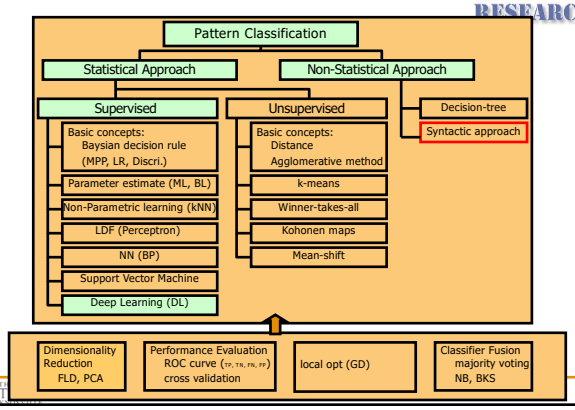

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References

- King Sun Fu, *Syntactic Pattern Recognition, Applications*. Springer, 1977
- International Association for Pattern Recognition (IAPR), 1976
- TPAMI, 1978
  - DL Davies, DW Bouldin - Pattern Analysis and Machine …, 1979 (citation: 2275)

Key Concept

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- If we can draw it (automatically), then we can recognize it
- Based on formal language

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Philosophy

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- A grammar generates a (possibly infinite) set of strings (pictures)
- If we can design a grammar which generates a class of strings, then we can build a machine which will recognize any string in that class

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Types of Grammars - Symbols

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- V_N: the set of non-terminal symbols
- V_T: the set of terminal symbols
- P: the set of rewriting rules (productions)
- S: the start symbol
- $\emptyset$: the empty (null) symbol

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Type 0 Grammar

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- No restrictions on rewriting rules

$$\alpha \rightarrow \beta$$

- The string α (whenever it occurs in a deviation) may be replaced by the string β

Type 1 – Context Sensitive

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$$\alpha \rightarrow \beta \text{ is allowed only if } |\alpha| \leq |\beta| \text{ (length)}$$

Type 2 – Context Free

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- Left side must be a single non-terminal

$$A \rightarrow \alpha$$

- Example

$S \rightarrow 0S1$
$S \rightarrow 01$

Type 3 - Regular

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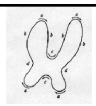
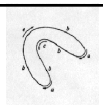
- A → aB, or A → a
- A and B are single non-terminal
- Is a regular grammar also context-free?

Example

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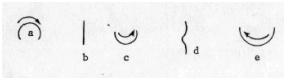
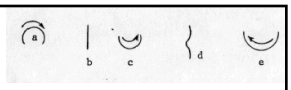
- Describe two types of chromosomes for recognition (submedian chromosome and telocentric chromosome)
- Chromosome is represented as a string, obtained by tracing the outline in clockwise direction
- Pattern primitives = terminal symbols



Example (cont')



- Grammar for recognition of submedian and telocentric chromosomes
  - $G = (V_N, V_T, P, S)$
- Non-terminals
  - $V_N = \{S, S_1^*, S_2^*, A, B, C, D, E, F\}$
  - S – start symbol
  - S_1^* – submedian chromosome
  - S_2^* – telocentric chromosome
  - A – armpair, B – bottom, C – side, D – arm, E – rightpart, F - leftpart

Example (cont')

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- Production (rewriting rules)

$S \rightarrow S_1^*$	$B \rightarrow e$	$S \rightarrow S2^*$	$C \rightarrow bC$
$S_1^* \rightarrow AA$	$C \rightarrow Cb$	$S_2^* \rightarrow BA$	$C \rightarrow b$
$A \rightarrow CA$	$C \rightarrow d$	$A \rightarrow AC$	$D \rightarrow bD$
$A \rightarrow DE$	$D \rightarrow Db$	$A \rightarrow FD$	$D \rightarrow a$
$B \rightarrow bD$	$E \rightarrow cD$	$B \rightarrow Bb$	$F \rightarrow Dc$

Example (cont')

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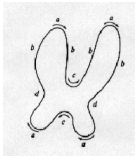
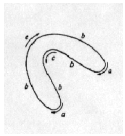


babcbabdacad



ebabcbab

$S \rightarrow S_1^* \rightarrow AA \rightarrow ACA \rightarrow FDCA \rightarrow DcDCA \rightarrow$
$bDcDCA \rightarrow bDbcDCA \rightarrow babcDCA \rightarrow$
$babcbDCA \rightarrow babcbDbCA \rightarrow babcbabCA \rightarrow$
$babcbabdA \rightarrow babcbabdAC \rightarrow babcbabdDEC \rightarrow$
$babcbabdaEC \rightarrow babcbabdacDC \rightarrow$
$babcbabdacaC \rightarrow babcbabdacad$

Finite State Machine

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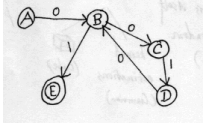
- A regular expression determines a finite-state machine
  - 0(010)*1



  - S → A, A → 0B, B → 0C, C → 1D, D → 0B, B → 1

Recognition of Abnormal ECG

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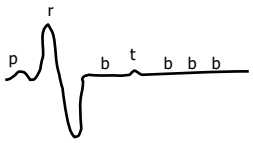
- Regular grammar
  - G = ({S, A, B, C, D, E, H}, {p, r, t, b}, P, S)
- Productions:
  - S → pA, A → rB, B→ bC, C → tD, D → b, D → bE, E → b, E → bH, E → pA, H → b, H → bS, H → pA



ECG (cont')

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- Example of derivation of a well formed ECG wave:
  - S → pA → prB → prbC → prbtD → prbtbE → prbtbbH → prbtbbbS → prbtbbbpA → prbtbbbprB → prbtbbbprbC → prbtbbbprbtD → prbtbbbprbtbE → prbtbbbprbtbb → … etc.
- Note possibility of variable number of "b's"
  - One to three to accommodate normal variations of heart rate

The FSM

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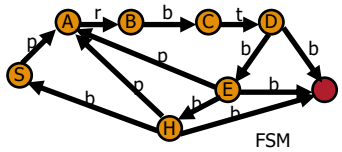

FSM

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Education is what remains after one has forgotten everything one learned in school. -- Albert Einstein

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