Zhu, Song-Chun and Mumford, David. **A Stochastic Grammar of Images.** Foundations and Trends in Computer Graphics and Vision 2(4), 259-362 (2006)

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Most of the pictures used in this presentation were extracted from Zhu's paper

Grammars as Universal And-Or Trees

Grammar

$V_T = \{a, b\}$
$V_N = \{S\}$
$R = \{r_1 : \ S \to aS, \ r_2 : \ S \to b\}$

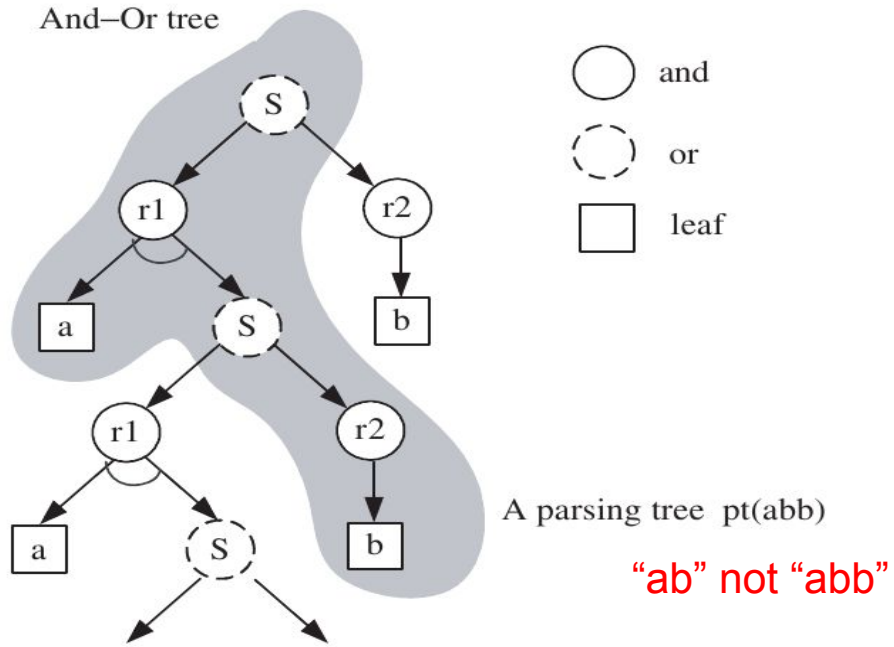
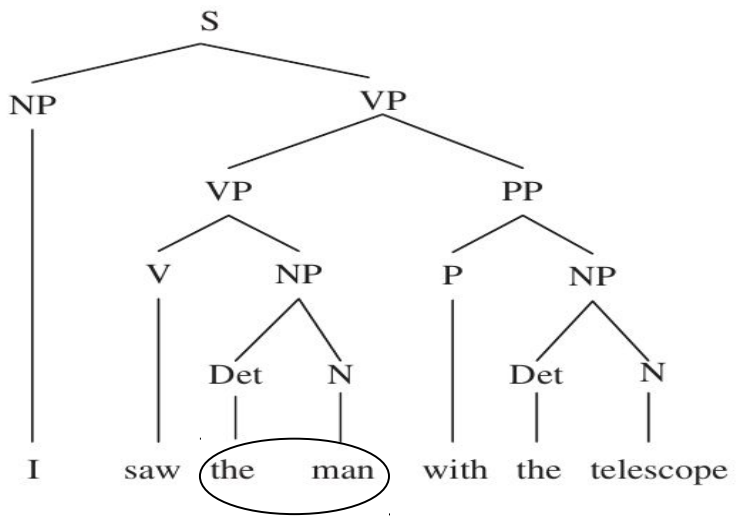
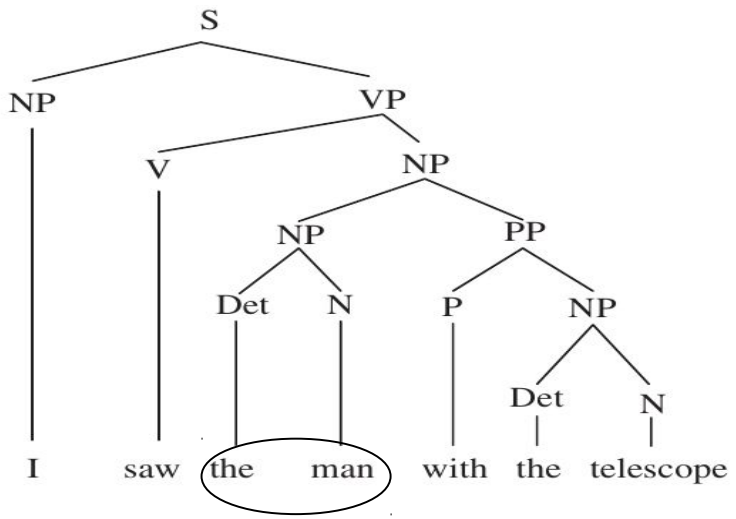


Fig. 2.2 A very simple grammar, its universal And–Or tree and a specific parse tree in shadow.

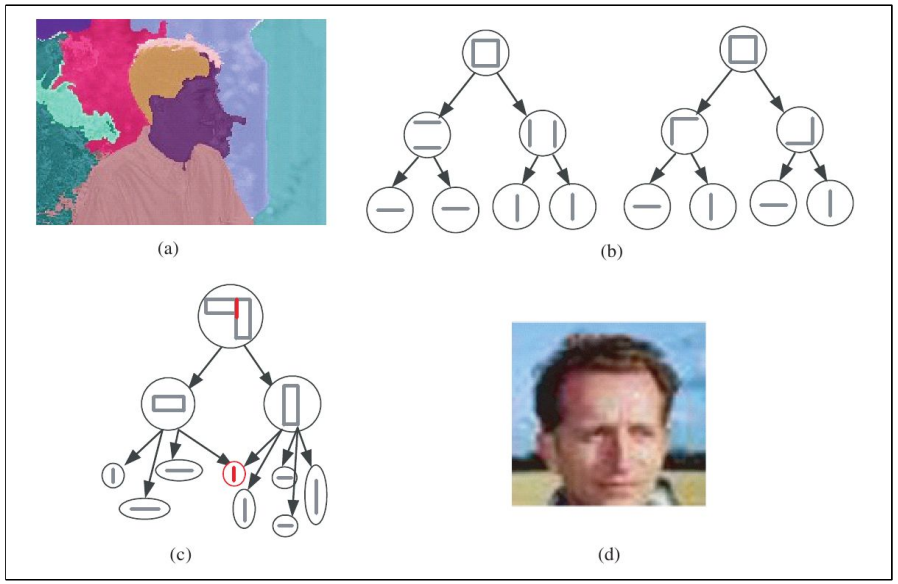
- Universal And-Or Tree can have an infinite size (as in the example)
- Rules are explicitly named (r1 , r2 , …)
- Each or-node A have one child for each rule having A at its left side
- A parsing tree is a sub-graph of a universal and-or tree

Ambiguity in Visual And-Or Trees





- Cycles or Diamonds
- Overlaping Reusable Parts
- Not dealt with yet (2007)
- Most common causes in images:
  - Ambiguous scenes
  - Multiple partial patterns
  - Joints
  - **Occlusion (most common) … extra leaves, interpolation**



Main issues in Visual Grammars unseen in Textual Grammars

- No left-to-right ordering in language

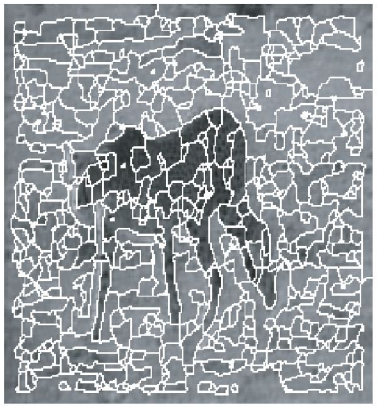
Solution: explicitly add horizontal edges to represent adjancy

- Objects appear in arbitrary scales

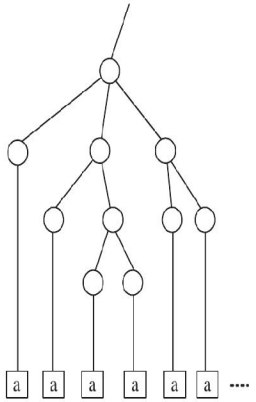
Solution: termination rules at different levels (higher leaves)

- Much wider spectrum of quite irregular local patterns

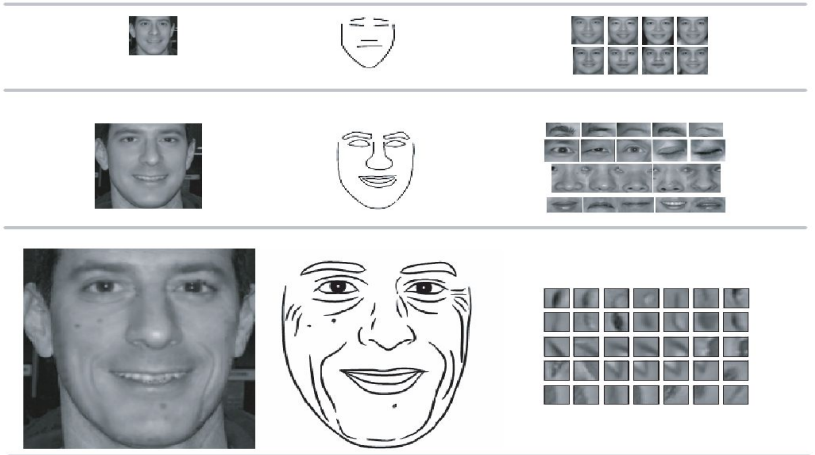
Solution: combine Markov random fields with stochastic grammars



(a)



(b)



Contextual information

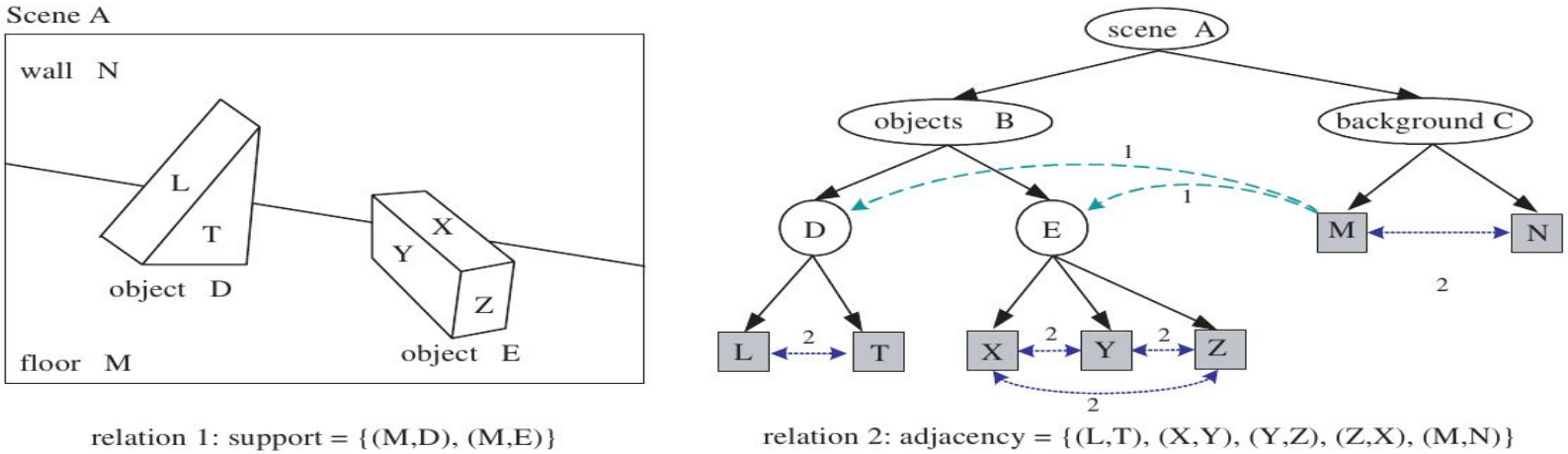


Fig. 2.11 A parser tree for a block world from [22]. The ellipses represents non-terminal nodes and the squares are for terminal nodes. The parse tree is augmented into a parse graph with horizontal connections for relations, such as one object supporting the other, or two adjacent objects sharing a boundary.

- Horizontal lines to represent relations and constraints:
  - Bonds and connections (more dense)
  - Joints and junctions
  - Interactions and semantics (less dense). E.g.: person eating an apple

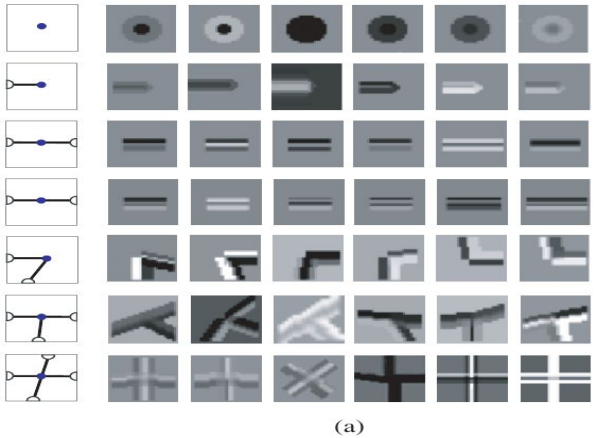
Stochastic information

- Probabilities for rules (stochastic grammars). One local probability at each Or-node to account for the relative frequency of each alternative
- Probabilities of relations (Markov random fields). Local energies associated with each horizontal link.
- A Configurations is a “word” of the “visual language”.

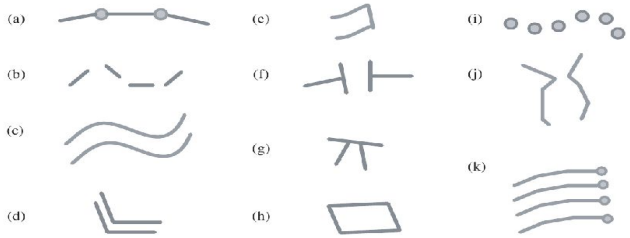
Visual Vocabulary

- Bonds – topological information
- Three hierarchical and connected levels

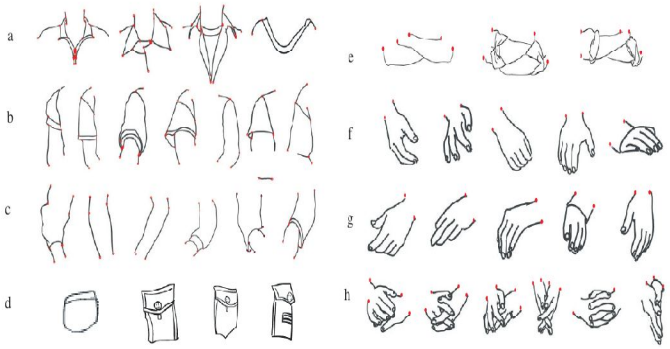
Image **primitives**: Textons (blobs, bars, terminators and crosses)



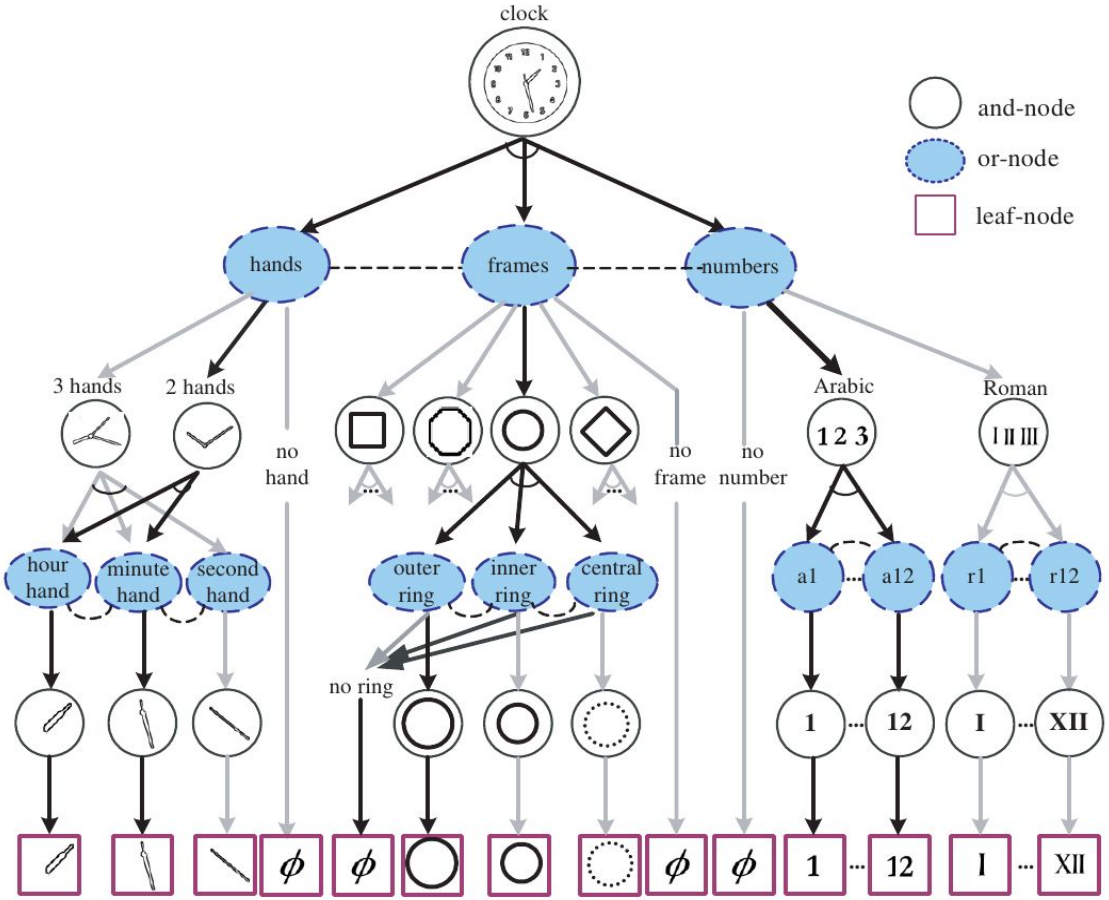
Geometric **groupings**: Graphlets



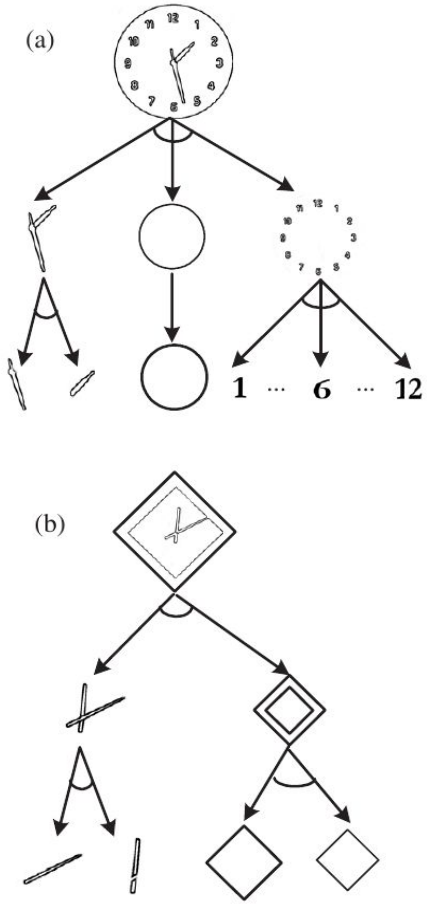
Object parts



Clock example



And-Or Graph (Grammar)



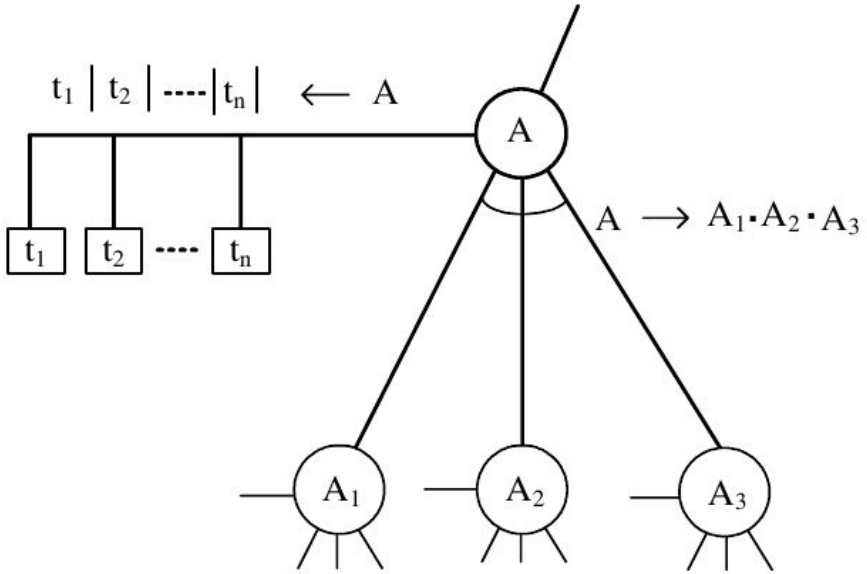
And-Or Parse Graphs

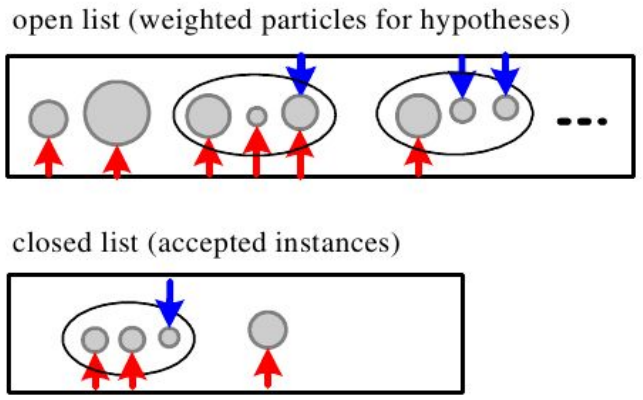
Learning and Estimation with And-Or Graphs

- Main elements to be learned: (1) Vocabulary and And-Or tree, (2) Relations – Horizontal Line and (3) Parameters
- What is available (training data): Images and parse trees (manually constructed ground-truths)
- Three phases:
  - Learning parameters from training data given relations and vocabulary (gradient method)
  - Learning news relations given vocabulary and learned parameters (inspired in texture synthesis)
  - Learning vocabulary and And-Or tree

Image Parsing

- Iterative Heuristic top-down + bottom-up search
- Bottom-up:
  - Hough transforms, Adaboosting … identify possible terminals from images
  - Bind a number of parts
- Top-down:
  - Expand top level nodes
  - Update the weights of the current hypothesis
- Key issue: schudeling of bottom-up and top-down search steps (depends on the problem)





What we can explore

- Learning visual structure from pure textual information
- Top level grammars or constraints based on Santini's work on Semiological Level of Significance
- Define and Adaptive Stochastic And-Or Graph to deal with non-static scenes
- Propose a way to deal with temporal information in the context of Visual Grammars