Image understanding [1]

Vocabulary

What is image understanding?
Beyond individual object recognition.
Objects in their context, spatial arrangement.
Global scene interpretation.
Semantics extraction.
Providing verbal descriptions of image content.
Dynamic scenes: recognition and description of actions, gestures, emotions..
Inference, higher level reasoning.
exemples
image annotation - fuzzy modeling
graphs and grammars - spatial reasoning, abduction
Bayesian tracking
representations of imperfect information
probabilities and statistics
belief functions
fuzzy sets and possibility theory
Basic types of reasoning
deduction: consequences from facts $\frac{A \to B, A}{B}$
contraposition: non-observations $\frac{A \to B, \neg B}{\neg A}$
abduction: causes explaining $A \to B, B$ infer A
induction: rules from observations $\frac{B \text{ whenever } A}{A \to B}$
projection: consequences from actions $\frac{A \to B, \text{ do } A}{\text{expect } B}$
planning: actions from goals $\frac{A \to B, \quad \text{want } B}{\text{do } A}$ **Symbol grounding**: "How is symbol meaning to be grounded in something other than just more meaningless symbols?" (Harnad).
Anchoring: "creating and maintaining the correspondence between symbols and sensor data that refer to the same physical object"
Semantic gap: "lack of coincidence between the information that one can extract from the visual data and the interpretation of these data by a user in a given situation" (Smeulders).

Spatial Reasoning

Linguistics:Rich variety of lexical terms for describing spatial location of entities.
Cognition:Cognitive understanding of a spatial environment is issued from two types of processes.route knowledge acquisition and survey knowledge acquisition.

Spatial Reasoning

Spatial reasoning formalisms

Spatial entities

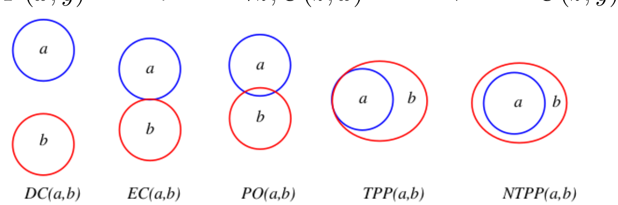
Regions, fuzzy regions.
Simplified regions (centroid, bounding box...).
Abstract representations

Quantitative representations

Precisely defined objects.
Computation of well defined relations.
Many limitations (on the objects, the relations, the type of representations, for reasoning...)

Qualitative / symbolic representations

Cardinal directions: N, NE, E, SE, S, SW, W, NW
Only few compositions can be exactly determined.
Allen's intervals: 13 base relations: s - p - m - o - s - e - d - f
RCC: Region Connection Calculus
Connection predicate C.
Parthood predicate P :
$P(x,y) \quad : \quad \forall z, C(z,x) \quad \to \quad C(z,y)$



Qualitative trajectory calculus: RCC + Allen
Semi-quantitative: fuzzy approaches
Fuzzy set: $\mu \quad : \quad \mathcal{S} \quad \to \quad [0,1] \quad - \quad \mu(x) \quad =$ membership degree of x to μ

Graphs

$$\text{Graph : } \quad G = (X, E)$$

X set of nodes ($|X|$ order of the graph)
E set of edges ($|E|$ size of the graph)
complete graph size $\left(\frac{n(n-1)}{2}\right)$

Graphs

partial graph $G = (X, E')$ with E' part of E
subgraph $F = (Y, E'), Y \subseteq X$ et $E' \subseteq E$
degree of a node $x : d(x) =$ number of edges
connected graph: each pair of nodes you find a path linking them tree: connected graph without cycle
clique: complete subgraph dual graph (face $\to$ node)
segment graph (edge $\to$ node)
weight of an edge linking i et $j : w_{ij}$
adjacency matrix W of size $|X| \times |X|$ defined by

$$W_{ij} = \begin{cases} w_{ij} & \text{if} \quad e_{ij} \in E \\ 0 & \text{else} \end{cases}$$

Examples of graphs: Graph of fuzzy attributes, Hierarchical graph, Graph for reasoning.
Some classical algorithms

- Search of the minimum spanning tree
  Kruskal algorithm $O\left(n^2 + m\log_2(m)\right)$
  Prim algorithm $O\left(n^2\right)$
- Shortest path problems
  positive weights: Dijkstra algorithm $O\left(n^2\right)$
  arbitrary weights but without cycle: Bellman algorithm $O\left(n^2\right)$
- Max flow and Min cut
  $G = (X, E)$
  partitioning in two sets A et $B (A \cup B = X, A \cap B = \emptyset)$
  $\text{cut}(A, B) = \sum_{x \in A, y \in B} w(x, y)$
  Ford and Fulkerson algorithm
- Search of maximal clique in a graph
  decision tree
  cut of already explored branches

Reference

References

[1] Image understanding. https://perso.telecom-paristech.fr/bloch/AIC/OptionsImage.html.