Contents (1)

Einführung in Bildverstehen
- Übersicht über Ziele und Methoden von Bildverstehen
- Ziele der höheren Bilddeutung
- Stand der Kunst für Szeneninterpretation

Historische Beispiele
- Arbeiten von Badler, Tsotsos, Hogg
- NAOS: Sprachliche Beschreibung von Verkehrsszenen

Relationalvergleich
- Repräsentation von Szenen als Relationalstrukturen
- Vergleichsverfahren

Regelbasierte Interpretationsverfahren
- OPS5 Regelsysteme
- Fuzzy-Regeln

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Website

The website for this course can be reached via

http://kogs-www.informatik.uni-hamburg.de/~neumann/HBD-WS-2003/

You will find PDF copies of the slides and possibly other useful information related to the course.

The website will be updated each week on Monday.

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What is Computer Vision?

Computer Vision is the academic discipline which deals with task-oriented reconstruction and interpretation of a scene by means of images.

scene:	section of the real world stationary (3D) or moving (4D)
image:	view of a scene projection, density image (2D) depth image (2 1/2D) image sequence (3D)
reconstruction and interpretation:	computer-internal scene description quantitative + qualitative + symbolic
task-oriented:	for a purpose, to fulfill a particular task context-dependent, supporting actions of an agent

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What Is High-level Vision?

High-level vision is the task of "understanding" a scene beyond single-object recognition. Typical examples are traffic scene understanding for driver assistance, inferring user intentions in smart-room scenarios, recognizing team behavior in robocup games, discovering criminal acts in monitoring tasks.

Characteristics:

- Interpretations involve several objects and occurrences.
- Interpretations depend on temporal and spatial relations between parts of a scene
- Interpretations describe the scene in qualitative terms, omitting geometric details.
- Interpretations include inferred facts, unobservable in the scene.
- Interpretations are based on conceptual knowledge and experience about the world.

"Scene understanding" means roughly the same as "high-level vision".

Cognitive Computer Vision

High-level vision is strongly related to "cognitive vision", a term created for vision comparable to human vision:

Cognitive computer vision is concerned with integration and control of vision systems using explicit but not necessarily symbolic models of context, situation and goal-directed behaviour. Cognitive vision implies functionalities for knowledge representation, learning, reasoning about events & structures, recognition and categorization, and goal specification, all of which are concerned with the semantics of the relationship between the visual agent and its environment.

Topics of cognitive vision:

- integration and control
- explicit models
- not necessarily symbolic
- context
- situation
- goal-directed behaviour

- knowledge representation
- learning
- reasoning
- recognition
- categorization
- goal specification
- visual agent

Examples for High-level Vision (1)

high-level vision means understanding every-day occurrences

Garbage collection in Hamburg (1 frame of a sequence)

We want to recognize parts, activities, intentions, spatial & temporal relations

Examples for High-level Vision (2)

High-level vision is silent movie understanding

Buster Keaton in "The Navigator"

We want to recognize episodes, the "story", emotions, funnyness

Some application scenarios for high-level vision

- street traffic observations (long history)
- cameras monitoring parking lots, railway platforms, supermarkets, nuclear power plants, ...
- video archiving and retrieval
- soccer commentator
- smart room cameras
- autonomous robot applications
  (e.g. robot watchmen, playmate for children)

Characteristics of High-level Scene Interpretation Tasks

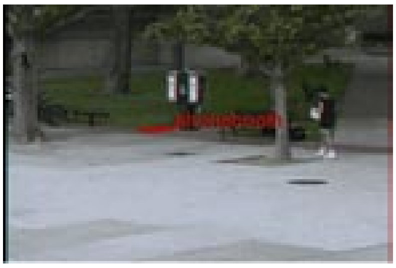
- interpretations typically involve several interrelated objects
- spatial and temporal relations are important
- interpretations may build on common sense knowledge
- application scenarios are highly diverse
- domains may be very large
- learning and adaptation may be required
- reliability and complexity management may become important issues
- economical application development requires generic approach

Context and Task Dependence

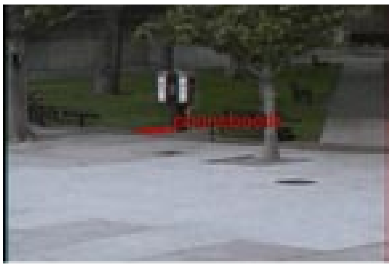
Interpretations may depend on
- domain context
- spatial context
- temporal context
- intentional context
- task context
- communicative context
- focus of attention
- a priori probabilities

Constructing an interpretation is not a mapping from image data into interpretation space.

A State-of-the-art Example of Scene Interpretation



recognizing assaults



recognizing thefts at a phonebooth

Multidisciplinary Contributions to Cognitive Vision

Cognitive Vision research requires multidisciplinary efforts and escape from traditional research community boundaries.

Knowledge Representation & Reasoning
- KR languages
- logic-based reasoning services
- default theories
- reasoning about actions & change
- Description Logics
- spatial and temporal calculi

Computer Vision
- object recognition, tracking
- bottom-up image analysis
- geometry and shape
- hypothesize-and-test control
- probabilistic methods

Learning & Data Mining
- concept learning
- inductive generalization
- clustering
- knowledge discovery

Cognitive Vision

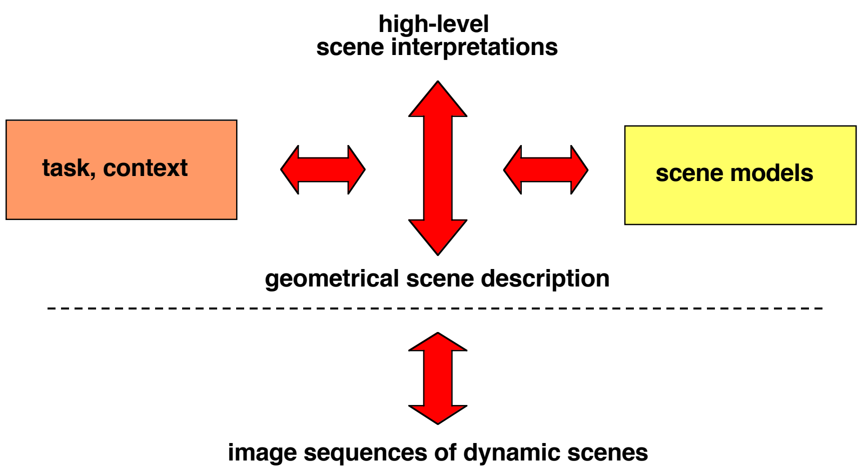
Natural Language
- high-level concepts
- qualitative descriptions
- NL scene descriptions
- communication

Robotics
- planning, goal-directed behaviour
- manipulation
- sensor integration
- navigation
- localization, mapping, SLAM
- integrative architectures

Cognitive Science
- psychophysical models
- neural models
- conceptual spaces
- qualitative representations
- naive physics

Uncertain Reasoning
- Bayesian nets, belief nets
- decision & estimation
- causality
- probabilistic learning

Basic Structure of High-level Scene Interpretation



Representation Levels for High-level Scene Interpretation

symbolic scene descriptions — **symbolic domain**

pictorial scene representations

metric domain (pictorial scene representations, metric feature representations)

metric feature representations

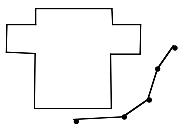
map-type feature representations — **signal domain** (metric feature representations, map-type feature representations, raw image sequence)

raw image sequence

Signal-symbol Problems (1)

Mapping from quantitative into qualitative representations

Example:

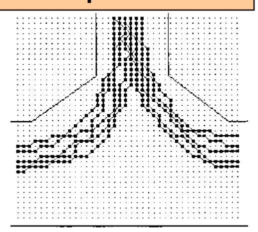


"along"

"Citytour" (Wahlster 87)

Mapping from qualitative into quantitative representations

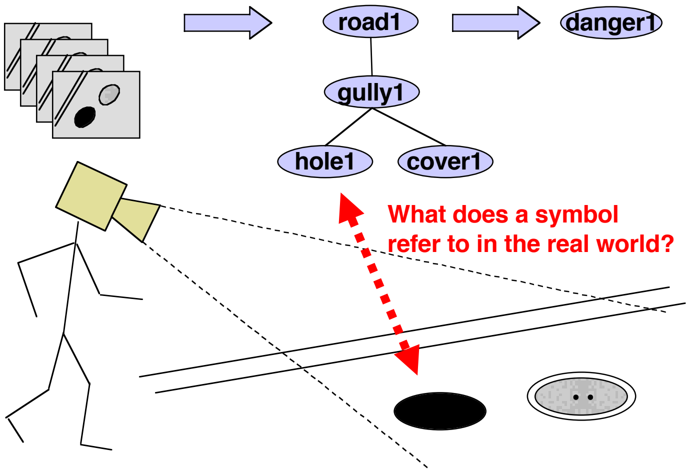
Example: *"abbiegen"*



"typicality fields" (Mohnhaupt & Neumann 91)

Signal-symbol Problems (2)

Symbol grounding



Signal-symbol Problems (3)

Grounded symbolic reasoning

Deductions from symbolic knowledge about a scene should not only be correct w.r.t. to the underlying logic but also w.r.t. to common sense.

Examples:

(implies (and house (some near lake)) mosquito-house)
(instance house1 house)
(instance lake1 lake)
(related house1 lake1 near)
(instance house1 (not (mosquito-house)))
=> inconsistent!

(instance house1 house)
(instance cup1 cup)
(related house1 cup1 inside)
=> inconsistent???

Uncertainty Problems (1)

Fuzzyness of concepts

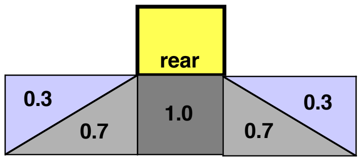
Many high-level concepts have unsharp boundaries.

"behind" "overtake" "meet"

=> mapping into logical propositions may be problematic

- Fuzzy set theory offers "degree of applicability"

- Probability theory offers statistical measures for language use



Fuzzy definition of behind

Uncertainty Problems (2)

Uncertainty of data

Example: Object boundaries

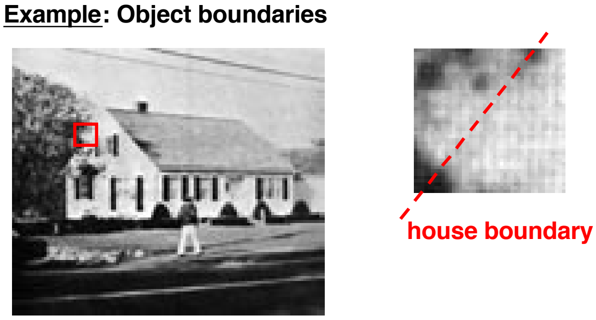


Image interpretation is fundamentally ill-defined

Uncertainty Problems (3)

Exploring multiple hypotheses

Answers from several disciplines:

- graph matching
- heuristic search
- optimization theory
- logic theories
- probability & utility theory
- case-based reasoning
- neural networks
- particle physics

(and others)

Mixed bottom-up and top-down interpretation strategies have been rarely explored

Uncertainty Problems (4)

Cultural clash betweeen logical and probabilistic reasoning

Probabilistic methods are nor yet seamlessly integrated with logical calculi

Interesting recent developments:

- First-order probabilistic inference (Poole 03)
- Probabilistic relational models (http://dags.stanford.edu/PRMs/)

Example for reasoning in image interpretation:
(from Kanade´s invited lecture at IJCAI-03:
"Computer Vision: AI or Non-AI Problem?")

car on left side of street
(uncertain orientation of car)

japanese signs => left-hand traffic

} orientation of car resolved