Object Identification and Recognition (II)

Introduction to Computational and Biological Vision

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Interpretation Trees for Feature-Based Identification

The scope - objects as sets of features

Measurements (Image)

\((f_1, f_2, \ldots, f_n)\)

Extraction process

Model Database

\(\rightarrow (F_1, F_2, \ldots, F_{m_1})\)

\(\rightarrow (F_1, F_2, \ldots, F_{m_2})\)

\(\rightarrow (F_1, F_2, \ldots, F_{m_3})\)

\(\vdots\)

\(\rightarrow (F_1, F_2, \ldots, F_{m_k})\)
**Interpretation Trees for Feature-Based Identification**

Objects as local geometrical features and their inter-relationships

Measurements (Image)  Model

Recognition = **Consistent interpretation** of the measurements in terms of the model features
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Recognition as search
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The correspondence space

\[ f_1 \Leftrightarrow F_3 \]
\[ f_2 \Leftrightarrow F_5 \]
\[ f_3 \Leftrightarrow F_4 \]
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Challenges in feature matching

• Search space size
• Cost of match verification
• Occlusions (partial/missing measured features)
• Multiple objects and complex scenes
• Measurement errors in feature position and pose
• Spurious measurements
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The use of constraints

Unary constraints

\[ U_k(f_i, F_p) \in \{\text{True, False}\} \]

Binary constraints

\[ B_k(f_i, F_p; f_j, F_q) \in \{\text{True, False}\} \]
Interpretation Trees for Feature-Based Identification

The Interpretation Tree

\[ f_1 \leftrightarrow \]

\[ F_1 \quad F_2 \quad F_3 \quad F_4 \quad F_5 \quad F_6 \]
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The Interpretation Tree

\[ f_1 \iff F_1 \]
and

\[ f_2 \iff F_2 \]
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Constraint-based DFS of the interpretation tree

To go down deeper must satisfy all relevant unary and binary constraints. Otherwise, backtrack.
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Verification of hypothetical interpretations
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Partial, misleading, or spurious features

Measurements (Image)  Model

\[ f_1 \quad f_3 \quad f_2 \quad f_4 \]

\[ F_1 \quad F_2 \quad F_3 \quad F_4 \quad F_5 \quad F_6 \]
**Interpretation Trees for Feature-Based Identification**

The wild card

![Diagram showing wild card in feature space](attachment:image.png)
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The wild card

\[ f_1 \Leftrightarrow F_1 \rightarrow F_2 \rightarrow F_3 \rightarrow F_4 \rightarrow F_5 \rightarrow F_6 \rightarrow * \]

\[ f_1 \]

irrelevant
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Partial, misleading, or spurious features
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Allowing wild cards = redundant interpretations

\[ \sum_{i=0}^{c-1} \binom{c}{i} = 2^c - 1 \]

redundant interpretations

c-interpretation

(c-1)-interpretation
**Interpretation Trees for Feature-Based Identification**

Branch and bound heuristics

\[
\mu((f_1, F_{j_1}); (f_2, F_{j_2}); \ldots; (f_s, F_{j_s}))
\]

\[
\mu = \sum_{i=1}^{s} \delta_i w_i
\]

\[
\delta_i = \begin{cases} 
1 & F_{j_i} \neq * \\
0 & \text{otherwise}
\end{cases}
\]

\[
W_i = \text{Match score}
\]
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Branch and bound heuristics

\[ \mu = \sum_{i=1}^{s} \delta_i \]

\[ \delta_i = \begin{cases} 1 & F_{j_i} \neq * \\ 0 & \text{otherwise} \end{cases} \]

At each node

- Compute \( \mu, \mu_{\text{bound}} \)
- If \( \mu_{\text{bound}} \leq \mu_{\text{max}} \)
  - backtrack
- else
  - \( \mu_{\text{max}} = \mu \)
Interpretation Trees for Feature-Based Identification

Example
Interpretation Trees for Feature-Based Identification

Example