Towards Robust Matching & Relational Representations of Objects in Images

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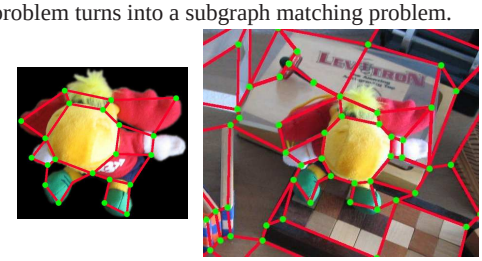
1 Object Recognition

Using a relational graph representation of objects and scenes the object recognition problem turns into a subgraph matching problem.



1.1 Integer Program for Subgraph Matching

The subgraph matching problem can be formulated as the following quadratic integer program:

$$\min_x \; w^\top x + x^\top Q x$$
$$\text{s.t. } A_K x = e_K \;,\; A_L x \leq e_L \;,\; x \in \{0,1\}^{KL}$$

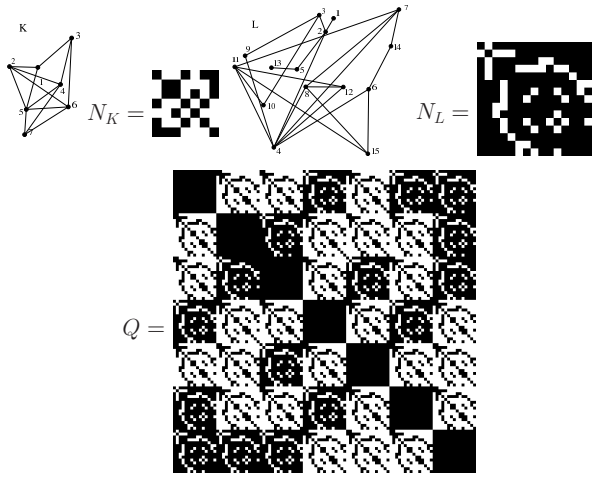
with Structure-matrix

$$Q = N_K \otimes \bar{N}_L + \bar{N}_K \otimes N_L$$

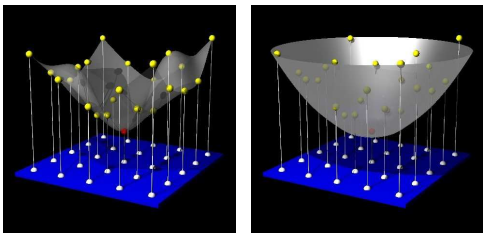
w : vector with similarity values between the nodes
N_K, N_L :adjacency-matrices
$\bar{N}_L, \bar{N}_K$: complementary adjacency matrices
$A \otimes B$: Kronecker product of A and B
e_K, e_L : $e_n = (1, ..., 1)^\top \in R^n$ vector with all elements one

(-) combinatorial problem

1.2 Example for Structure Matrix Q



1.3 Convex Semidefinite Approximation



Using

$$w^\top x + \alpha x^\top Q x \;=\; \text{Tr}\left[\underbrace{\begin{pmatrix} 0 & \frac{1}{2}w^\top \\ \frac{1}{2}w & \alpha Q \end{pmatrix}}_{\tilde{Q}} \underbrace{\begin{pmatrix} 1 & x^\top \\ x & xx^\top \end{pmatrix}}_{X}\right]$$

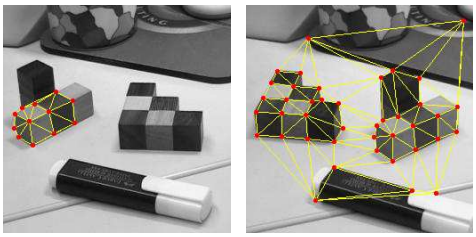
the problem can be approximated by the following semidefinite program (SDP):

$$\min_x \; \text{Tr}\left[\tilde{Q}X\right]$$
$$\text{s.t. } \text{Tr}[A_1 X] = c_1, \text{Tr}[A_2 X] = c_2, ..., \text{Tr}[A_m X] = c_m$$
$$X \succeq 0$$

Tr $[Y]$: trace of matrix Y

(+) convex optimisation problem
(-) no integer solution

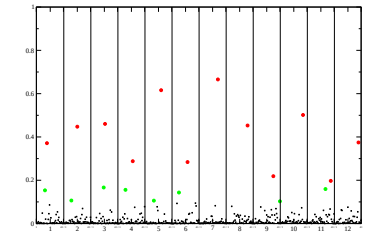
2 Real World Example

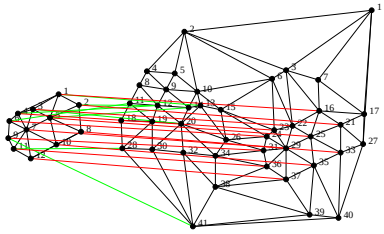


2.1 Post-processing

Find the best bipartite matching from the solution vector x_{sol}:

$$\max_x x_{sol}^\top x \;,\; x \in \{0,1\}^{KL}$$
$$A_K x = e_K \;,\; A_L x \leq e_L$$





3 Extraction of Graph Representations from Images

3.1 Discussion

How to extract robust features suitable for a relational representation of an object ?
How to measure the complexity of a relational structure ?