T-61.5070 COMPUTER VISION, Exercise 10/08

1.

Measures for graph similarity are shortly explained in Sec. 7.5.2, pp. 328.

a) The relation structures A and B are represented as graphs in Fig. 1. The unary relations (i.e., properties) P, R, and Q are represented as circles, squares, and triangles, respectively. The binary relations (i.e., between two nodes) are represented as arrows, for example $F(u, v)$ as an arrow from u to v.

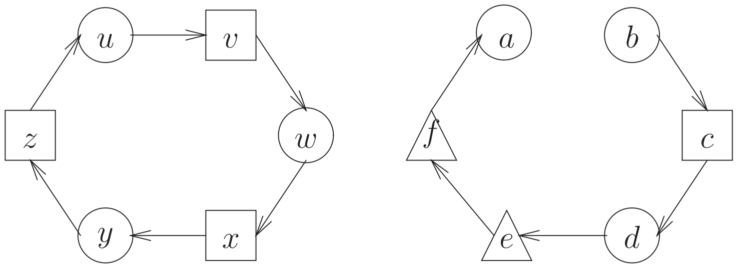

Figure 1: Graphs corresponding to the relation structures A and B.

b) Ballard and Brown defined the association graph in their book *Computer vision* (1982, p. 366) as follows:

> The *association graph* defined in this section is an auxiliary data structure produced from two relational structures to be matched. [...]
>
> Let a relational structure be a set of elements V, a set of properties (or more simply unary predicates) P defined over the elements, and a set of binary relations (or binary predicates) R defined over pairs of the elements. [...]
>
> Given two structures defined by (V_1, P, R) and (V_2, P, R), say that "similar" and "compatible" actually mean "the same". Then we construct an association graph G as follows [...]. For each v_1 in V_1 and v_2 in V_2, construct a node of G labeled (v_1, v_2) if v_1 and v_2 have the same properties [$p(v_1)$ iff $p(v_2)$ for each p in P]. [...] Now connect two nodes (v_1, v_2) and (v_1', v_2') of G if they represent *compatible* assignments according to R, that is, if the pairs satisfy the same binary predicates [$r(v_1, v_1')$ iff $r(v_2, v_2')$ for each r in R].
>
> A match between (V_1, P, R) and (V_2, P, R) [...] is just a set of assignments that are mutually compatible. The "best match" could well be taken to be the largest set of assignments (node correspondences) that were all mutually compatible under the relations. But this in the association graph G is just the largest totally connected (completely mutually compatible) set of nodes. It is a *clique*. A clique to which no new nodes may be added without destroying the clique properties is a *maximal clique*. In this formulation of matching, larger cliques are taken to indicate better matches, since they account for more nodes. Thus the best matches are determined by the largest maximal cliques in the association graph.

The association graph corresponding to the relation structures A and B is depicted in Fig. 2.

c) There are three maximal cliques of the same size: $\{ub, vc, wd\}$,$\{wb, xc, yd\}$, and $\{yb, zc, ud\}$.

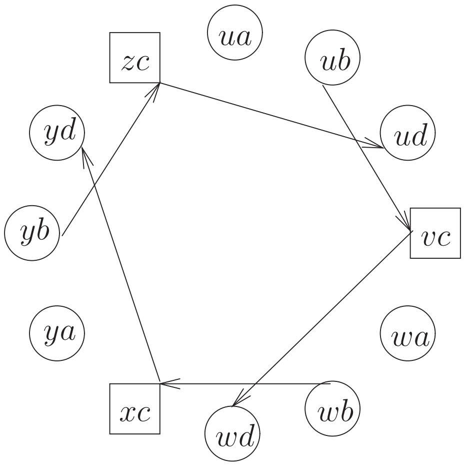

Figure 2: Association graph corresponding to the relation structures A and B.

2.

Semantic nets are explained in Sec. 7.1, pp. 294–295.

a) A semantic net for a simple dial telephone is depicted in Fig. 3

b) The network in Fig. 4 describes both rotary dial and pushbutton dial telephones. The node 'dial' is a generic concept and it has two instances, 'rotary' and 'pushbutton' which is expressed with the 'instance-of' relation.

c) The network in Fig. 5 depicts an office set with the elements table, window, drawer, and phone.

3.

Discrete relaxation is explained in Sec. 8.5.1, pp. 398–400. A set of binary constraints, adjacency relations, may be developed. Allowable labels on adjacent regions are:

car is adjacent to road, $a(\mathrm{C}, \mathrm{R})$

road is adjacent to grass, $a(\mathrm{R}, \mathrm{G})$

grass is adjacent to trees, $a(\mathrm{G}, \mathrm{T})$

road is adjacent to trees, $a(\mathrm{R}, \mathrm{T})$

sky is adjacent to trees, $a(\mathrm{S}, \mathrm{T})$

A set of unary constraints or properties may be defined as

sky is the highest region, $h(\mathrm{S})$

car is moving, $m(\mathrm{C})$

The sample image was segmented into six regions (1–6) and their adjacency was represented as a graph. In the segmented image region 1 is the highest region and region 5 is moving. All possible labels are assigned to each region; the second column in Table 1. Considering the unary constraints, locally inconsistent labels are removed; the third column in Table 1. Region 1 is labeled as 'sky' and region 5 is labeled as 'car'. The labels 'sky' and 'car' are removed from

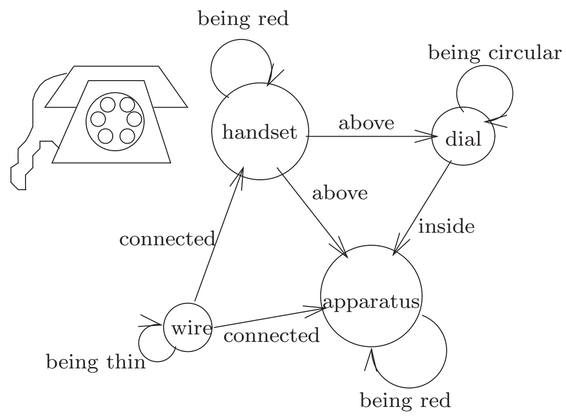

Figure 3: Semantic net for a simple dial telephone

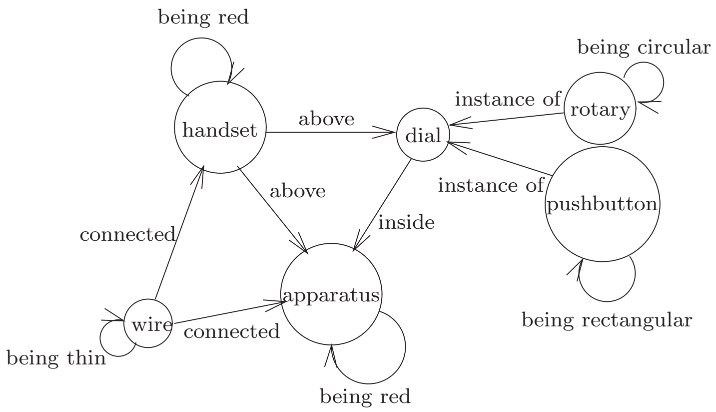

Figure 4: The network for telephones with either a rotary or a pushbutton dial.

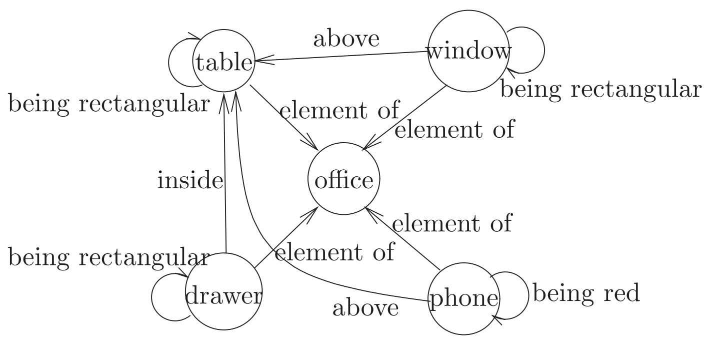

Figure 5: Office set.

1	STGRC	S	S	S
2	STGRC	TGR	T	T
3	STGRC	TGR	GR	G
4	STGRC	TGR	R	R
5	STGRC	C	C	C
6	STGRC	TGR	G	G

Table 1: Label removals in discrete relaxation.

the other regions. Inconsistent labels are then deleted from the regions considering the binary relations; the fourth and fifth columns in Table 1.
Region 2 is chosen for updating. It is adjacent to region 'sky'. Therefore, according to the binary constraints, it cannot be labeled otherwise as 'trees'.
Region 3 is chosen for updating. It is adjacent to regions labeled as 'trees' (region 2) and as 'trees, grass, road' (region 4). It is labeled as 'grass, road'.
Region 4 is chosen for updating. It is adjacent to region labeled as 'car'. It is labeled as 'road'.
Region 6 is chosen for updating. It is adjacent to regions 'trees' (region 2) and 'road' (region 4). 'Grass' is the only possible region adjacent to both 'trees' and 'road'.
Region 3 is chosen for updating. It is adjacent to regions labeled as 'trees' (region 2) and 'road' (region 4). It is labeled as 'grass'.
If either of the unary constraints is removed then several solutions are possible for labeling, i.e., the problem becomes underconstrained. For instance, using the single unary constraint 'highest' results in four other solutions in addition to the "correct solution", Table 2.

1	S	S	S	S	S
2	T	T	T	T	T
3	G	R	R	G	G
4	R	G	G	R	R
5	C	R	T	G	T
6	G	R	R	G	G

Table 2: Possible labelings using single unary constraint highest.