Efficient Matching by Movement Approximation

Tracking Objects with Common Movement

One challenge is to find out a matching between identical objects that are close to each other, and have the similar motions.

Figure 2.a shows a scene where object A and B forms a slope and there are three identical squares o_1, o_2 and o_3 lying on the slope. Figure 2.b is a subsequent image where the three squares went down a bit. There are 6 ways to match between the squares while only $\{o_1 \sim o_4, o_2 \sim o_5, o_3 \sim o_6\}$ is possible. Without reasoning about the spatial relations between the squares, some optimization algorithms, e.g. minimizing centroid shift, will tend to match o_2 with o_6. In many cases, objects dynamics such as velocities are unavailable, thus most of state of the art tracking algorithms do not apply well because of the lack of a suitable dynamic model.

Human can solve this case efficiently by spatial reasoning. Since we know the objects are moving at the similar velocity, the relative spatial changes among them can be subtle. Hence the spatial relations between those objects can hardly change to the converse as they are moving. When matching, we are trying to keep the original spatial relations among the subsequent objects.

We emulate this reasoning to test a match in the way that first identify those objects that will follow the similar motion and then check whether a relation changes to the converse in the subsequent image.

[PLEASE EDIT]"We observe that objects are likely to follow a common motion if they have the same contact relations with the same objects." We call such objects as $spatially\ correlated\ objects$ (SCO). Figure 1 shows some examples of SCO in a typical angry birds scenario.

Given a set of initial objects, we obtain the SCOs by checking the node equivalence in the corresponding EGSR network. A node is equivalent to another if they hold the same contact relations with the same other nodes. Thus the slope example has only one SCO $\{o_1, o_2, o_3\}$(see Figure 2.c)

Having identified the SCOs, we then check the spatial relations between their matched objects in the subsequent image. Formally, let R be a set of EGSR relations, the converse of a relation $r \in R$ is written as $r' \in R$. Given a group of spatially correlated objects in the initial image $O = \{o_1, o_2, ..., o_k\}$ and set of subsequent objects $O' = \{o'_1, o'_2, ..., o'_k\}$ with a match $\forall i \leq k, o_i \sim o'_i$ between them, the spatial constraints can be written as $\forall o_i, o_j \in O \exists r \in R, o_i\{r\}o_j \Rightarrow o'_i\{r'\}o'_j does\, not\, hold, i, j \leq k$. If a match violates the constraints, we will try all the other possible matches among the SCO until the violation is resolved.

In the slope example, a match $\{o_1 \sim o_4, o_3 \sim o_5, o_2 \sim o_6\}$ violates the constraint because $o_2\{LEFT\}o_3$, $o_6\{RIGHT\}o_5$ while $RIGHT$ is the converse of $LEFT$

Figure 1: (a) A typical Angry Birds scenario (b) The corresponding SCOs (highlighted by different color)

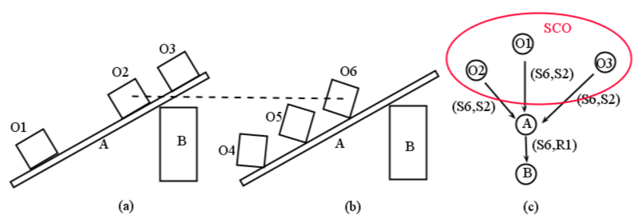

Figure 2: (a) An initial scene (b) A subsequent scene where the squares slide down a bit (c) The EGSR constraint network of the initial scene (only retain the edges indicating contacts) and the SCO