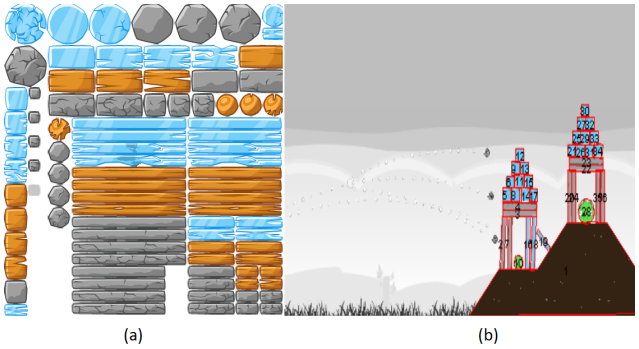
Implementation

We implemented our method and applied it to the Angry Birds where the vision can detect the exact shapes of the objects(). The objects' visual appearance are restricted to a finite number of templates (see Figure 1).

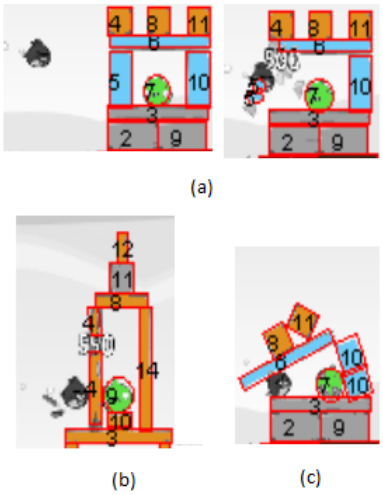
The vision has the following limitations:

- Damaged objects will be detected as a few separate smaller pieces. (Figure 2.b)
- Debris are not recognized so that one cannot determine whether an object, say a stone, is a real stone or just a debris from a previously destroyed stone. (Figure 2.a)
- Objects occlusion is not handled. Objects can be partially or entirely occluded by debris or other game effects e.g. prompted scores or clouds around the hit point (See Figure 2.c)



(a) (b)

Figure 1: (a) Main Templates used in Angry Birds (b) The vision detects the real shapes of the objects in a typical Angry Birds scenario



(a) (b) (c)

Figure 2: (a) An object (ID 5) is broken into pieces by a hit (b) An object (ID 4) is partially occluded (c) An object (ID 10) is damaged and detected as two separate blocks

Handling Fragmentation and Occlusion

Objects fragmentation creates new objects in subsequent images and the new objects are not directly related to the initial objects. The varying number of objects from one scenario to another can introduce ambiguities making a tracking algorithm off the track.

In angry birds, the fragmentation is mainly due to objects destruction, partially occlusion, and damage. Handling fragmentation is important. By recognizing the fragments, we are able to infer whether an object is destroyed, damaged, or occluded, which leads to robust tracking. We achieve this in three steps:

First, we identify all the subsequent objects that can potentially be fragments. Specifically, we classify the initial and subsequent objects by their templates, respectively. For each template T, we have a set T_{ini} of initial objects and a set T_{sub} of subsequent objects of the same template. We treat all the objects in T_{sub} as potential fragments if T_{sub} contains more objects than T_{ini}.

Fragments are then arranged in groups where all the fragments in a group can form one of the templates. The shape formed by the fragments is an oriented minimum bounding rectangle (OMBR) that bounds all the fragments (see Figure 3.a). We then treat the OMBR as one object in the subsequent image, which can be matched with one of the initial objects. Once the OMBR is matched, all the fragments from the corresponding group are also matched. i.e. assigned with the same ID. In some rare cases, a fragment can be involved in more than one OMBR. So we add an additional constraint that all the matched OMBRs should not have a common fragment.

We label those unmatched fragments as debris. Destruction of an object will create a cluster of debris around the object's location. Those debris can be of any shape, e.g. circle, polygon and will diffuse until disappear after 2-4 seconds. Given an object o in the initial scenario, we search for its debris if there are no subsequent objects can be matched with o (including the OMBRs created from the fragments). We first draw the MBC of o, and get the set of the potential fragments falling in the MBC excluding those which have been matched. The set of the objects are labelled as debris of o and o is marked as destroyed (see Figure 3.b). By this process, there might be some debris shared by more than one initial objects, we do not explicitly label those debris with an ID.

An object can also be totally occluded. To deal with this, before the matching, we cache the spatial configurations of all the initial objects. At the end of the matching, we update the cache by replacing each initial object's configuration with the matched subsequent object's so that the cache always maintains the latest configuration of each initial object. If an occluded object recurs in one subsequent image, we match the object by searching through the cache for an unmatched initial object. The occlude object will be matched if it lies in the MBC of that initial object.

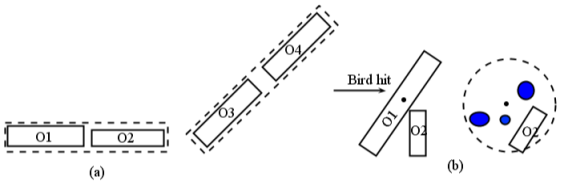


Figure 3: (a) OMBRs are indicated by the dotted rectangles (b) o_1 has been destroyed by a bird hit, and the blue dots are recognized as debris