Kaiyu has introduced how to obtain detection and prediction results given an input image. Notice that for each image, there can be one more cars, so there will be multiple detection and prediction boxes. Thus, we need to find an algorithm to match the results with each other. Firstly, I’d like to introduce an important parameter called Intersection-over-Union. As we can see from the formula, the value of IoU is 1 if the two boxes are perfectly overlapped; the value is 0 if the two boxes have no intersection. In this way, by calculating the IoU with each detection and prediction boxes, we can have a matrix just like this.

For convenience, we call the prediction boxes trackers, and call the detection boxes detections. From the matrix, we know there are 3 trackers, T1 to T3, and 4 detections, D1 to D4. Then we can maximize the overall IoU sum by matching D3 to T1 and D1 to T2. This can be done by linear assignment, which is a fundamental optimization algorithm intended to find a maximum weight matching in a weighted biograph, in our case, the IoU matrix. Python package Sci-kit learn can implement linear assignment in just one line of code. We can also see that T3 and D2, D4 have no matched results, so we can simply put T3 into unmatched\_trackers and put D2, D4 into unmatched\_detections. These three lists are of great importance for the pipeline of our program.

Since our input is a video, we need to capture each frame of the video. This is done by MoviePy package. And then we can obtain the matched, unmatched\_detections and unmatched\_trackers for each frame using linear assignment. Before explaining how to use the three lists for our tracking problem, I’d like to say a little about the two situations happened in detection process, false alarm and missed detection. False alarm happens when there is a detection box produced by SSD, but in fact there is no car in the bounding box. Missed detection happens when there is a car in the current frame, but there are no matched detection boxes. These two situations can harm the performance of the system. In order to solve this, we introduce two important parameters, min\_hits and max\_losses. We call a tracker has one hit if we have a matched detection and tracker. We call a tracker has one loss if the tracker doesn’t have a matched detection. Using the previous matrix as an example, T1 and T2 has one hit, and T3 has one loss. Min\_hits is a constant, standing for the minimum number of consecutive matches to establish a tracker. Similarly, max\_losses stands for the maximum number of consecutive losses to delete a current tracker. We also introduce another variable to discriminate false alarm and real target. A tracker is called good tracker if it has reached min\_hits.

This is the pipeline diagram of the processing algorithm. The input the current frame extracted from the given video and tracker list, which the output of the previous frame. Then using SSD we can obtain the detection boxes. Along with the tracking boxes stored in tracker list, we can calculate IoU matrix and using linear assignment to produce unmatched\_detection list, matched list and unmatched\_tracker list.

* For each tracker in unmatched\_detection list, we have no previous tracking information, so we initialize a new tracker based on detection results and append it to tracker list. Every new tracker will be assigned a new ID sequentially from 0 to 99.
* For each tracker in matched list, we have both detection and prediction results, so we can perform time update & measurement update, and then we have one more hit for the current tracker and set its losses to 0. We also judge if this tracker is a good tracker based on its total number of hits.
* For each tracker in unmatched\_tracker list, we don’t have detection results, so we only perform time update, then set its hits to 0, and add 1 to its total number of losses. In this way, we obtain an updated tracker list. Then for each tracker in the tracker list, we check if the tracker is lost based on the value of its hits, losses and whether the tracker is a good tracker. If the tracker is lost, we can delete the tracker from the tracker list. Then this ID can be reused for later trackers.