Integrating Boundary and Center Correlation Filters for Visual Tracking with Aspect Ratio Variation
(Supplementary Material)

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In the supplementary material, we first provide the results under all 11 video attributes on OTB-2015, then analyze the effects of each component on IBCCF and different layer weights in boundary CFs on the tracking performance.

1. Evaluation under different video attributes
To investigate the performance under different attributes, we compare IBCCF with 12 state-of-the-art trackers: HCF [9], C-COT [5], SRDCF [4], DeepSRDCF [3], RPT [7], SCF [8], SAMF [6], Scale-DLSSVM [10], Staple [1], DSST [2], MEEM [12] and SKSCF [13]. Fig. 1 shows the overlap success plots of all competing trackers. We can see that our IBCCF is among the top three trackers on all video attributes and achieves the second best performance on 7 of total 11 attributes. Note that SINT+ [11] is not used for comparison since we cannot find its code on OTB-2015.

2. Impacts of BCFs and near-orthogonality
Here, we investigate the impact of boundary CFs and near-orthogonality on the proposed IBCCF approach. To achieve this, we make four different variants of IBCCF: the tracker only with 1D boundary CFs (BCFs), the tracker only with the center CF (i.e., HCF), the IBCCF tracker without orthogonality constraints denoted by IBCCF (w/o constraint) and full IBCCF model. Table 1 summarizes the mean OP and AUC score of four methods on OTB-2015.

From Table 1, one can observe that BCFs underperforms the center CF. It is not difficult to explain the reason that the searching windows of BCFs contain less context information than the center CF for localizing the targets, so it drifts earlier as the target with large appearance variations. However, incorporating BCFs tracker into the center CF can bring significant improvements even without orthogonality constraints. It indicates BCFs tracker and center CF tracker are complementary. Moreover, orthogonality constraint can further improve 6.4% Mean OP and 4.1% AUC score over IBCCF (w/o constraint). These results validate the effectiveness of BCFs tracker and orthogonality constraint, and they are key parts of the proposed IBCCF tracker.

3. Effects of Feature Weights in Boundary CFs
In this paper, we introduce a family of boundary CFs, which are different from the center CF and aim at detecting the subtle changes in boundary positions. Therefore, we would like to study the impact of weights of different layers in boundary CFs on tracking performance. For center CF, the weights for the layer conv3-4, conv4-4 and conv5-4 are set to 0.02, 0.5 and 1, respectively. We empirically find it is not optimal for the boundary CFs as a better performance can be obtained when all weights are set to 1.

To investigate this issue, we conduct experiments on OTB-2015 dataset, and the results are illustrated in Fig. 2. In Fig. 2(a), we fix the weights of conv4-4 and conv5-4 as 1, and change the layer conv3-4 weights. The results show that it has little effect on the performance, and the best result is obtained at weight being 0. Hence, we discard the features from conv3-4, and only employ layer conv4-4 and conv5-4 in boundary CFs for improving efficiency. As shown in Fig. 2(b), the best performance is achieved when the weights of both layer conv4-4 and conv5-4 equal to 1. We use this weights setting throughout all the experiments.
Figure 1: Overlap success plots of the competing trackers under all eleven attributes on the OTB-2015 dataset.

<table>
<thead>
<tr>
<th>Mean OP</th>
<th>AUC Score</th>
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<tbody>
<tr>
<td>BCFs</td>
<td>50.2</td>
</tr>
<tr>
<td>Center CF</td>
<td>65.6</td>
</tr>
<tr>
<td>IBCCF (w/o constraints)</td>
<td>72</td>
</tr>
<tr>
<td>IBCCF</td>
<td>78.4</td>
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</tbody>
</table>

Table 1: Evaluation results of component experiments on both mean OP and AUC score metrics (in %).
Figure 2: Effect of layer weights in the boundary CFs on OTB-2015 dataset. (a) Fix the weights of layer conv4-4 and conv5-4 equal to 1 and change layer conv3-4 response weights. (b) Fix the weights of layer conv3-4 and conv5-4 equal to 0 and 1, then change layer conv4-4 response weights.

References