Adjustment with classification predictions further improves localization results.

Multiple crops on regular grid and selective crops based on objectness [4] score are used for classification.

**Our Approach**

- Classification
- Localization
- Recursive localization
- Predicted classes
- Bounding box prediction
- Adjust localization with classification predictions

**Classification Network**

Images → Multiple crops (on regular grid) → Selective crops → Models (VGG16, VGG19) → Ensembles → Classification Results

Classification process

Multiple crops

Multiple crops on regular grid, selective crops based on objectness score using similar method with BING [4].

**Our Contribution**

- Recursive localization improves the localization performance by adjusting the bounding box with near 50% overlap.
- Objectness based cropping improves classification performance.
- Adjustment with classification predictions further improves localization performance.

**Results**

- Classification results

<table>
<thead>
<tr>
<th>Models</th>
<th>No. of Crops</th>
<th>Multiple Crops</th>
<th>Retrained W</th>
<th>CLS Error (Top-1/Top-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VGG16</td>
<td>150</td>
<td>Regular(50)</td>
<td>-</td>
<td>26.73%/8.23%</td>
</tr>
<tr>
<td>VGG16</td>
<td>20</td>
<td>Selective(20)</td>
<td>W_1 (20K)</td>
<td>25.94%/8.33%</td>
</tr>
<tr>
<td>VGG16</td>
<td>20</td>
<td>Selective(20)</td>
<td>W_2 (150K)</td>
<td>26.04%/8.37%</td>
</tr>
<tr>
<td>VGG16</td>
<td>40</td>
<td>Selective(20)+flips</td>
<td>W_1 (20K)</td>
<td>25.87%/8.24%</td>
</tr>
<tr>
<td>VGG16</td>
<td>40</td>
<td>Selective(20)+flips</td>
<td>W_2 (150K)</td>
<td>25.93%/8.21%</td>
</tr>
<tr>
<td>VGG16</td>
<td>210</td>
<td>Regular(50)</td>
<td>W_1 (20K)</td>
<td>24.58%/7.34%</td>
</tr>
<tr>
<td>VGG16</td>
<td>230</td>
<td>Regular(50)</td>
<td>W_2 (150K)</td>
<td>24.49%/7.32% (best set)</td>
</tr>
</tbody>
</table>

Ensembles with multiple crops

- Localization results

<table>
<thead>
<tr>
<th>Margin(pixel)</th>
<th>Iter</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>0.69%</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
<td>3.1%</td>
</tr>
<tr>
<td>70</td>
<td>5</td>
<td>3.96%</td>
</tr>
<tr>
<td>70</td>
<td>10</td>
<td>4.36%</td>
</tr>
</tbody>
</table>

Effectiveness of Recursive localization

Rejection criteria

- top1: 0.26%
- top2: 0.27%
- top3: 0.23%

Adjustment using classification predictions

- 28.21%
- 7.338%
- 28.7%
- 7.338%
- 28.5%

Final results

**References**