OPTIMAL PARAMETER SELECTION FOR MEANSHIFT TYPE SEGMENTATION
Dragos Bozdog1, Ionut Florescu1, Rustam Stolkin2
1Department of Mathematical Sciences, Stevens Institute of Technology, USA
2School of Computer Science, University of Birmingham, UK

MOTIVATION

Many vision papers are concerned with development of the best and the fastest computer vision algorithms. However, in many cases when independently implemented, these algorithms fail to perform as advertised. The reason is that, in the vast majority of situations, vision algorithms are very sensitive to the choice of parameter values used. Hence, in most cases vision algorithms fail to apply the algorithm to a different image sequence than the one presented in the article and very likely have no understanding of the algorithm.

PURPOSE:
Study the possibility of adapting an algorithm’s parameters with respect to the current image space.

For convenience we choose to study the Click! algorithm presented on the parallel slide.

THE PARAMETERS

Study the possibility of adapting an algorithm’s parameters with respect to the current image space.

We are studying the influence of four parameters, originally present in the meanshift algorithm.

\( h_0 \) = image size of pixels in the image included in the meanshift calculation

\( h_2 \) = image size of pixels in the color space included in the meanshift calculation.

\( \mu \) = initial selection defining the ellipse level set

\( a = \) Confidence level defining the ellipse level set.

We consider the following levels for each parameter:

\( \mu = (3,5,7,9,11) \)

\( a = (1.0, 1.0, 1.0, 1.0, 1.0) \)

The number of possible combinations is 600. We repeat the segmentation for 10 different randomly chosen starting points within each object, which gives a total of 60,000 data points for each object. We analyze a total of 25 objects in 5 images and thus the total number of observations in our study is 138,000. For each object chosen, the Bentley data set records the whole segment, as determined by human operators. Thus, for each of our data points we run the segmentation algorithm and we record two types of error:

Error I = number of object pixels erroneously classified by the algorithm as background

Error II = number of background pixels erroneously classified by the algorithm as object.

Then we calculate a response variable \( Y \) as the total error expressed as a proportion of total object size:

\[ Y = \frac{\text{Error I} + \text{Error II}}{\text{Object Size}} \]

Clearly, the two types of error are fundamentally different and could have penalized one type or the other, however, for our current analysis we decided to penalize them equally.

THE IMAGES UNDER STUDY

![Image 1](image1.png)

Objective 2: We did find parameters that work for all objects in the image, with the exception of Image 3. Here are the optimal values:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image 1</td>
<td>(5, 7, 9, 97%)</td>
<td>(5, 7, 9, 97%)</td>
<td>(5, 7, 9, 97%)</td>
<td>(11, 9, 20, 97%)</td>
</tr>
<tr>
<td>Image 2</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
</tr>
<tr>
<td>Image 3</td>
<td>(9, 7, 9, 97%)</td>
<td>(9, 7, 9, 97%)</td>
<td>(9, 7, 9, 97%)</td>
<td>(9, 7, 9, 97%)</td>
</tr>
<tr>
<td>Image 4</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
<td>(9, 7, 9, 97%)</td>
</tr>
<tr>
<td>Image 5</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
<td>(3, 7, 9, 97%)</td>
<td>(9, 7, 9, 97%)</td>
</tr>
</tbody>
</table>

Answer: We cannot eliminate interaction terms (checkmark denotes term is statistically significant).

All 4 parameters have to be studied together.

Objective 3:

It is not possible to use the same parameters working well in all situations. Furthermore, looking at image 3 we see that even in the same image the optimal set is varies from object to object.

Objective 4:

This preliminary study indicates that relations between local measurements around the segmented object are beneficial and could be put in relation with the optimal parameter choice. In particular we found that the following measurements would help choose the best parameters:

- A local measure of cluster
- A local measure of variation of color histogram
- A degree of texture change

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<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large object, background color, clear background</td>
<td>large</td>
<td>small</td>
<td>small</td>
<td>small</td>
</tr>
<tr>
<td>Large object, background color, clear background</td>
<td>large</td>
<td>small</td>
<td>small</td>
<td>small</td>
</tr>
<tr>
<td>Small object, background color, clear background</td>
<td>small</td>
<td>small</td>
<td>small</td>
<td>small</td>
</tr>
<tr>
<td>Small object, background color, clear background</td>
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