Symbolic Segmentation Using Algorithm Selection and Semantic Feedback

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Abstract

In this paper we present an alternative approach to symbolic segmentation; instead of implementing a new method we approach symbolic segmentation as an algorithm selection problem. That is, let there be \( n \) available algorithms for symbolic segmentation, a selection mechanism forms a set of input features and image attributes and selects on a case by case basis the best algorithm. The selection mechanism uses an iterative method to build high-level image representation that is analyzed for logical contradictions. This verification and subsequent reasoning allows to select algorithms on a object-class basis and allows to compose the final result of semantic segmentation from multiple partial segmentations. We show that despite the problem of algorithm selection is very hard the framework is an alternative for semantic segmentation.

1. Introduction

The research field of computer vision contains currently several very hard open issues. One of the problems being investigated is the problem of the symbolic segmentation; in this task the algorithm must segment images into meaningful regions and then detect objects present in the image. For instance semantic segmentation has been implemented as a combination of segmentation and recognition \cite{1}, probabilistic models \cite{3}, convolutional networks \cite{2} or other approaches such as \cite{4,5}.

In this paper we propose the algorithm selection approach to the problem of symbolic segmentation. We base our work on the previously proposed platform for algorithm selection in \cite{6}. We show that using algorithm selection and high level reasoning about the results of algorithm processing allows to iteratively improve result of semantic segmentation. We analyze two different approaches for algorithm selection using either Bayesian Network (BN) or Support Vector Machine (SVM). The main contributions of this paper are the analysis of an iterative algorithm selection framework in the context of symbolic segmentation, evaluation of two different machine learning approaches for semantic segmentation algorithms and the demonstration of the fact that despite the low precision of the algorithm selector the resulting semantic segmentation is improved.

2. Algorithm Selection for Symbolic Segmentation

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{algorithm_selection.png}
\caption{Algorithm Selection Platform}
\end{figure}

The framework called Iterative Analysis (AI) used in this experiments was originally introduced in \cite{6}. The schematic representation is shown in Figure 1. The processing start by extracting features (1) from the input image which are used by the algorithm selector (2) to determine the most appropriate algorithm. The input image is processed by the selected network of algorithms (3) which results in symbolic segmentation of the input image. The symbolic segmentation result is interpreted by constructing a multi-relational graph representing the high level description. The graph is then analyzed for symbolic contradiction (5). If a contradiction is detected a new hypothesis about a region containing a contradiction is generated. The new hypothesis is used as an input to the algorithm selector in addition to the features that have been extracted from the region of the contradiction. This new set of features values
and hypothesis attributes are used for a new algorithm selection. The newly selected algorithm processes the whole image and generates a new symbolic segmentation. The region that before contained the contradiction is now extracted and is merged with the original high-level description (4). The new high-level description is analyzed and the cycle begins again. The processing stops when for a given input there are no more contradictions or when no more algorithms can be selected. An example of IA processing an image is shown in Figure 2.

3. Experiments

To evaluate the proposed framework we used three different algorithms for symbolic segmentation [3, 1, 2] on the VOC2012 data. As introduced in Section 2 the high level verification requires multiple objects detections in one image. Consequently the testing and the training of the IA platform was carried only on images that contain more than one distinct object.

The average precision of the three algorithms and the iterative analysis approach is shown in Table 1. The reason for the presented approach not to outperform the best algorithm is the fact that the algorithm selection accuracy using a Bayesian Network is 50% and using SVM 60%. Consequently in many cases the selection did not use the best possible algorithm.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>average f-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP6 [2]</td>
<td>44.409%</td>
</tr>
<tr>
<td>IA</td>
<td>43.554%</td>
</tr>
<tr>
<td>ALE [3]</td>
<td>43.144%</td>
</tr>
<tr>
<td>CPMC [1]</td>
<td>32.060%</td>
</tr>
</tbody>
</table>

4. Conclusion

In this paper we introduced a soft computing approach to the semantic segmentation problem. The IA platform for image understanding iteratively improves the high level understanding and even with a very weak algorithm selector can outperform in many cases the best algorithm by combining the best results of each available algorithm.

In the future several direct extensions and improvements are planned to the IA platform: the algorithm selection accuracy must be improved, the high level verification requires a more robust method of contradiction detection and hypothesis generation and finally extension to other problems must be demonstrated.

References