1D-5

Learning-Based Adaptive Algorithm Selection Scheme for Real-World Image Processing

Martin Lukac and Michitaka Kameyama
Graduate School of Information Sciences,
Tohoku University, Miyagi, Sendai, Japan.
email: {lukacm,kameyama@ecei.tohoku.ac.jp}

Abstract

In this paper we propose a real-world information processing universal platform. The main target of the proposed platform is real-world image and information understanding. The platform uses the algorithm selection to chose the best algorithm on a case by case basis. The selection mechanism is obtained using machine learning from a sample data set. We demonstrate advantages of this platform compared to classical single algorithm approach on examples.

1 INTRODUCTION

The image understanding process includes includes in general several processing steps. One of the approaches consists in an initial use of one (or more) low level algorithms such as de-noising, filtering, normalizing, edge detection and so on. The next step is a region level processing, region manipulation and and pixel aggregation. Finally the last step is an object detection and recognition complemented by a high level interpretation algorithm resulting in a high level symbolic description. This algorithm sequence is only one of the available flow and other algorithms might rely on a different framework such as Random Fields or other purely statistical image processing where such serial processing is not used.

At each level of the above described sequential image processing, there exist a large amount of algorithms. For real-world applications that require robust image processing this is problematic because so far there is no mechanism to select efficiently the desired algorithms on a case by case basis as well as on a task requirement basis.

In this paper we propose a framework for intelligent algorithm selection that uses a bottom-up image-features based algorithm selection and a top-down high level verification selection modulation using meta-level analysis of algorithm suitability. For this a machine learning based bottom-up algorithm selector from [1] is used. The resulting set of detected objects is then verified using an off the shelf verifier and a contradiction is obtained if inconsistencies are present in the objects labeling. The contradiction, is then used to generate feedback to the initial algorithm selection that will result in a different algorithm. The feedback is based on algorithm suitability: the advantages and the disadvantages of each algorithm are used in a meta-level of analysis in such manner as to reduce the problem space. The estimation of the information required for the suitability determination is performed by a Bayesian Network. Using this combined algorithm selection, the input image is reprocessed and verified again. This loop is repeated until no contradiction is generated during the verification or until no more other algorithms are available and thus the best high-level description has been achieved.

2 ALGORITHM SELECTION FOR IMAGE PROCESSING

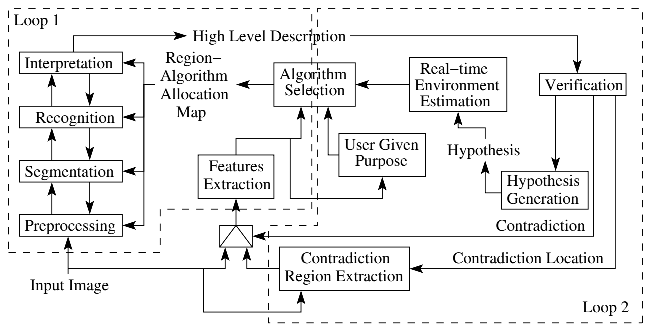


Figure 1: High-level feedback from symbolic verification to algorithm selection.

The general schema of the overall system is shown in Figure 1. In fact the system operates in two distinct modes; initially, the input image is processed by algorithm selected using only the image features (Section 2). The resulting high level description of the image from the object recognition, is verified for logical contradictions both on the context level as well as a part-level verification. The result of the verification is a possible contradiction. If such contradiction exists, the features used in the processing are used in the meta level to estimate what other algorithm should be used to correct the contradiction. This second loop is iterated over all contradictions until all contradictions are resolved.

3 Bayesian Network

The second loop in Figure 1 is using a Byaesina Network (BN). The BN estimates the suitability information that is determined for each level of processing separately. For instance Figure 2; the red nodes represents input nodes and the blue nodes represents the inference nodes. For segmentation we determined that only the features of neighboring regions - resulting from previous segmentation and recognition are required as inputs. These features are then used to estimate visible properties representing truth about the real world information.

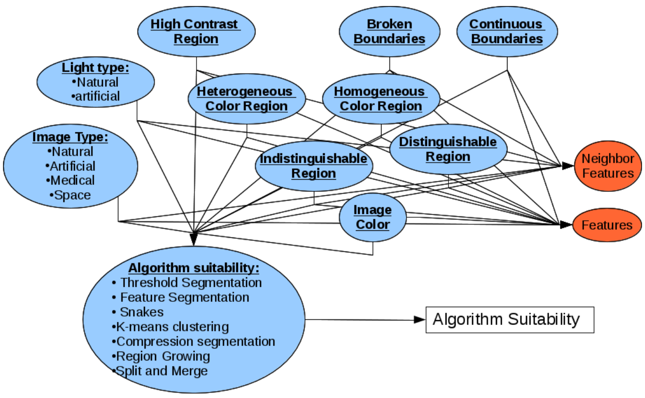


Figure 2: The BN used for the feedback to the segmentation algorithm selection.

As can be espected using only information of each processing level is not sufficient enough for robust algorithm selection; often symbolic information is required to modify lower level processing. Thus, BN for each level of processing is integrated into a global BN. The model of BNs for all levels is shown in Figure 3. Notice that the connections between different level of information and processing are shown in color: red represents the connection from the highest level of processing and green shows the connections from the middle level of processing.

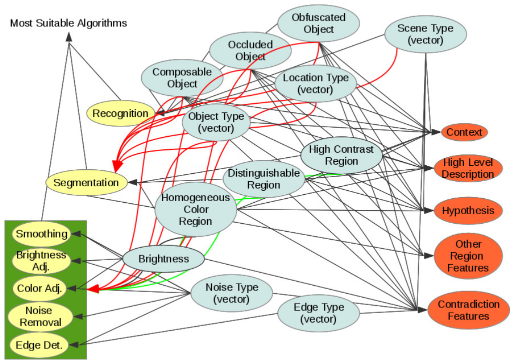
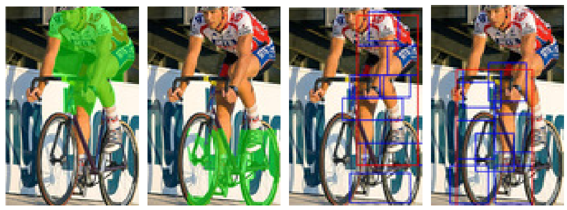


Figure 3: The BN used for the feedback to the algorithm selection. Notice all levels of processing are integrated in a top-down manner but not in a bottom-up manner.

3.1 Example of Contradiction Resolution by Algorithm Selection

For this example we have chosen two algorithms with similar application targets. Both algorithms performs aobject detection: one performs a symbolic segmentation (reffered as CPMC) and the other performs object detection by detecting object's parts (referred here as the ADP).

The example in Figure 4 shows (two leftmost images) that initially CPMC algorithm is selected, and a contradiction was obtained by triggering the location rule: the person and the bike are disoined. This lead to selecting the second algorithm that resolved this contradiction.



(a) Human Detection - CPMC (b) Bike Detection - CPMC (c) Human Detection - ADP (d) Bike Detection - ADP

Figure 4: Examples of the object detection using two different algorithms.

References

[1] M. Lukac, Tanizawa, and M. R., Kameyama. Machine learning based adaptive contour detection using algorithm selection and image splitting. *Interdisciplinary Information Sciences*, 18(2):123–134, 2012.