TSB-funded Project 'TADD' - Trainable vision-based anomaly detection and diagnosis Technical Report for September 2013

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Abstract

We report our improvements over the original TADD system which was initially designed for detecting defects and blemishes on potatoes. Also, such improvements are analysed through small-scale experiments using the image acquisition equipment and lighting settings of the original TADD system. In general, the technical improvements are based on our previous work done in July and August. However, most of our previous work were implemented in MATLAB. In September, we have reimplemented them fully in C++ for fast implementation and integrated them with the original TADD system.

1. Introduction

Technically, the TADD system is a prototype low-cost machine vision system which generally lays emphasis on real-time implementation. To meet the industrial standard of software development, it incorporates an intuitive graphical user interface (GUI). These two points make it a desirable platform to be augmented with the techniques that we specifically develop for the vision-based anomaly detection on food trays (e.g. graph-based background segmentation, intelligent detection for tray position and orientation and semantic labelling, etc[1]).

In September, based on our previous work, we make some significant improvements on TADD. They are mainly twofold:

[1]Please refer to our previous project reports for details.

Figure 1: The backgrounds of tray images are often non-black and inconsistent.

1. We replace the original thresholding-based background segmentation with the newly developed graph-based segmentation and it also achieves the real-time implementation. The huge advantages of graph-based segmentation will be discussed later in this report.
2. To meet the requirements of the project, we integrate fast contour and bounding box detection of the tray with the TADD system to visualise its position and the orientation.

2. Review

The original TADD system consists of both hardware and software components. Its off-the-shell hardware comprises of a low-cost webcam of 60Hz, a standard desktop PC with GPU and a light chamber with 2 LED bulbs inside. The entire software system including the image capture unit, the background segmentation unit, the superpixel-based over-segmentation unit, the feature-generation unit, the Adaboost-based classifier training unit, the classification unit and the quality analysis unit, is based on such hardware, in particular, the settings inside the light chamber. For instance, to achieve an efficient and accurate background segmentation, the original TADD actually relies on a black felt which is used as the background and greatly reduces the complexity of background. However, in our project, the background colour is not always black and consistent as shown in Fig. 1.

The original TADD system employs simple thresholding for background segmentation, which is obviously based on the assumption that the object

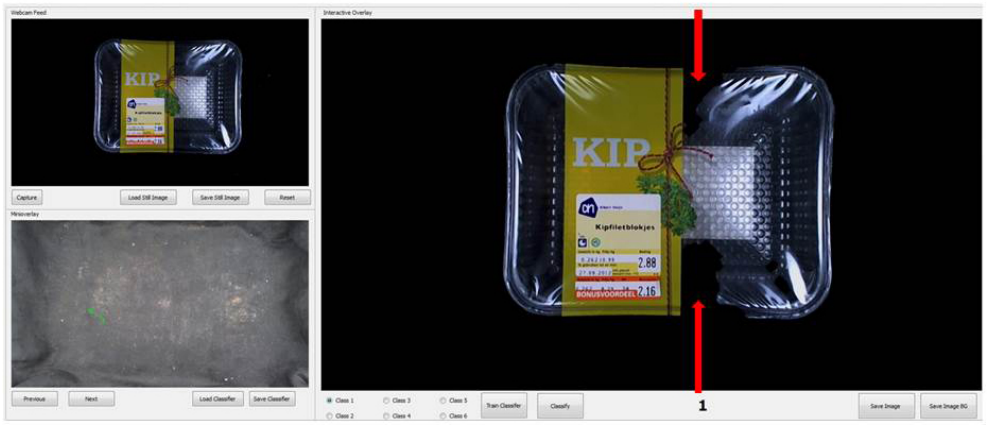

Figure 2: Some regions of the tray are incorrectly regarded as background region by the original TADD system. And thus users cannot select superpixels within those regions for the following classifier training and classification. Note that according to the system design, users should be allowed to select superpixels in the region of interest (ROI) and be prohibited from doing so in the background region.

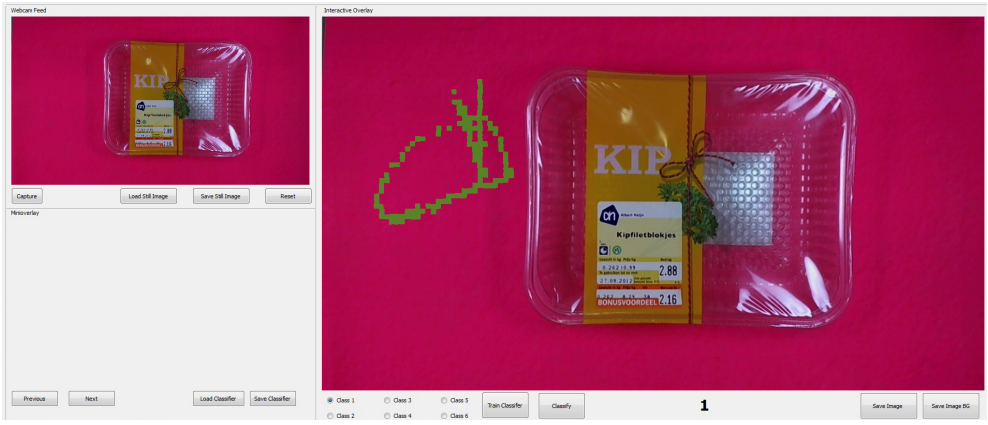

Figure 3: The original TADD system cannot handle non-black background.

of interest has higher intensity values than the background. Perhaps this is true for potatoes. However, in our project, such an assumption will lead to errors illustrated in Fig. 2. This error could frequently occur since it is usual that the tray is not fully filled and thus transparent, which means some regions within the tray might have similar intensity to the background. In addition, Fig. 3 shows that the original TADD system cannot handle non-black background.

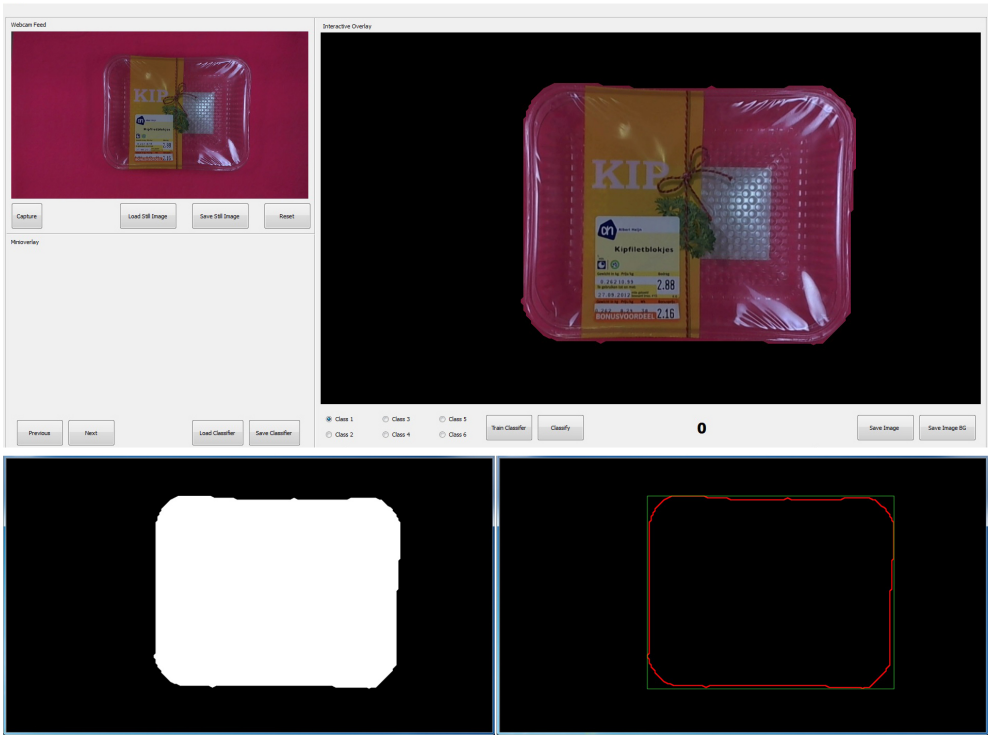

Figure 4: Background segmentation result using our system. Please compare it with Fig. 3.

3. Our method

Aiming at the aforementioned limitations of the original TADD system, in our system, we incorporate the graph-based method for background segmentation. The graph-based method treats the whole image as a graph consisting of nodes and edges. Therefore, it does not only consider the independent properties of each node (such as intensity value), but also utilises the connectivity information between nodes. In this way, the algorithm can recognise that a black pixel within the ROI (i.e. the tray region) is different from a black pixel in the background. The improvement delivered by the graph-based background segmentation is significant. To visualise such improvement, and to more clearly answer the key issues (position of tray and tray size) raised in the project plan, we also developed some code to visualise the contour and the bounding box of the tray. Figs. 4 and 5 show the results of our background segmentation as comparisons to the background segmentation of the original TADD.

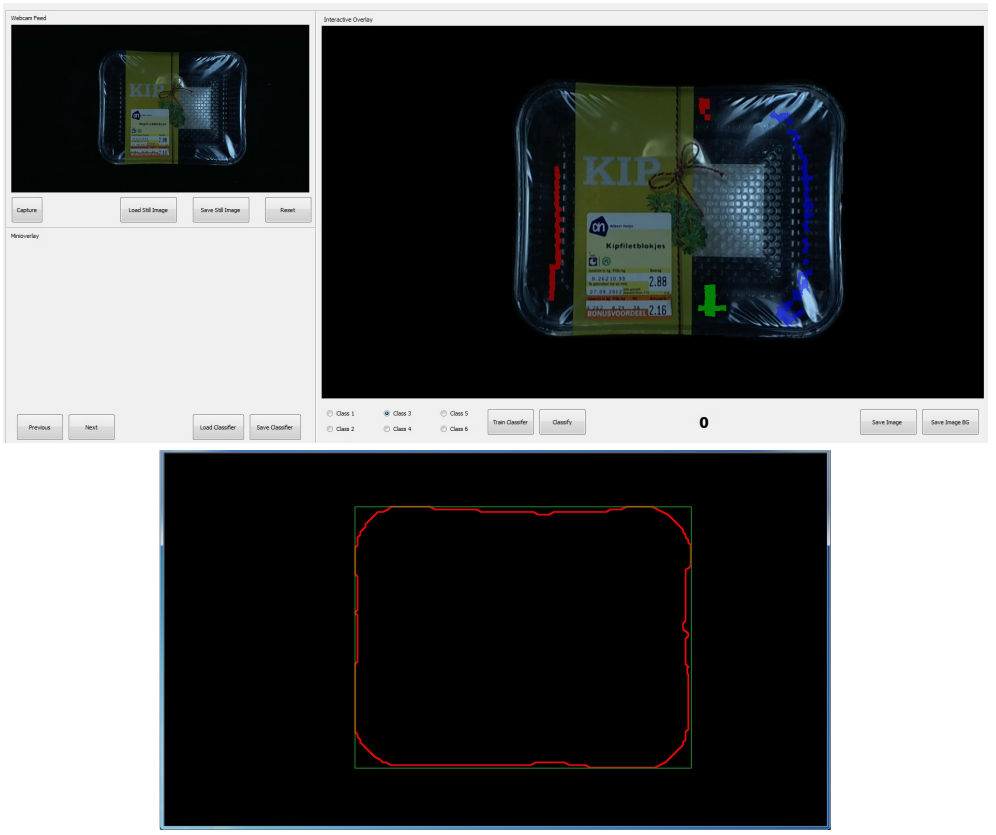

Figure 5: Background segmentation result using our system. Please compare it with Fig. 2.

The new TADD system is actually more powerful as demonstrated in Figs. 6, 7 and 8. It is worth noting that all of these implementations are fully automatic and work in real-time.

4. Future work

Although with the graph-based background segmentation method, the new version of TADD is more powerful, there is still a large room to improve it, making the system more accurate and reliable. For example, we currently use the default parameter settings for the graph-based background segmentation. Further work will focus on the development of a training-based parameter selection mechanism (two key parameters to be trained). Also, in our experiments, we found that the reflection caused by the LED

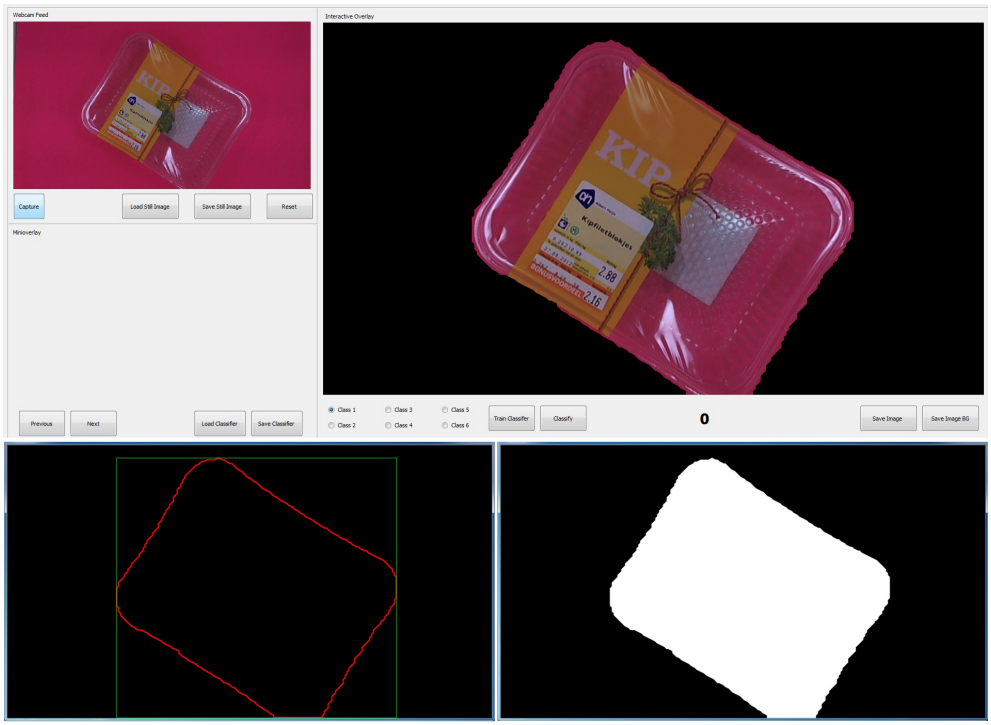

Figure 6: Detection of tray position and size with a non-black background.

light sometimes forms a significant interference and potentially makes the background segmentation a difficult task. Considering that the current light chamber is specifically designed for anomaly detection on potatoes, we are waiting for the new sensor (with the capability of providing colour and range information) believed to be more suitable for our project.

To catch up with the task of barcode detection mentioned in the project plan, we also review some papers in the related field. More accurately, it should be called 1-D barcode localisation in complex backgrounds. It typically requires various region-based image analysis algorithms. It is actually a research topic very different from the well-known barcode reader techniques and quite new in computer vision and computational intelligence. We can see that lots of researchers are focusing on it due to the huge commercial interest behind it. Note that currently, the prevalent barcode readers are devices with laser-scanners which require that laser-scanners must be close enough to the barcode region (so that the scanned non-barcode region is small). With the development of artificial intelligence and various personal mobile

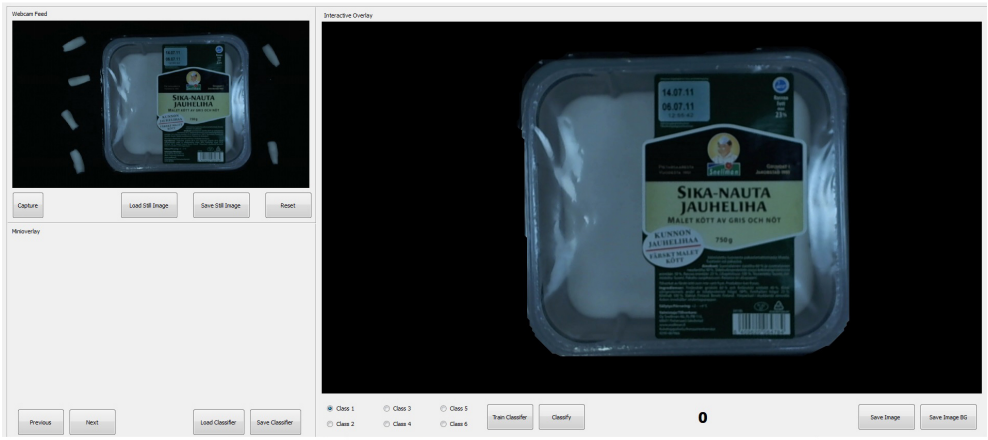

Figure 7: Background segmentation on an image with low brightness and some objects of interference.

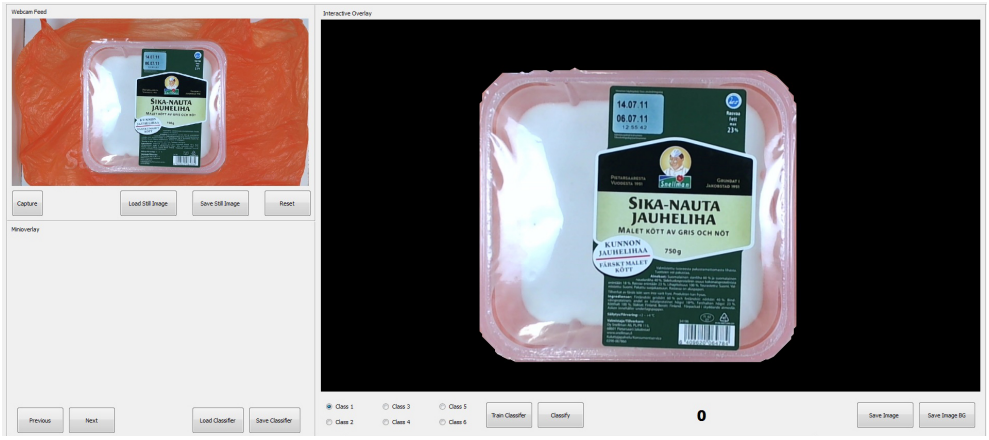

Figure 8: Background segmentation on an image with non-black and inconsistent background

devices, people are paying more and more attention to computer vision, pattern recognition and human-computer interaction. Recognising barcode by understanding image context is a new tendency. [1] is a short paper where the authors proposed an algorithm for barcode localisation in the spatial domain of an image. Hence, barcode localisation in complex backgrounds will be definitely within our future work plan.

References

[1] L. Fang, C. Xie, 1-d barcode localization in complex background, in: Computational Intelligence and Software Engineering (CiSE), 2010 International Conference on, IEEE, pp. 1–3.