REPUBLIC OF TURKEY
FIRAT UNIVERSITY
THE GRADUATE SHCHOOL OF NATURAL AND APPLIED SCIENCES

DETECTION OF MOVING OBJECTS AND THEIR CLASSIFICATION USING INTERACTIVE SEGMENTATION METHODS

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Master Thesis
Department: Computer Engineering
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MASTER THESIS

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ABSTRACT

DETECTION OF MOVING OBJECTS AND THEIR CLASSIFICATION USING INTERACTIVE SEGMENTATION METHODS

In recent years, the rise of the digital image and video data available has led to an increasing demand for image processing. Moving object detection for a fixed camera has become an active research area. It can be used for many vision-based applications. The main concern is subtracting the moving target object from image sequences and tracking them in the next frames. As the first step in a video analysis, object detection is an important issue in the system. Object detection and classification are two very important tasks for quality control in the industrial process. The first step of a quality algorithm is the detection of the moving object. Afterward, the detected object is classified according to its size and color related properties. In this framework, an interactive image segmentation method will be proposed to detect a moving object. The segmentation method is based on three steps: the calculation of the high contrast gray-level image of a color image, separation of the background and objects using Otsu thresholding, and morphological process to fill holes in segmented images. After the moving object is detected, the class of this object will be determined by using image moments. The proposed method separates the moving object from the background. The algorithm will test two videos that were taken from a high-resolution camera. The performance of the proposed method is assessed a real data and good results were obtained. In the other hand, more recently the quality control is a very important task in industrial systems. When the quality control of a product has been made during production, the manufacturing defects will be minimized. For this purpose, automatic inspection system planned to be developed. In this research, a new vision based method will be proposed for quality control and inspection purposes. The proposed method uses interactive segmentation which the main principle is based on Gaussian mixture models. After the current frame is segmented, some morphological operators will be applied to the segmented image in order to reduce noise. Some geometrical features are supposed to be calculated and the objects will be inspected according to their sizes. The efficiency of the proposed method will be ensuring by using real videos.

Keywords: Classification of object detection methods, image segmentation, automatic inspection, classification using interactive segmentation method.

ÖZET

İNTERAKTİF SEGMENTASYON METOTLARINI KULLANARAK HAREKETLİ NESNELERİN TESPİTİ VE SINIFLANDIRILMASI

Son yıllarda, sayısal görüntü ve video verilerinin artması, görüntü işlenmesinde artan bir talebe yol açtı. Sabit bir kamera için hareket eden nesnenin tespiti aktif bir araştırma alanı haline geldi. Bu yöntem birçok görme tabanlı uygulama için kullanılabilir. Ana işlem, hareketli hedef nesnenin görüntü dizilerinden çıkarılması ve sonraki karelerde izlenmesidir. Bir video analizinde ilk adım olarak, nesne tespiti sistem için önemli bir konudur. Nesne tespiti ve sınıflandırma, endüstriyel süreçte kalite kontrolünde iki önemli görevdir. Bir kalite kontrol algoritmasının ilk adımı, hareket eden nesnenin tespitidir. Daha sonra, tespit edilen nesne boyut ve renk ile ilgili özelliklerine göre sınıflandırılır. Bu çerçevede, hareketli bir nesneyi tespit etmek için interaktif bir resim bölütleme yöntemi önerilecektir. Bölütleme yöntemi üç aşamaya dayanır: Bunlar bir renkli görüntünün yüksek kontrastlı gri seviyeli görüntüsünün hesaplanması, arka planın ve nesnelerin Otsu eşik değerlemesi kullanılarak ayrılması ve parçalanmış görüntülerin deliklerini doldurmak için morfolojik işlemddir. Hareketli nesne algılandıktan sonra, bu nesnenin sınıfı görüntü momentleri kullanarak belirlenecektir. Önerilen yöntem, hareketli nesneyi arka plandan ayırır. Algoritma, yüksek çözünürlüklü bir kameradan alınan iki video ile test edilmiştir. Önerilen yöntemin performansı gerçek bir veri olarak değerlendirilmiş ve iyi sonuçlar alınmıştır. Diğer taraftan, son zamanlarda kalite kontrolü endüstriyel sistemlerde çok önemli bir görev alanı olmuştur. Bir ürünün kalite kontrolü üretim sırasında yapıldığında imalat hataları en aza indirgenir. Bu amaçla otomatik kontrol sistemi geliştirilmesi planlanmaktadır. Bu tezde, kalite kontrol ve denetim amaçları için yeni bir görme tabanlı yöntem önerilmiştir. Önerilen yöntem, temeli Gauss karışım modellerine dayanan interaktif bölütlemeyi kullanmaktadır. Geçerli çerçeve bölütlendikten sonra, gürültüyü azaltmak için bölütlenmiş görüntüye bazı morfolojik operatörler uygulanmıştır. Daha sonra bazı geometrik özellikler hesaplanır ve nesnelerin boyutlarına göre incelenecektir. Önerilen yöntemin etkinliği gerçek videolar kullanılarak sağlanmıştır.

Anahtar Kelimeler: Nesne tespit yöntemlerinin sınıflandırılması, görüntü bölütleme, otomatik kontrol, etkileşimli bölütleme yöntemini kullanarak sınıflandırma.

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ABBREVIATIONS

ANN : Artificial Neural Network

BOW : Bag of Words

CNN : Convolution Neural Network

CRF : Conditional Random Field

DOG : Difference of Gaussian

FPR : False Positive Rate

GMM : Gaussian Mixture Model

HOG : Histogram of Oriented Gradient

KNN : K-Nearest Neighbor

LBP : Local Binary Patterns

MSER : Maximally Stable External Region

OTSU : Operational Test Support Unit

SRC : Sparse Representation-based Classification

SVM : Support Vector Machine

TPR : True Positive Rate

SYMBOLES

Δ	: Delta
$\boldsymbol{\nu}$	: Upsilon
$\leq$	: Less than or equal to
$\geq$	: Greater than or equal to
$\boldsymbol{\Sigma}$	: Summation - sum of all values in range of series
$\boldsymbol{\nabla f}$	: Gradient divergence operator
$\boldsymbol{\sigma}$	: Variance of population values
$\boldsymbol{\pi}$	: pi
$\boldsymbol{p_{o\,(cx)}}$	: Probability of a pixel
$\boldsymbol{A/p^2}$	: Represent the area and perimeter
$\Delta_{\boldsymbol{r}}, \Delta_{\boldsymbol{g}}$	: Computed using the gradient of variance of a monochrome image
$\boldsymbol{\mu_b}, \boldsymbol{\mu_f}$	: Values of background, foreground, and, image, respectively
$\boldsymbol{p_b}, \boldsymbol{p_f}$	: Probabilities of background and foreground classes respectively

1. INTRODUCTION

Moving object detection for a fixed camera has been a popular research area in recent years. This method can be used for many visions based on applications in industrial systems. The main principle of the moving object detection is the subtraction of the background and tracks, the detected object in the next frames [1]. The object detection methods can be classified into two modes. A static camera and a static background are used for acquiring frames [2]. In the second mode, the background is not static and it dynamically changes.

Moving object detection has been used in many visual surveillance systems such as object tracking [3], action recognition [4], gesture recognition [5], and semantic image description [6]. The moving object can be detected by applying optical flow [7], background subtraction [8], and segmentation [9]. Background subtraction is robust when compared to the others. Background subtraction constructs a background mode and detects moving objects by using deviation from this model. This model is suitable for slow moving objects. However, it is affected by background variations such as illumination, shadows, and sudden changes. Background subtraction based on methods can be classified as pixel-based and region based methods according to established background model. In pixel-based approaches, each pixel is taken as an independent component, while the model is constructed. A general system of pixel based object detection is given as follows. Region or block-based approaches divide each frame into overlapped blocks and calculates some features of each block such as covariance, histogram, and correlation to model the block.

Motion-based object detection methods have been used in many research areas such as transportation, people counting, and object detection in an industrial system. The object detection methods can be classified into four general categories: template matching based methods, knowledge-based methods, OBIA-based methods, and machine learning based methods. Template-based methods use various rigid templates and detect some objects with small variations [10]. However, it depends on scale and orientation. Knowledge-based methods translate the object detection problem into a hypothesis testing problem [11]. This is made by establishing a set of rules and knowledge. Machine learning based methods apply some methods such as HOG, BoW, Haar-like, or Lucas-Kanade based methods to the

image and extracts some features [12]. The obtained features constitute the inputs of a machine learning method such as SVM, KNN, and Adaboost. Afterward, the objects are detected. Segmentation-based object detection involves two steps: image segmentation and object classification. The various forms of image segmentation have been applied to the image for the object detection purpose. However, the main problem of this method is inadequate pre-processing.

The interactive segmentation starts the process by using interaction with the user. The user enters the parameters and the segmentation process is run by using these inputs. In this study, an interactive segmentation based quality control system is proposed. The proposed method takes some points from user to obtain the background and object in the initial frame. Afterward, the model of these points is constructed by using Gaussian process. After the algorithm extract the segmented image, the position of each object, their size, and missing objects are detected. a new approach is proposed to detect some elliptical objects. For this purpose, an interactive segmentation method is proposed to detect the inspecting object. Two scribbles are selected from the background and foreground of the image. Afterward, the background and foreground objects are separated. The detection process uses the size of objects and roundness parameters. The proposed method does not require training. So, it is faster than existing machine learning methods. The method is used for inspection of bottle closures in a water-filling plant.

A new method has been proposed for detection of moving objects. The proposed method converts a color image to a high contrast image and a threshold value is obtained by applying Otsu method. After a threshold value, has been obtained as offline, this threshold value is used to detect the object in a high contrast image. Some geometrical features such as gravity center, height, width, orientation, area, and perimeter.

1.1 A Literature Review

In the last years, a lot of methods have been created for detection object aerial through images satellite. It has possessed the capacity to for the most part of them into four fundamental classes: knowledge-based methods, machine learning-based methods, OBIA-based methods and template-based methods. These four classes are unquestionably not free

and frequently precisely, so a similar technique exists in different categories. Figure 1.1. shows the classification of object detection methods, for which adjusted rectangles with solid outskirts outline our degree in this thesis, there are two classes of template-based methods: deformable template matching and rigid template matching [13]. As for as knowledge-based object recognition techniques, we for the most part audit two sorts of most broadly utilized earlier learning, specifically: context knowledge and geometric knowledge. Mostly, OBIA-based object detection methods include two phases: object classification and image segmentation. When it comes to machine learning-based methods, we mostly focus on reviewing three important proceedings roles in the performance of object detection they have been feature fusion, feature extraction and classifier training.

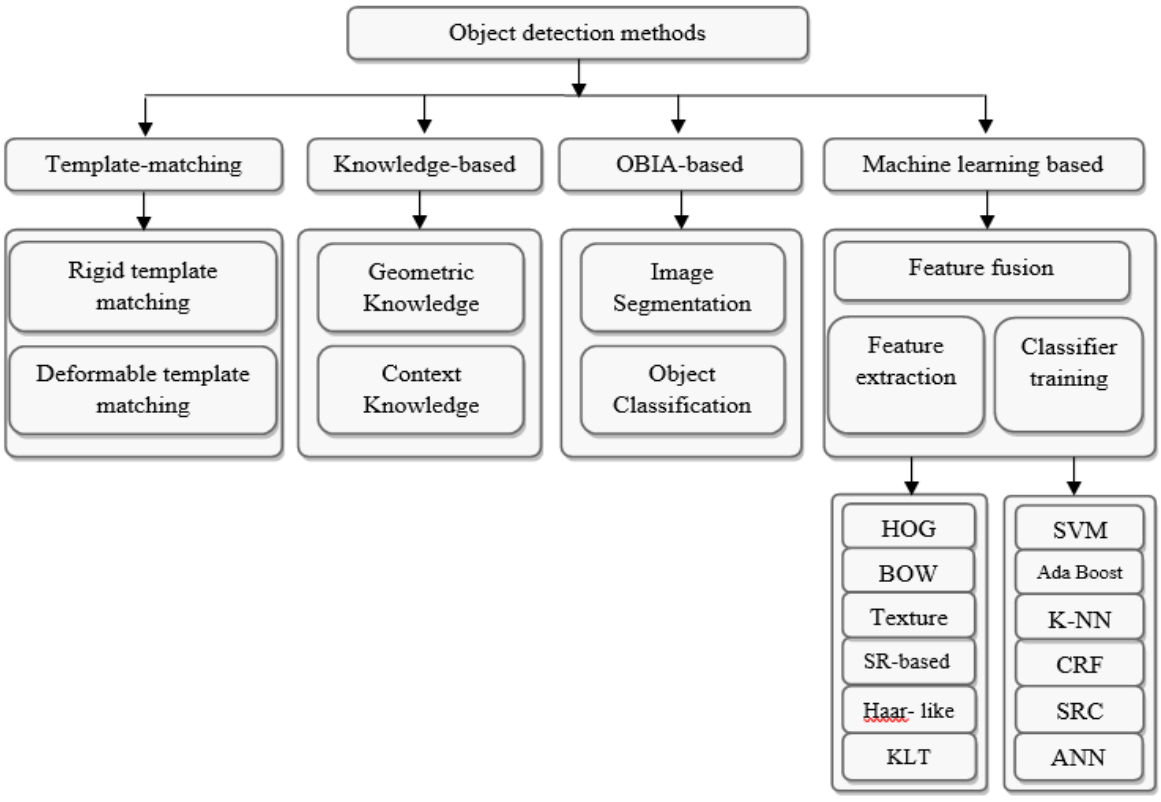


Figure 1.1. Classification of object detection method [13]

1.1.1 Template Matching-based Methods

Template matching based methods are one series of the most ideal courses for object detection. It is a technique in digital image for select small components of an image which fit a template image. Figure 1.2. shows flowchart of general steps of template matching for object detection [14]. It was utilized as a part of quality control, a way to navigate a mobile, or as a way to recognize edges in images for the most part, the most utilized likeness measures are the sum of the squared differences (SSD), the sum of absolute differences (SAD), the Euclidean distance (ED), along with the normalized cross correlation (NCC). On the premise of the template kind picked by an individual, the template object detection methodologies are generally arranged into two sorts:

- Rigid template matching,
- Deformable template matching.

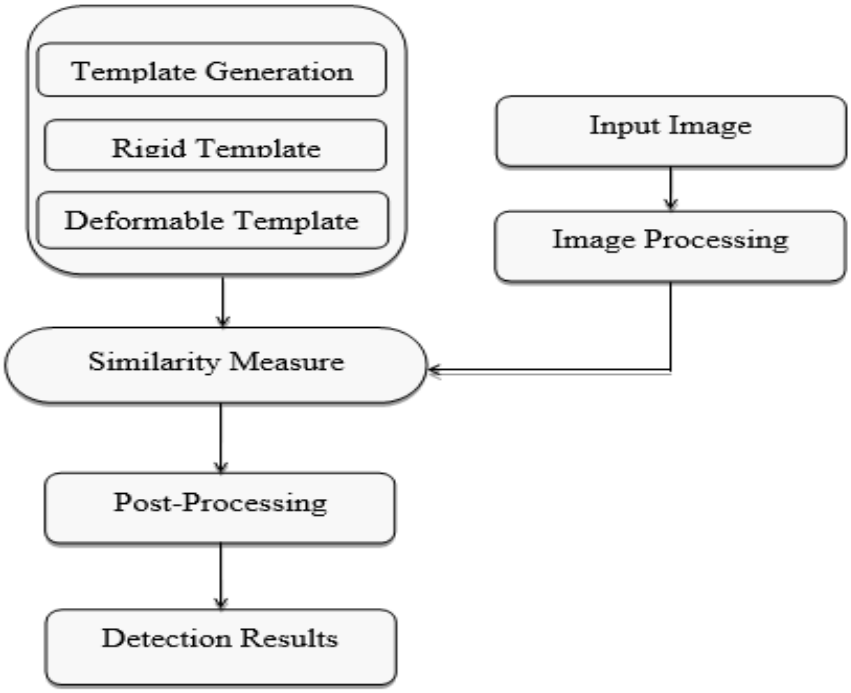


Figure 1.2. The flowchart of general steps of template matching for object detection [14]

1.1.1.1 Rigid Template Matching

Very early study in this locale essentially focused on rigid template matching. Different rigid templates were made for detecting particular objects with straightforward

look and little varieties for instance road [15]. Presented a road checking technique in view of the road profile relationship, for which reality of the distortion of a reference profile and furthermore target profile is calculated by selecting two geometrical factors to change and including two radiometric parameters lighting and contrast [16]. Presented a road monitoring framework with the guide of two profiles one orthogonal to the road bearing and also another parallel onto the road path.

1.1.1.2 Deformable Template Matching

The idea of the deformable template had been originally presented to the computer vision community according to the spring-loaded templates [17]. Deformable template matching is dramatically effective and flexible than rigid form matching in dealing with form deformations and intra-class modifications due to the ability to each enforce geometrical constraints during the form and also to include the image evidence that is local. There has been plenty of scientific studies on deformable template matching during the past several years. This studies could be approximately divided possibly in to two forms:

- Parametric deformable templates,
- Free-form deformable templates.

1.1.2 Knowledge-based Object Detection

Knowledge-based object detection techniques are one the other kind of the common techniques for object detection in optical RSIs [18], Figure 1.3. shows flowchart of knowledge based object detection. This particular strategy commonly converts the object detection concern directly into a hypothesis testing problem by implementing a number of understanding and procedures [19]. The algorithm consists of two procedures:

- Geometric knowledge,
- Context knowledge.

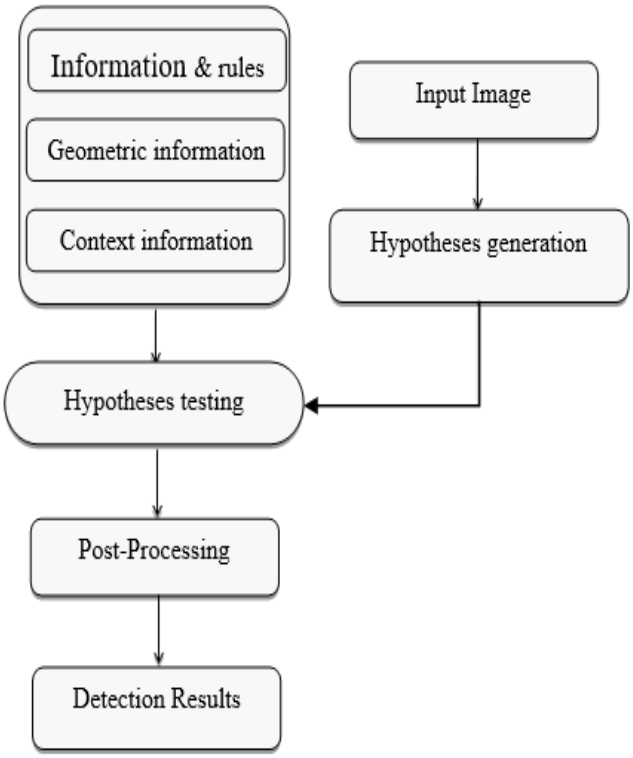


Figure 1.3. The flowchart of knowledge based object detection [18]

1.1.2.1 Geometric Knowledge

The geometric knowledge looks their more essential as well as ordinarily utilized data for the object detection, that encodes earlier data with firmly using parametric particular as non-exclusive frame objects suggested a path object such as geometric and radiometric properties, where that speculation to roadways was produced utilizing handcrafted guidelines, as well as a high reduced procedure, is actually connected to confirm the road theories [20].

1.1.2.2 Context Knowledge

The context knowledge is an actually different crucial cue for knowledge based object detection as well as also more favored context knowledge is the spatial imperatives as connections between objects and background as their data about how the object associates utilizing its neighboring areas [21]. Newly, at their growing accessibility to wide usage of

image processing methods, object-based image analysis is now a new methodology to classify images into significant objects.

1.1.3 OBIA-based Object Detection

OBIA involves two steps: image segmentation and object classification. Firstly, the image is first segmented into homogeneous region additionally called objects speaking to a generally homogeneous gathering of pixels by selecting craved scale, shape and smallness criteria [22]. And in a second step, a classification process is applied to these objects. Figure 1.4. shows general steps of object-based image analysis [23]. In recent times, interactive image segmentation is exceptionally mainstream for object detection. Just a couple tests are taken from every object in a video outline and the segmentation images are separated from a video.

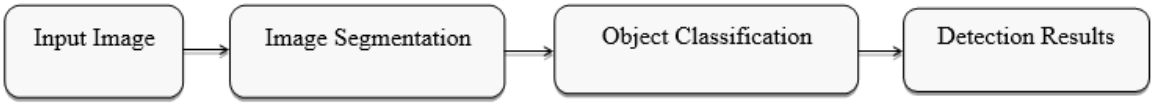


Figure 1.4. General steps of object-based image analysis [23]

1.1.4 Maechine Learning-based Object Detection

Utilizing their progress of machine learning-based object detection, particularly their intense element representations and classifiers numerous current methodologies viewed object detection as an arrangement issue and furthermore have accomplished noteworthy enhancements. Figure 1.5. gives the flowchart of machine learning-based object detection [24], by which protest detection could be completed with taking in a classifier that captures the variation in question appearances and perspectives from an arrangement of preparing information in an administered or semi-directed or low regulated framework. The contribution for the classifier is an arrangement of regions sliding windows or question proposition alongside their relating highlight representations and furthermore, their production is the comparing anticipated labels matter or not really.

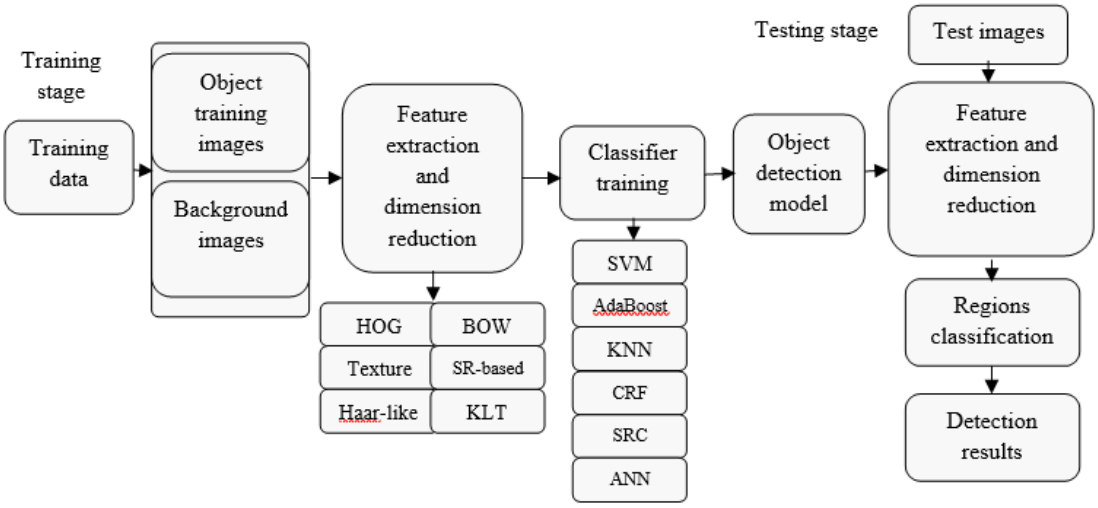


Figure 1.5. Machine learning-based object detection [24]

1.1.4.1 Feature Extraction

Feature extraction is the mapping from line image pixels to a discriminative high-dimensional information space. Since high- rendering object detection is ordinarily conveyed call at Feature space [25], the Feature extraction is fundamental to make elite protest detection methods. The next we mainly focus on explore some widely-used features for object detection.

A) **Histogram of Oriented Gradient (HOG) feature and its extensions:** Histogram of oriented gradients (HOG) is a quality descriptor used to detect objects in computer vision and image processing. The (HOG) descriptor technique include occasions of inclination introduction limited parts of an image detection window or region of interest (ROI). Separate the image into little connected area called cells, in addition to for every cell count a histogram of gradient arrows or edge orientations with regards to pixels in the cell [26].

B) **Bag-of-Words (BOW) feature:** In computer vision, the Bag-of-words feature could be connected to image order by regarding image includes as words. In record arrangement, a pack of words is an inadequate vector of event checks of words; this

is surely [27]. A strewn about histogram on the vocabulary in a pack of visual words is a vector of event checks of a vocabulary of regional image feature.

C) **Texture Features:** A texture feature is a set of metrics calculated in image processing made to quantify the perceived texture of an image. Image texture gives us details about the spatial arrangement of color or intensities in an image or selected region of an image [28]. Image textures could be artificially created or present in natural scenes captured in an image. Image textures are one of the ways you can use to simply help in segmentation or classification of images. To get more accurate segmentation probably the most useful features are spatial frequency and a typical Gray level. To investigate an image texture in computer graphics, there are two main methods to approach this problem which is structured approach and statistical approach.

D) **Sparse Representation (SR)-based features:** Recently utilizing the development of packed detecting hypothesis, SR-based features have now been broadly put on hyperspectral image demising [29], hyperspectral image classification and object detection in RSIs. The centre thought of SR would be meagrely encoding high distance unique flags by a few basic primitives in an insignificant distance complex. The way toward looking for the sparsest model for test with regards to an over-total lexicon blesses itself with a discriminative nature to do classification. The SR-based feature could be for the most part figured through settling a slightest square based improvement issue with requirements in the inadequate coefficients.

E) **Haar-like Features:** A Haar-like feature views contiguous rectangular districts at a specific area in a discovery window totals up the pixel forces in every locale and computes the fundamental contrast between these totals. This distinction will be utilized to sort subsections of an image [30]. For example, now have an image database with human appearances. It truly is a run of the mill perception that among all faces the area for the eyes is darker when contrasted with a district for the cheeks. Subsequently, a commonplace Haar-like component for face detection is two or three nearby rectangles that over a man's eye and furthermore the cheek

locale. The situating of the rectangles is characterized as per a detection window that demonstrations like a jumping box to your objective question.

F) **Kanade Lucas Tomasi (KLT):** Kanade Lucas Tomasi is a method to feature extraction. It is really proposed chiefly for the planned motivation behind working with the issue that conventional image registration way is frequently expensive. KLT makes usage of spatial force data to coordinate the search for the position that creates the best match. It is quicker than conventional methodologies for analysing far less potential matches between your images.

1.1.4.2 Classifier Training

A classifier could be prepared utilizing some conceivable methodologies with the purpose of minimizing the classification mistake in the training. In practice, a variety of learning approaches could be selected including, but they are not restricted to support vector machine (SVM), Adaboost, k-nearest-neighbor (KNN), conditional random field (CRF), sparse representation-based classification (SRC), and artificial neural network (ANN).

1.2 The Aim of Thesis

The first aim of this thesis is to research object detection methods for static camera object detection and classification. Afterward, a new static camera interactive segmentation method is proposed to detect objects in a video. For this purpose, the Gaussian mixture model based foreground detection method is utilized for background extraction. The holes in the detected objects are eliminated by applying mathematical morphology-based methods. The effectiveness and efficiency of the proposed approach will be proved by applying the proposed method to moving object detection in industrial systems and vehicle or other component detection in the transportation system. The detected objects are classified according to their simple features by using machine learning methods.

1.3 Organization of the Thesis

The rest of this thesis is organized as follows:

Chapter 2: Image segmentation, gives a definition of segmentation, types of segmentation, image segmentation using GMM, OTSU and MSER algorithm.

Chapter 3: The proposed interactive segmentation based object detection, Gaussian mixture model for object modeling, determining the size of an object, experimental results.

Chapter 4: Object detection and classification using interactive segmentation method, starts with short information about interactive segmentation, the proposed object detection, and classification method segmentation and counting object classification information are addressed in this chapter.

Chapter 5: Conclusions, this is the final chapter, which is dedicated to concluding remarks on the work of this thesis as well as providing the final insight into possible ways of further enhancing.

2. IMAGE SEGMENTATION

As in computer concepts, images are tested as required principle to fetch information by clarifying images. Segmentation is the departure of unique or more regions or objects in an image built on a cutout or a likeness standard. Every segment will represent to some sort of data to client in the shape of color, force, or texture. Henceforth, it is imperative to segregate the boundaries of any image as its segments [31].

Image segmentation is elementary or front stage handling of image compression. The productivity of segmentation process is its speed, great shape coordinating and better shape connectivity with its dividing result [32].

2.1 Types of Segmentation

A digital image consists of image elements that defined as pixels. Pixels are the smallest part of an image. A pixel represents either brightness or darkness of certain point which also represents as one or zero (1 and 0). This technique for segmentation will appoint only one esteem each and every pixel of an image in order to make it easy to separate between various districts of any image [33]. This separation between various segments of an image is finished in view of three properties of image: texture, color, and intensity of the image. Figure 2.1. shows different types of segmentation. In this way, the decision of each image division technique is finished after monitor the issue space [34], the main types of image segmentation consist of edge-based segmentation, region based segmentation, threshold based segmentation, feature based clustering segmentation and model-based segmentation.

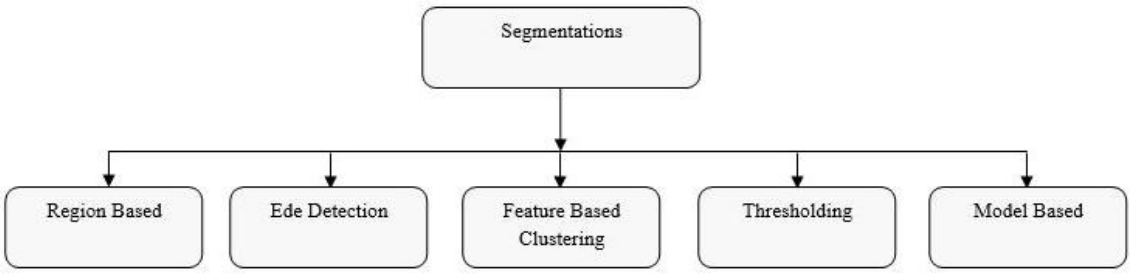


Figure 2.1. Different type of segmentation

2.1.1 Region Based Segmentation

The principle thought here's to group a particular image into a number of regions or classes. Thus, for each and every pixel of the image we need to by one means or another choose or gauge which class it has a place with [35]. There are various approaches to do locale based segmentation additionally to our knowing the execution won't change starting with one great way then onto the next significantly. RBS way has two processes: splitting and integrate. The primary method merging is:

- Get a first above segmentation of this image,
- Combine these surrounding segments which are like in many regards to make one segments,
- Get to move two while any segments that need to be to be combined stay.

The first segmentation might essentially stay each pixel; every pixel is a fragment with no someone else. The focal point of this rising methodology could be the likeness foundation used to choose whether or maybe not two fragments should positively be merged. This standard may be founded on dark esteem similitude, the edge quality of this limit among the portions, the surface of this fragment, or a standout amongst the hugest different potential outcomes. The main method dividing is:

- Get a preliminary below segmentation of this image,
- Divide every segment this is certainly inhomogeneous in a few regard each segment this is surely not likely to actually be just one segment,
- Go to move two while all segments are homogeneous.

The rule for inhomogeneity of a part could be the distinction of the black values, the change of the surface, the function of sturdy inside sides, or a few other requirements [36]. The basic blending and component methods are apparently the top-down and base up method for precisely the same of segmentation, be that as it may, there is an inborn distinction, the converging of two fragments is simple, nonetheless, the element of a part needs we build up reasonable sub-portions the sections might be divided into.

2.1.2 Edge Based Segmentation

Edge detection is a straight forward step for image segmentation technique [37]. It separates an image in to object in addition to splitting its background. Edge detection splits the image by watching the modification in level or pixels of an image. Grey histogram and slope are a few main methods for edge detection for image segmentation process. Some providers can be used by edge detection method, edge detectors no crossing, color edge detectors and etc. [38]. Given that a digital object is completely displayed by it is edges, and any image segmentation will be achieved by selecting the edges associated with the objects. A popular method for segmentation using edges is:

- Calculate the edge of image, that has almost all edges of the initial image,
- The edge of an image to enclose the limitations of an object that are collected,
- Change the effect to a common segmented image by stuffing out the object limitations.

The stuffing of limitations, is obviously not a hard stage [39], and a good example of how this could be attained is provided with regards to method below. The matter often is dependent on the center stage: changing an edge or edginess image to enclosed borders frequently needs the reduction of edges as a result of noise or just about any other issues, the non-recognized edges at those locations of the filling gaps and intelligent choices to be able to associate those edge components that comprise just one single object. According to the following algorithm EBS can be accomplished as shown in image *f*,

- Calculate edge of image ∇f from *f*. Any chosen gradient agent can be utilized for this,
- Threshold ∇f to an image (∇f) *t*, pixels can be shown by the edge of the binary image,
- Calculate a Laplacian image Δf from *f*, we are able to choose either discrete or continuous Laplacian operator.

Thus, the image g has only three values: 0 at non-edge pixels of f, 1 at edge pixels within the bright side of an edge, and 1 at edge pixels through the dark side of an edge. To segment the given boundaries of image g for the objects [40].

2.1.3 Threshold Based Segmentation

Thresholding has turned into the most consistently utilized procedure for image segmentation. Gray level mapping is the thresholding operation that operates g and described by

$$g(v) = \begin{cases} 0 & if \quad v < t \\ 1 & if \quad v \geq t, \end{cases} \tag{2.1}$$

Where *v* shows the value of grey and threshold value shown as *t*. After the operation of thresholding, the image segmented into two parts, due to the pixel values 0 and 1. When we have an image that contains shiny and reflecting objects or surface on a black background, thresholding can support the image segmentation. As in many types of images the grey values of objects have not turned in to the same as the back-ground value, for segmenting an image into objects and background thresholding is the most suitable method [41].

For thresholding, the objects segment value will be 1 and background segment value will be 0 by using compatible threshold for image segmentation. Histogram, and we get the result of the thresholding by using four different values of threshold which achieved from the histogram. After several required segments that recognized by their grey values in an image, expansion will be noticed by threshold segmentation just to utilize several thresholds to segment an image into more than two segments: each smaller value pixels will be compared to the primary threshold that are assigned to segment 0, and all other pixels that have values between first and second threshold will be assigned to segment 1. If *n* thresholds (t1, t2, . . ., tn) are utilized.

$$g(v) = \begin{cases} 0 & if \quad v < t1 \\ 1 & if \quad t1 \leq v \leq t2 \\ 2 & if \quad t2 \leq v \leq t3 \\ & \quad . \\ & \quad . \\ & \quad . \\ n & if \quad tn \leq v\,. \end{cases} \tag{2.2}$$

2.1.4 Feature Based Clustering Segmentation

Image segmentation is among the most utilized approaches for any pixels of an image, classification will be done in effective way to choose arranged application. It truly is a vital instrument in lots of field including human services, image processing, traffic image, pattern recognition. For image segmentation, we can mention different types like cluster based, neural network based, edge based and threshold based [42].

Through the various methods, the most effective methods may be the clustering method. Once again, clustering can be classified to many types like, fuzzy C-means, K-means, subtractive method and mountain method. Certainly, k-means clustering is the most common clustering algorithm. It's for sure basic, flexible and able to do simple calculation speedier when contrasted with progressive clustering. And it may also work with numerous variable. However, it creates various cluster result for the various total of a quantity of clusters. Therefore, it is necessary to initialize the correct quantity of a quantity of cluster, K2. Again, it is really necessary to initialize the *k* quantity of centroid, the various cluster would be the result of a different value of primary centroid.

2.1.5 Model Based Segmentation

Their model-based segmentation since the project of labels to pixels by organizing identified object model to the image data, there are possibilities for labels to show their suspicion. While model-based segmentation is a conventional segmentation's generalization [43], that assigns accurate labels to pixels with the use of only low-level appearance such as homogeneity and discontinuity; it is normally a special case of object recognition. Thus, computational strategies for object recognition.

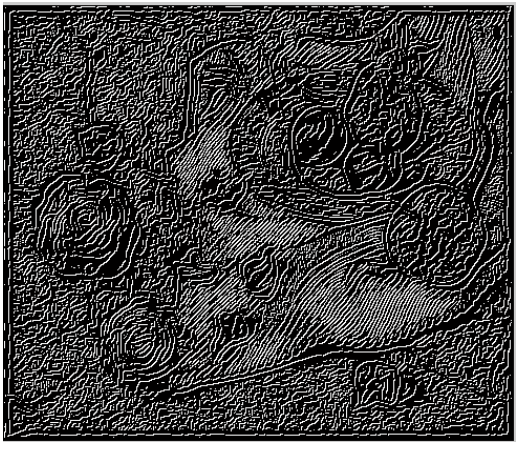
Markov Random Field (MRF) based segmentation is recognized as model-based segmentation. A part that is inbuilt limitation is known as an MRF which is applied for color segmentation [44]. The color pixel tuples facets are concepts as individual constants that are hierarchically processing. For exact identification of the edges MRF is along with edge detection. MRF has the region that is the spatial restriction and we can notice a connection through the elements of colour. Expectation-Maximization (EM) algorithm is depending on an unattended process. Multi-resolution depends on segmented method

named as “Narrow Band”. It is way faster in comparison to conventional, and by utilizing Gaussian Markov Random Field (GMRF), the segmentation can also be done in which the spatial conditions between pixels are thought for the strategy GMM based segmentation can be the expansion of GMM, that recognizes the locale alongside edge prompts and for applying this mechanism in the GMM system the space form can be recognized by distinguishing [45].

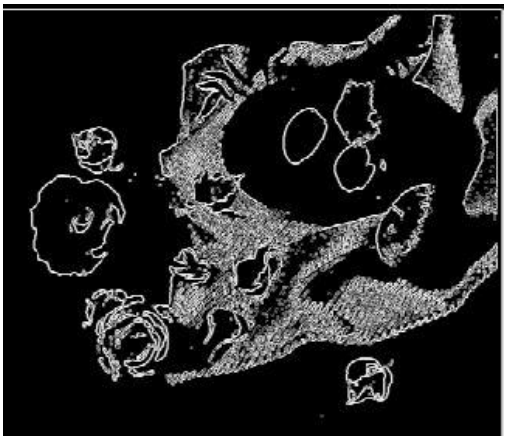
2.2 The Different Segmentation Results

The different segmentation results are idealized around there. Figure 2.2. shows the result of each algorithm, a re-enactment contemplates is done to take a gander at the diverse systems for segmentation and to detect the edges correctly.

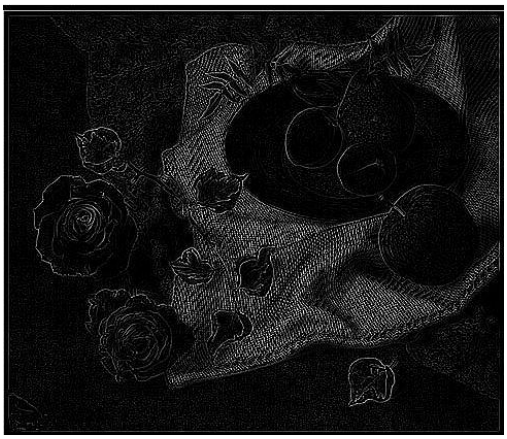
(a) Original image



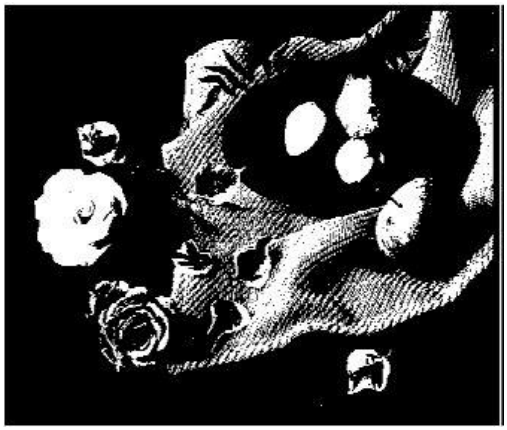
(b) Canny edge detection



(c) Gradient edge detection



(d) Laplacian edge detection



(e) Thresholding

Figure 2.2. The result of each algorithm

2.3 Image Segmentation Using Gaussian Mixture Model

The image is an array that every element is a pixel. The worth linked to the pixel is an amount that presents strength or color of the image. Let *x* is an arbitrary variable that takes these standards [46]. For a probability model dedication, we could have likely to have GMM model that preceding structure

$$f(x) = \sum_{i=1}^{k} pi N(x|\mu i, \sigma i^2) \tag{2.3}$$

in which *k*, may be the amount of areas and *pi* 0 are weights in a way that ∑*k i*1 *pi* 1

$$N(\mu i, \sigma i^2) = \frac{1}{\sigma\sqrt{2pi}} exp \frac{-(x-\mu i)^2}{2\sigma i^2} \tag{2.4}$$

Where $\mu i, \sigma i^2$ typical difference of course *i*. For a provided image *x*, the plan data is the values of pixels and GMM is every pixel basis version. Nevertheless, the factors would be $\theta(p1, \ldots, pk, \mu 1, \ldots, mk, \sigma 1^2, \ldots, \sigma k^2)$ and it's also can see right now the quantity of areas in GMM by histogram of arrangement data.

2.3.1 Image Segmentation GMM Algorithm

Give consideration to a mix design with $m > 1$ elements in $n < 1$ for $n > 1$: $(x|\theta) = \sum_{m-1}^{m} \sum m\, m = 1\, \alpha mp(x|\theta_m), \forall x \in Rn$ Where $\{\alpha 1 \ldots\ldots \alpha m\}$ would be the mixing amounts, each θm may be the set of variables determining the m the component, and $\theta\ m = \{\theta 1, \theta 2, \ldots, \theta n\}$ will be the whole group of variables required to specify the mixture. Becoming probabilities, the must satisfies. Figure 2.3 shows the GMM algorithm code.

$$a_n > 0, m = 1,2,3, \ldots, m, \sum_{m=1}^{m} a_m = 1 \quad (2.5)$$

The Gaussian mixtures, every single element density p $(x|\theta\ m)$ is a standard probability distribution

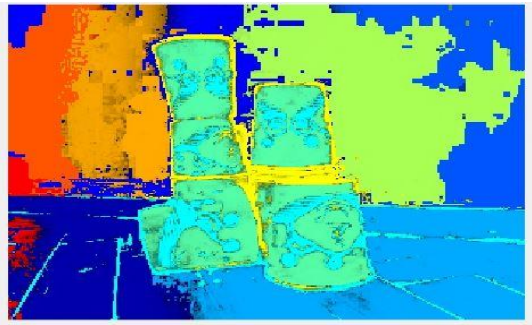
$$P(x|\theta m) = \frac{1}{(2\pi)\det(\sum m)^{\frac{1}{2}}} * \exp\left\{-\frac{1}{2(x-\mu m)}\right)^{t} \sum_{m}^{-1} (x - \mu m) \quad (2.6)$$

```
img_RGB = imread('gmm.jpg');
Ncol = size(img_RGB,2);
Nrow = size(img_RGB,1);
convert to Lab color space
cform = makecform('srgb2lab');
img_LAB = applycform(img_RGB,cform);
normalize the color pixel
I = img_LAB;
I = double(I)/255;
% figure; imagesc(I); title('image plotted in Lab color space');
Y = reshape(I(:),Ncol*Nrow,[]); % align the image pixels by NxD
% create pixel location
[xI,yI] = meshgrid(1:Ncol,1:Nrow);
% figure; imagesc(xI); daspect([1 1 1]); % 4test
% figure; imagesc(yI); daspect([1 1 1]); % 4test
% normalize the location
xI = xI(:); yI = yI(:);
xI = xI/max(xI,[],1);
yI = yI/max(yI,[],1);
Y = [Y xI yI];
Y = Y(:,W~=0); % pick non-zero weights
W = W(W~=0); % pick non-zero weights
Y = Y - repmat( mean(Y,1), length(Y), 1);
Y = Y./repmat(std(Y,1), length(Y), 1); % standardize the normal data
W = W/sum(W,2)*10; % scale by 10 to prevent underflow of any dimension
Y = Y.*repmat(W,size(Y,1),1);
C_num = length(C);
GmmObj = cell(C_num,2);
BIC = zeros(C_num,1);
D = size(Y,2);
tic;
tmp_cnt = 1;
disp(['GMM spend ',num2str(toc),' sec']);    0
find the winner model ----
[~, index_min] = min(BIC,[],1);
gmm_obj = GmmObj{index_min,2};
plot the BIC curve
figure; plot(C,BIC,'b.-');
classification using MAP
gmm_posterior = posterior(gmm_obj,Y);
[max_postr, class_result] = max(gmm_posterior,[],2);
```

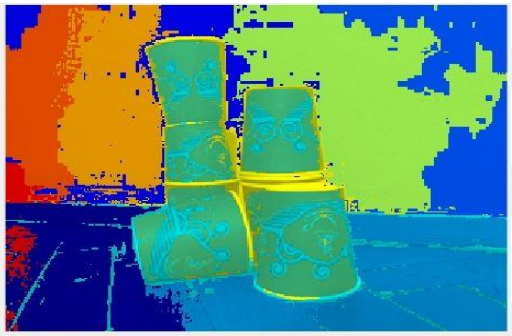
Figure 2.3 The GMM algorithm code

In this essay we encapsulate these variables into a quantity vector [47], creating the parameters of each element as $\theta m \{\alpha 1, \alpha 2, \alpha 3, \ldots \alpha n\}$ and also to get ($\sum m$, μm) perhaps, could be rewritten as $p(x|\theta) = \sum_{m-1}^{m} \alpha_m N(x|\mu m, \sum m), \forall x \in R_n$ Where N ($x|$ μ_m, $\sum$ m) is a Gaussian distribution with μ_m mean and covariance $\sum m$. Figure 2.4. shows the result of GMM algorithm.

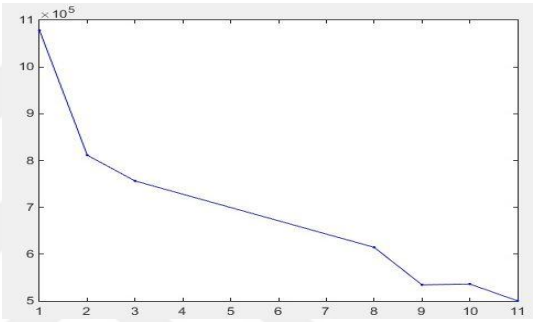
(a) Original image



(b) Classes 2

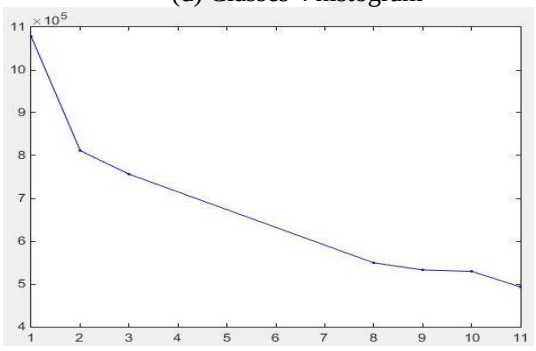


(c) Classes 3



(d) Classes 4 histogram

(e) Classes 5



(f) Classes 6 histogram

Figure 2.4. The result of GMM algorithm

2.4 Image Segmentation Using OTSU

Otsu's method is based on the concept that the gray-level for which the between-class difference is maximum or inside class variance is minimum is selected because the threshold. You can use it to immediately image thresholding organized by perform clustering, or the reduction of a gray stage image to a binary image. To calculate the maximum threshold the algorithm assumes that the image has two portions of pixels next

bi-modal histogram foreground pixels and background pixels. Threshold is an easy simple but efficient method of image segmentation methods. Threshold may be used to carry out a target from the background by simply utilizing an intensity value *t* of each pixel's threshold in a way that each pixel has classified usually as a background point or a target point. The objective of this process is that objects and background are sectioned off into non-overlapping sets [48]. The Otsu method is an approach that maximizes the between-class difference and a well-known nonparametric method of its simplicity and efficiency. Scientific method shows that, it contributes to a suitable threshold value and gets a greatest result in segmenting. In Otsu's method, search is ideal for the threshold that minimizes the intra-class variance, understand to be a weighted amount of differences from the two classes is given as.

$$\sigma_{\omega}^{2}(t) = \omega 1\,(t)\,\sigma_1^2(t) + \omega 2(t)\,\sigma_2^2(t) \quad (2.7)$$

Weights ωi will be the possibilities connected with two classes that threshold *t* and σi 2 separate variations of the classes [49]. Otsu methods indicate that reducing the intra-class distinction is like maximizing inter-class change may be detailed under and yes, it's indicated with regards to class possibilities ωi and class μi, could be modified iteratively.

$$\sigma_{b}^{2}(t) = \sigma^2 - \sigma_1^2\,\omega 2(t) = \omega_1(t)\,\omega_2(t)\,[\mu_1(t) - \mu_2(t)]^2 \quad (2.8)$$

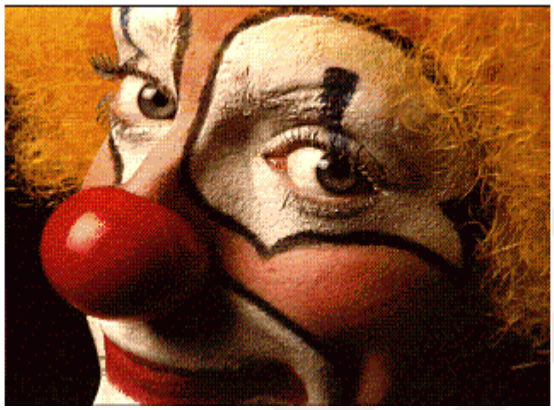
2.4.1 Experiments

In the deals of experiments, Matlab has been used. In many working fields, Matlab has been used. To segment the "Clown" image into 2, 3 and 4 classes that already fetched from Matlab. "load clown" has been utilized. For translate the indexed image to intensity grayscale image "imshow (*x*, map)" "*x* = ind2rgb (*x*, map);"

In another iteration show segmentation the gray-level image inside 2, 3 and 4 classes by using the Otsu's method. Figure 2.5. shows iteration segmentation by using Otsu's method.

```
for n = 2:4
   IDX = Otsu(X,n);
```

```
    figure, imagesc(IDX), axis image off
    title (['n = ' int2str(n)])
end
colormap(gray)
```



(a) Original image

(b) Image segmentation n=2

(c) Image segmentation n=3

(d) Image segmentation n=4

Figure 2.5. The iteration segmentation by using Otsu's method

2.5 Image Segmentation Using MSER

In this part, it explains the MSER algorithm as a foundation for the area identification. The MSER recognition uses a shedding procedure that would be explained within the future means that this function $I : \Omega \rightarrow [0..255]$ is able to show us gray-scale image, where in $\Omega = [1..W] \times [1..H]$ will be the group of most image organize. This has been

selected a strength threshold $t \in [0..255]$ and obtaining two set of pixels B (black) and W (white).

$$B := \{x \in \Omega^2 : I(x) < t\} \tag{2.9}$$

$$W := \Omega^2 \setminus B \tag{2.10}$$

Whenever threshold modified from maximum to minimum intensity, the cardinality from the two sets variants. During the 1st step, B and W will be responsible to show all pixel positions where vacant happens to be seen totally black image. While the threshold *t* is reduced, and white areas start to look while increasing bigger. White areas increase and in the finish, all combine after the threshold achieves near minimum intensity along with the entire image will be white wholly pixels have been around in W and B is empty. Figure 2.6. shows the development procedure alongside various threshold levels.

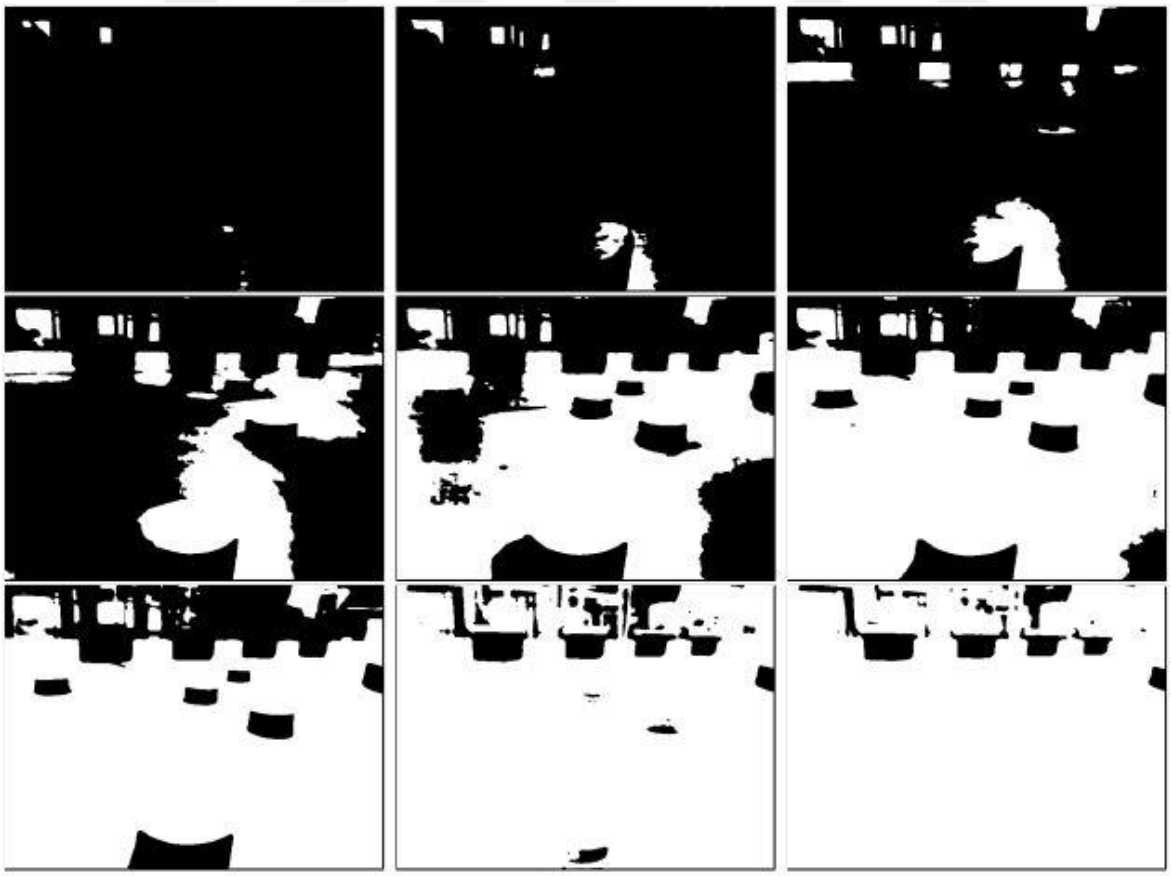


Figure 2.6. The development procedure alongside various threshold levels

MSER development from the insert image introduced in image 1. Results of 9 has shown assorted thresholding phases, every instant for reduce intensity threshold *t* components are involved and showing white areas of images and black areas that are generally utmost regions, and those that need modification in amounts of small throughout from the littlest numerous levels of threshold's intensity are maximal constant section. The quantity of levels necessary is a parameter from the algorithm [50]. In to the second part, we describe the MSER method as expansion of MSER from grayscale to color images.

To the text, we think the image in which to stay RGB color region, however it may be basically detected the MSER method is able to work along with other color areas too. To determine MSERs, we utilize the function of the image is I: Ω → R^3. Therefore, the function of the image *i* assign a color RGB station values to each positions of the pixels in the available image. Additionally, recognize image G, where image pixels can be shown as vertices, as the edge of the set E is referred to as follows realize that *x*, *y* is 2-dimensional vectors

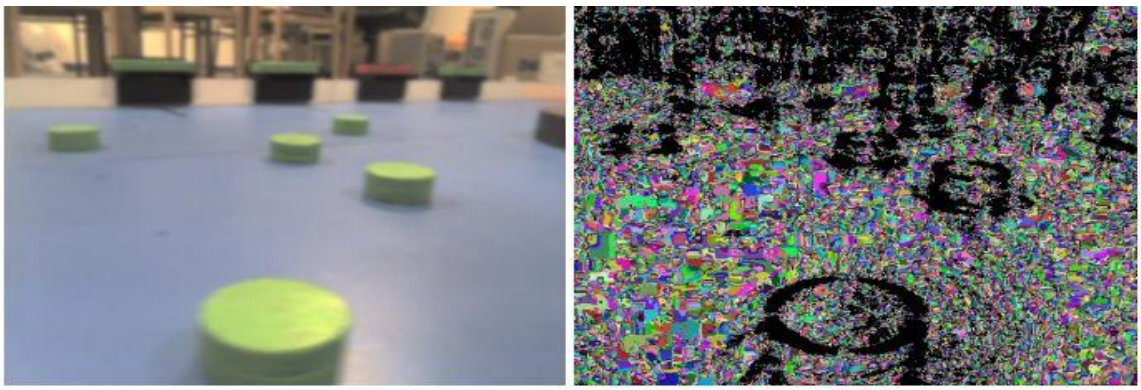
$$E := \{(x, y) \in \Omega^2 : |x - y| = 1\} \tag{2.11}$$

Wherein |*x* - *y*| is a Euclidean period of pixel organize *x* and *y* several other metrics. Any nearby pixels in the image are associated with the edge of the image. Every edge is allocated utilizing the weight *g* (x, y) that measures the color difference between the neighboring *x* and *y* pixels. In respect, it makes utilize of the Chi squared approximate for calculating the value of *g*

$$g^2(x, y) = \sum_{k=1}^{3} \frac{I_k(x) - I_k(y))^2}{I_k(x) + I_k(y)} \tag{2.12}$$

Where $I_k(x)$ indicates, the value associated with the *k*-th indicates the value associated with the *x*.

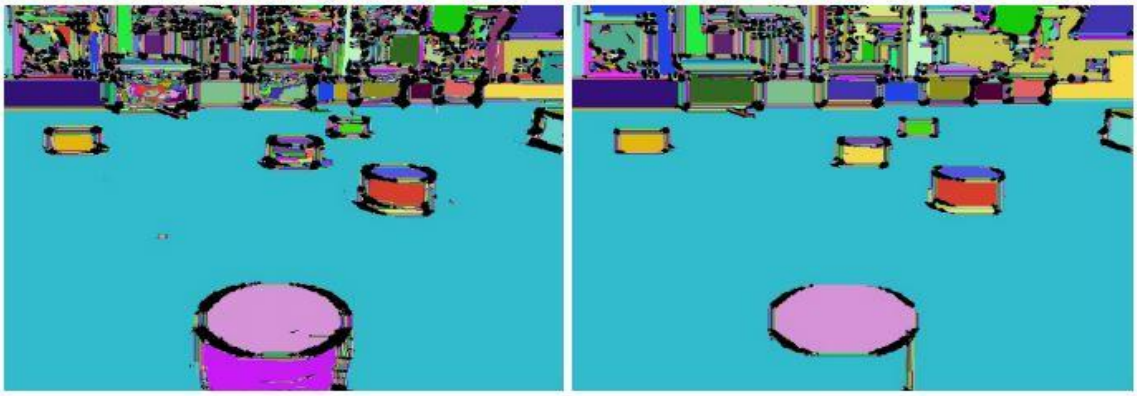
```
I = imread('uNg4a.jpg');
regions = detectMSERFeatures(I);
 figure; imshow(I); hold on;
 plot(regions,'showPixelList',true,'showEllipses',false);
 figure; imshow(I);
hold on;
plot(regions);
```



(a) (b)

Figure 2.7. Blurred input image and first level of MSER evolution

Then bring the quantity of sub-graphs Et ⊆ E, where in actuality the set Et contains just edges along with weight ≤ t. The attached aspects of Et will be referred to as regions. Into the MSER algorithm, start alongside Et, t = 0 and then slowly enhance t. As we continue this, new edges are available in the subgraph Et and regions start to increase and combine. MSER areas are the one's areas which can be stable for example, nearly unchanged in proportions around different thresholding stages, similar to MSER algorithm.



(a) (b)

Figure 2.8. Increasing threshold with regions evolution

Towards an average instance of known MSER areas, connect with Figures 2.7. And 2.8. Figure 2.6 (a) displays the insert image following we can use Gaussian kernel after being obscured because it's usually to handle the noise it must transported out in segmented image. Figure 2.7 (b) parts of image with edges can be shown, and E0 shown in incorrect colors and different aspects of this image that has various colors; insignificant separated 1-pixel components are black. Figures 2.8 (a) and 2.8 (b) show two additional steps associated with the calculation it may be improve the threshold *t* we are in a position to start to see the homogeneous regions of the image combine and form areas. We are able to realize that the adjusts of important arena elements might be clearly recognized from the last stated two images.

3. A VISION BASED INSPECTION SYSTEM USING GAUSSIAN MIXTURE MODEL BASED INTERACTIVE SEGMENTATION

The machine vision based visual inspection methods are vastly used for quality control and inspecting the missing products in a line. These methods provide fast inspection with a high accuracy rate in the industry. Moreover, the main contributions of these systems are to increase the production quality and to be low cost. Computer vision based methods are used as an aid to human-made work in modern production systems.

In recent years, machine vision based methods become an optimal alternative solution for inspecting different products. These methods are utilized in some areas such as the textile defect detection [51], inspecting of electrical components [52], and monitoring the condition of machine tools [53]. The main steps of a vision based inspection system are preprocessing by using filters, edge detection or image segmentation, feature extraction including statistical and shape related features, and classification. This strategy can be used to inspect the quality control of the production. Machine vision based methods have been used in many applications in industrial systems. Some of these applications can be given as follows.

- The inspection of the electrical contact by using machine vision [54],
- Defect detection in metal balls using machine vision [55],
- Automatic date quality evaluation by using computer vision for fruit control [56],
- The identification of weeds using machine vision [57],
- The classification of fruits by using segmentation and geometrical features [58].

The computer vision has become a standard technology in nondestructive inspection and quality control in industrial systems. The inspection is defined as a process of determining whether an object deviates from any given set of parameters. Generally, the inspection process is made by a human operator [59-60]. However, the human operator can make incorrect evaluations due to carelessness and produce erroneous results. An automatic inspection system has many advantages such as ensuring a high standard of production, high speed inspection, elimination of human operators. Three different approaches can be used for the visual inspection system [61]. The first system is based on template matching. This method compares an image with one or more reference images. A rule based system

for checking the violation of any defined rules. The last approach is based on machine vision and learning. In this method, an inspection system learns some features of an object and found the defects in test objects. The first two approaches require a definition of some rules and thresholds. However, machine vision based methods solve the shortcomings of the human operator's ability to reason. Many methods have been proposed for automatic visual inspection. The main areas of these systems are food quality, paper [62], fabric [63], metal [64], and ceramic tiles [65]. These systems use a supervised learning to learn the features obtained from the image. In order to detect objects and their parameters such as size, intensity, and shape, this algorithm is trained wit training images. Many supervised methods such as decision tree, neural networks, and support vector machines have been proposed. However, it is difficult to obtain good results and the classification process reduces the speed of machine vision.

In this study, a new approach is proposed to detect some elliptical objects. For this purpose, an interactive segmentation method is proposed to detect the inspecting object. Two scribbles are selected from the background and foreground of the image. Afterwards, the background and foreground objects are separated. The detection process uses the size of objects and roundness parameters. The proposed method does not require training. So, it is faster than existing machine learning methods. The method is used for inspection of bottle closures in a water-filling plant.

3.1 The Proposed Interactive Segmentation Based Object Detection

The interactive segmentation starts the process by using interaction with the user. The user enters the parameters and the segmentation process is run by using these inputs. In this study, an interactive segmentation based quality control system is proposed. The proposed method takes some points from user to obtain the background and object in the initial frame. Afterwards, the model of these points is constructed by using Gaussian process. After the algorithm extract the segmented image, the position of each object, their size, and missing objects are detected. The general framework of the proposed method is given in Figure 3.1.

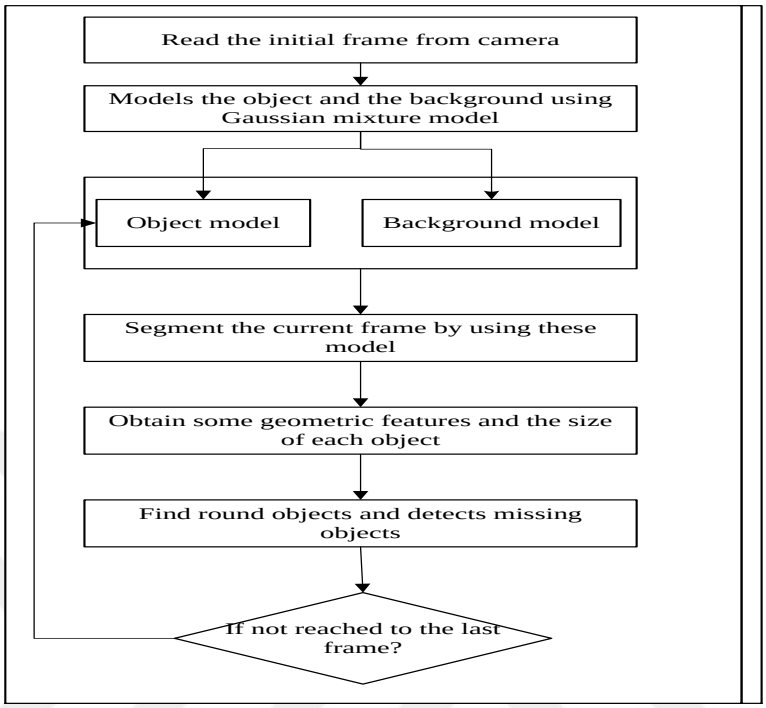


Figure 3.1. The block scheme of the proposed method

In Figure 3.1, the first frame is taken and the background and foreground models are constructed. The user draws two strips of pixels from the object and the background in order to Gaussian mixture models. After the models of background and foreground have been obtained, the next frames can be segmented. The moments of each detected objects are obtained by using some geometrical features. Afterwards, the center of each object and their size will be obtained. The objects used in quality control are round. Therefore, the roundness of the detected foreground objects is used to detect missing objects and to reduce the effect of the noise.

3.1.1 Gaussian Mixture Model for Object Modeling

The user draws two scribbles to model the background and foreground objects. The probability density values of other pixels in the image are determined by using the Gaussian mixture models of selected pixels. The Gaussian mixture models use probability density function to model the data. A Gaussian mixture model with M mixtures is calculated as

$$P(x) = \sum_{i=1}^{M} w_i g(x, \mu_i, \Sigma_i) \tag{3.1}$$

In (3.1), w_i represent the weight of each Gaussian component. The mean and covariance matrix are given by μ_i and, respectively. The Gaussian function g is given by

$$g(x, \mu_i, \Sigma_i) = \frac{1}{(2\pi)^{d/2} |\sum_i|^{1/2}} e^{-\frac{1}{2}(x-\mu_j)^T \sum^{-1} (x-\mu_j)} \tag{3.2}$$

Where the probability density function is obtained by using the mean and covariance matrix. The mixture parameters such as mean and covariance matrix are obtained by applying the k-means clustering. After the mixture models are constructed, the pixels of the new frame are given to the model and they are categorized as background or object. The probability of a pixel belonging to the object is given in (3.3).

$$P_O(c_x) = \frac{P_O(c_x \mid O)}{P_O(c_x \mid O) + P_O(c_x \mid B)} \tag{3.3}$$

In (3.3), c_x represent the color vector of the pixel x. The parameter O and B represent the object and background, respectively. The parameters $P_O(c_x \mid O)$ and $P_O(c_x \mid B)$ show the probability of a pixel belonging to object or background, respectively. Figure 3.2, depicts the probability distribution of pixels to background and object.

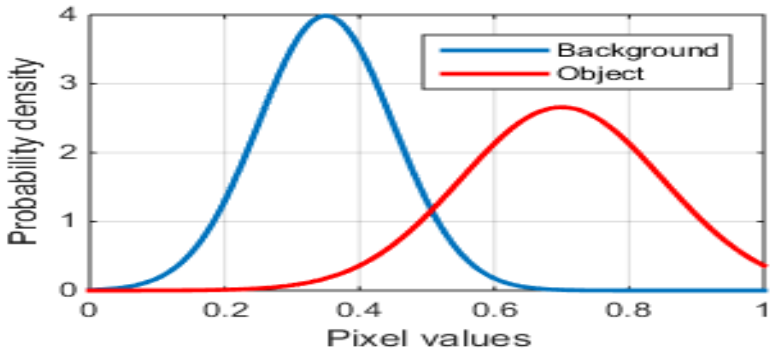
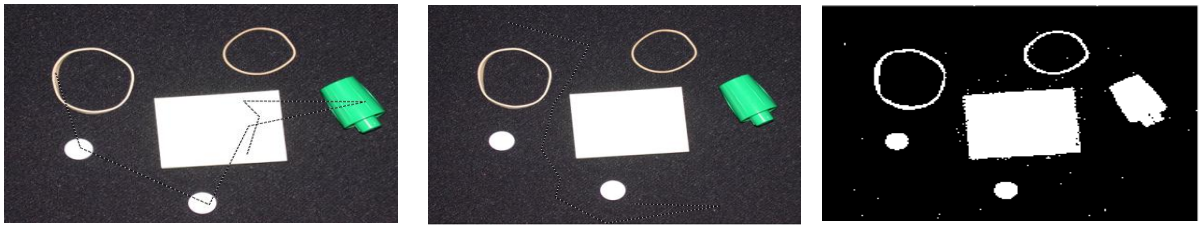


Figure 3.2. The probability density functions of the object and background

For the object detection, a few pixel examples should be sampled for objects and background. An image, the selected pixels of object and background, and the segmentation result are given in Figure 3.3.



(a) The selected pixels for the object

(b) The selected pixels for the background

(c) The interactive segmentation result

Figure 3.3. The background and object modeling and segmentation results

As shown in Figure 3.3, only a few samples are given to the model and the segmenation is done successfully.

3.1.2 Determining the Size of Object

After the image, has been segmented, the contour of each object should be determined. For this purpose, some geometrical features should be extracted. The height and weight of the object are calculated according to (3.4).

$$h = i_{\max} - i_{\min} + 1$$
$$w = j_{\max} - j_{\min} + 1$$

(3.4)

The obtained geometrical features are the center of gravity, major and minor axes, eccentricity, orientation, area of the object. An example about obtaining features are given in Figure 3.4.

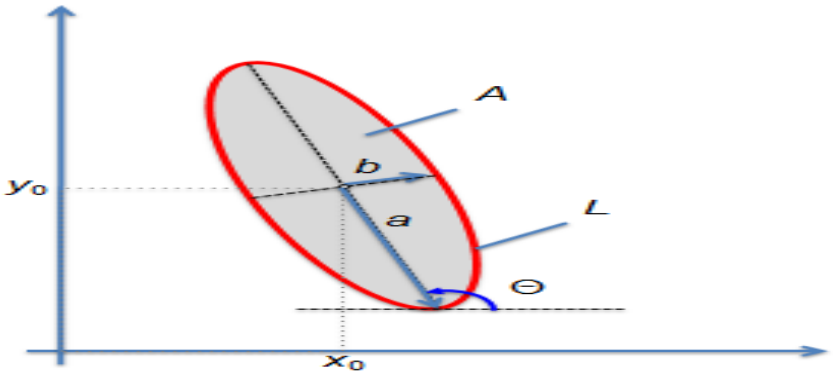


Figure 3.4. The obtained features by using an elliptical representation of an object

After the image has been segmented by using interactive segmentation, elliptical boundaries of each object will be drawn. Figure 3.5, represent the elliptical boundary of each object in the image.

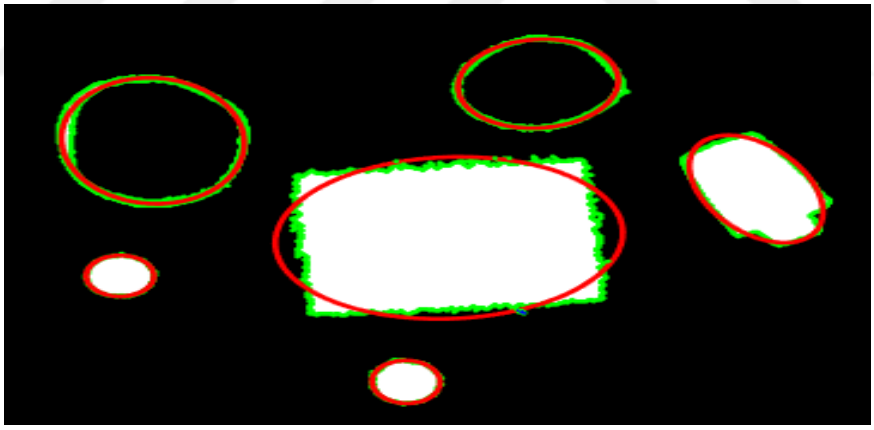


Figure 3.5. The elliptical boundary of each object

After the boundaries of each object has been obtained, the roundness of each detected object is found. For this purpose, a simple metric is used to indicate the roundness of an object. This metric is given in (3.5).

$$Roundness = 4 * \pi * A / P^2 \tag{3.5}$$

In (3.5), parameters A and P represent the area and perimeter of an object. A simple example of roundness process is given in Figure 3.6.

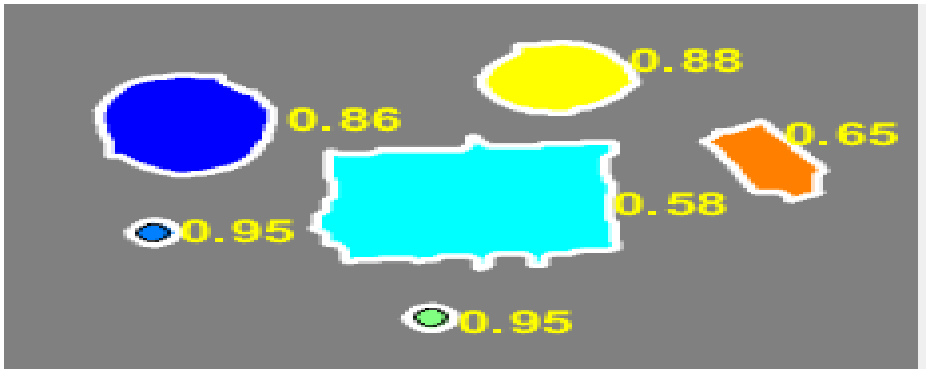


Figure 3.6. The roundness of the detected object

3.2 Experimental Results

The proposed interactive method is applied to an industrial quality control system. The proposed method is used to control the flaps of water bottles. The images of water bottles passing on a tape in a package are obtained through a camera. The experimental setup of the camera is given in Figure 3.7.

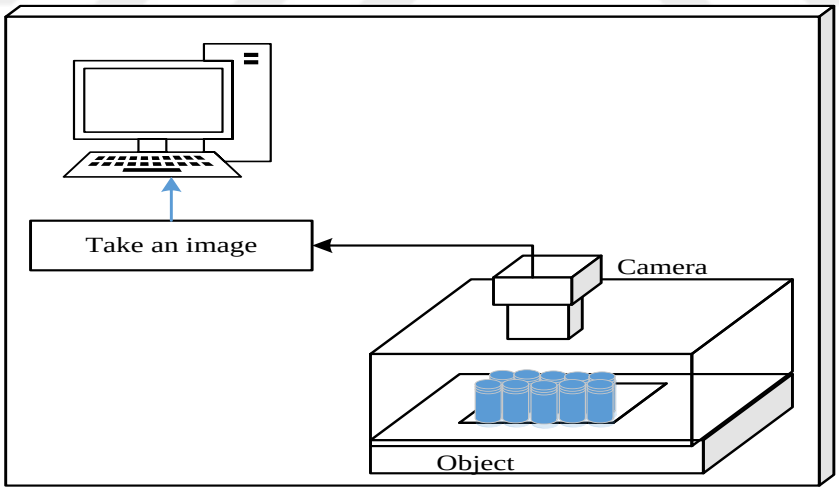
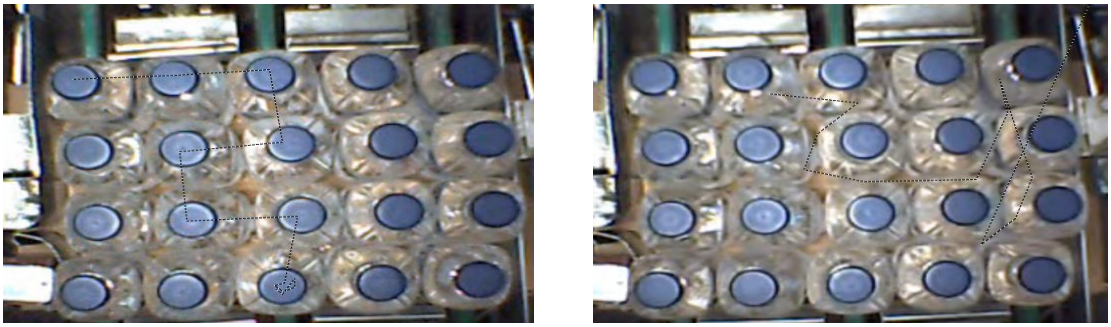


Figure 3.7. The acquiring images from the system

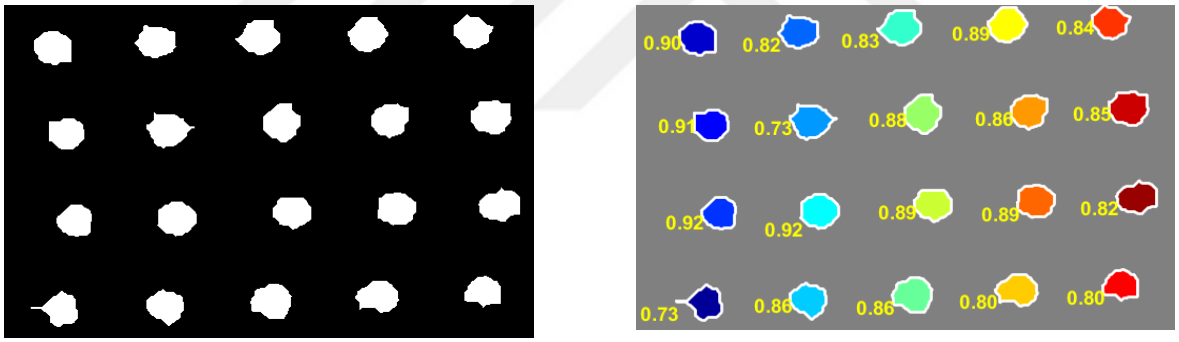
After the image, has been taken from the experimental setup, two scribbles will be drawn to model the background and cap of the bottles. Figure 3.8, represent the scribbles that selected from background and taps of the bottle.



(a) Modeling the cap of bottles (b) Modeling the background

Figure 3.8. Modeling background and object

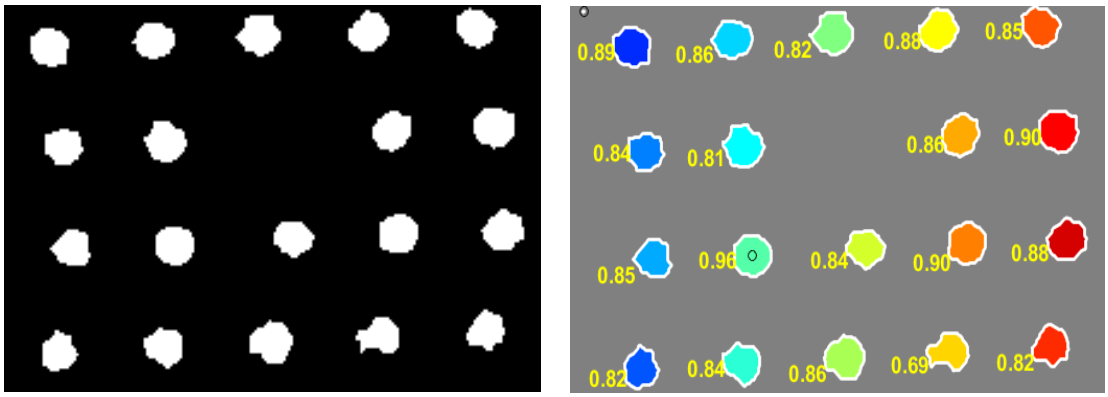
After the scribbles are selected, the image is segmented as object and background according to Gaussian components. The roundness of caps of bottles is used to detect deficiencies in the package. If the roundness of the extracted objects is bigger than a threshold value, the related object will be taken as the cap. The segmentation result and roundness results are given in Figure 3. 9, for healthy package.



(a) Segmentation result (b) Roundness of each object

Figure 3.9. The segmentation and rounds results for healthy condition

After the roundness of each cap is calculated, it is compared to a threshold value for each object. Objects with a high round value from the threshold are counted. If the value is lower than a number of bottles in a healthy package, there are missing bottles. This condition is given in Figure 3.10.



(a) Segmentation result (b) Roundness of each object

Figure 3.10. The segmentation and rounds results for missing condition

As shown in Figure 3.10, the objects have been missed if the number rounded objects are smaller than the number of real objects. The proposed method is quite fast and the processing speed of a frame is 0.15 seconds.

4. OBJECT DETECTION AND CLASSIFICATION USING INTERACTIVE SEGMENTATION METHOD

Moving object detection for a fixed camera has been a popular research area in recent years. This method can be used for many visions based on applications in industrial systems. The main principle of the moving object detection is the subtraction of the background and tracks, the detected object in the next frames [66]. The object detection methods can be classified into two modes. A static camera and a static background are used for acquiring frames [67]. In the second mode, the background is not static and it dynamically changes.

Moving object detection has been used in many visual surveillance systems such as object tracking [68], action recognition [69-70], gesture recognition [71], and semantic image description [72]. The moving object can be detected by applying optical flow [73], background subtraction [74], and segmentation [75]. Background subtraction is robust when compared to the others. Background subtraction constructs a background mode and detects moving objects by using deviation from this model. This model is suitable for slow moving objects. However, it is affected by background variations such as illumination, shadows, and sudden changes. Background subtraction based on methods can be classified as pixel-based and region based methods according to established background model. In pixel based approaches, each pixel is taken as an independent component, while the model is constructed. A general system of pixel based object detection is given as follows. Region or block based approaches divide each frame into overlapped blocks and calculates some features of each block such as covariance, histogram, and correlation to model the block.

Motion-based object detection methods have been used in many research areas such as transportation, people counting, and object detection in industrial system. The object detection methods can be classified into four general categories: template matching based methods, knowledge-based methods, OBIA-based methods, and machine learning based methods. Template based methods use various rigid templates and detects some objects with small variations [76]. However, it depends on scale and orientation. Knowledge-based methods translate the object detection problem into a hypothesis testing problem [77]. This is made by establishing a set of rules and knowledge. Machine learning based methods

applies some methods such as HOG, BoW, Haar-like, or Lucas Kanade based methods to the image and extracts some features [78-80]. The obtained features constitute the inputs of a machine learning method such as SVM, KNN, and Adaboost. Afterwards, the objects are detected. Segmentation-based object detection involves two steps: image segmentation and object classification [81-82]. The various forms of image segmentation have been applied to image for the object detection purpose. However, the main problem of this method is inadequate pre-processing.

In this study, a new approach has been proposed for detection of moving objects. The proposed method converts a colour image to a high contrast image and a threshold value is obtained by applying Otsu method. After a threshold value, has been obtained as offline, this threshold value is used to detect the object in a high contrast image. Some geometrical features such as gravity centre, height, width, orientation, area, and perimeter.

4.1 The Proposed Object Detection and Classification Method

The segmentation is a process to separate objects in an image. The accurate segmentation is very important in computer vision and pattern recognition processes based on image analysis of objects because they obtain features depending on the accuracy of this process. When the segmentation process is not made accurately, the interpretation of the object may fail. An interactive segmentation method is proposed to separate the object from the background. The algorithm has two steps. In the first step, some examples of different objects are used to extract geometrical features of the objects. In this stage, the frames, which have an object and have not an object, have been segmented to determine the threshold value. In the testing stage, the objects are detected and classified by using the obtained threshold and image moments. The schematic diagram of the proposed method is given in Figure 4.1.

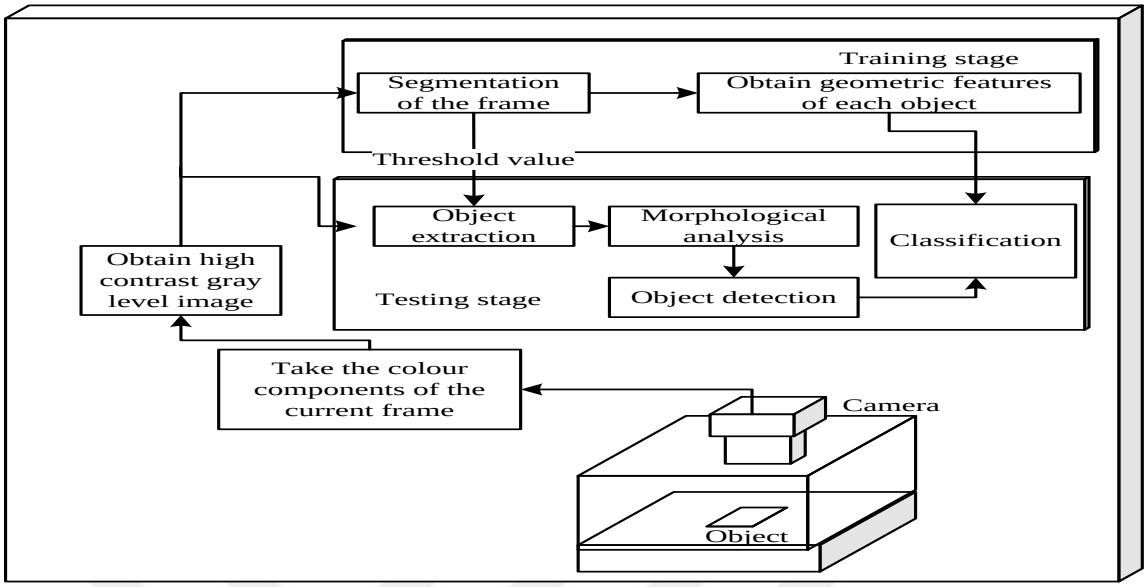


Figure 4.1. Schematic diagram of the object detection and classification

In Figure 4.1, the high contrast image of the current frame is obtained and this image is used both in training and testing stage. In the training stage, two frames, which have an object and does not an object, are given to segmentation algorithm and the threshold value has been obtained. Some segmented image examples are used to obtain geometric features. In the testing stage, the objects are detected and counted according to the threshold value and classified by using geometric features obtained in the training stage.

4.2 Obtaining a High Contrast Image

The first step of the algorithm is acquisition of a frame from a high-resolution camera. The obtained image is color image and has three components such as Red, Green, and Blue. These components represent the intensity of image and they are stored in three matrices called as R, G, and B. Some attempts have been proposed to obtain a better representation of an image. The general form of the image contrast enhancement is based on the following equation.

$$I(x,y) = k_r R(x,y) + k_g G(x,y) + k_b B(x,y) \tag{4.1}$$

In (4.1), the parameters (kr, kg, kb) represent the weights that adjust RGB components. The proposed method uses normalization for obtaining a monochrome image. This value is computed according to (4.2).

$$A(i,j) = \frac{I(i,j) _ I_{\min}}{I_{\max} - I_{\min}} \tag{4.2}$$

When an image has a high contrast, the homogeneity of the image will be low. Therefore, the variance of image A (i, j) should be maximized. The maximization equation is given in (4.3).

$$\arg\max_{k_r,k_g,k_b} \sigma_A^2 \tag{4.3}$$

The appropriate parameters should be selected to improve the quality of the image. The best high contrast image can be obtained by maximizing the variance. The weight parameters are updated by using (4.4).

$$(k_r, k_g)_{i+1} = (k_r, k_g)_i + (\Delta_r, \Delta_g)_i \tag{4.4}$$

In (4.4), values (Δ_r, Δ_g) are computed using the gradient of variance of a monochrome image. If there is not achieved any changes in values of *kr* and kg, the algorithm will be terminated.

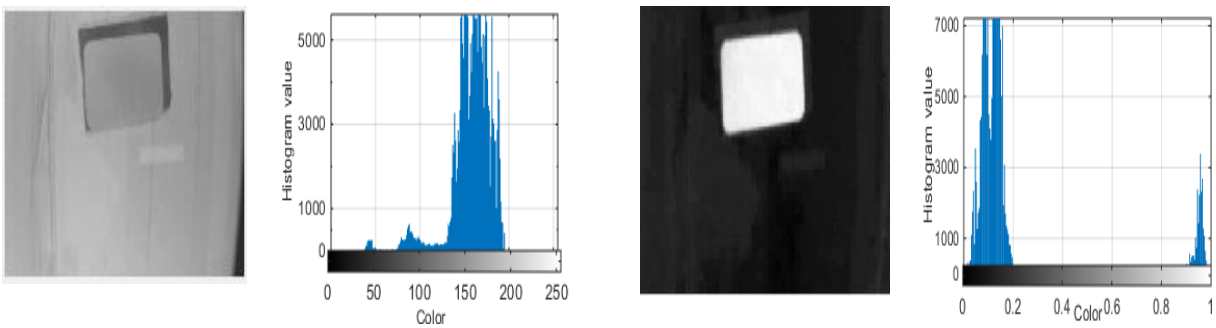


Figure 4.2. The best high difference image

4.3 Segmentation and Counting

The high contrast image of the current frame is segmented by applying Otsu method. For this purpose, a global threshold value *t* should be found to separate the background and foreground regions. The segmented image is defined as

$$S(x,y)=\begin{cases}255 & if\ \ J(x,y)>t\\ 0 & else\end{cases} \tag{4.5}$$

In (4.5), the image is separated into two regions: background (black) and foreground (white). An optimal threshold value should be selected in order to separate two regions. The Otsu method is based on two criteria. The first criterion is that the variation of gray values within each class is minimal. This criterion is provided by minimizing the weighted sum of intra class variance by using (4.6).

$$\sigma_w^2(t)=p_b(t)\sigma_b^2(t)+p_f(t)\sigma_f^2(t) \tag{4.6}$$

In (4.6), $p_b(t)$ and $p_f(t)$ represent the probabilities of background and foreground classes, respectively. The second criterion is based on the maximization of variance between two classes. This calculation is given by (4.7).

$$\sigma_B^2=p_b(\mu_b(t)-\mu)^2+p_f(\mu_f(t)-\mu)^2 \tag{4.7}$$

In (4.7), μ_b, μ_f and μ represent the mean values of background, foreground, and, image, respectively. The optimal threshold can be found by searching all possible values sequentially.

After the image, has been segmented, there may be inaccurate region over the object. Therefore, a morphological operation should be applied to fill holes in the image and eliminate unexpected noises. For this purpose, first false of objects are removed from the image. This operation eliminates isolated pixels of the background region. Afterwards, dilation and erosion operators are applied to the image in order to close the object. This

process closes the holes over the object and destroys false objects in the class of the foreground. Finally, the holes are filled in the close object.

The detection of the object is based on an intensity change of a region. In each frame, the intensity change of a rectangular region is calculated. If the calculated value is bigger than a threshold value, there is an object in this frame. The main problem is that an object remains for several frames. Thus, counting process should be done when the object leaves from the rectangular region. To do this, the rectangular region should be observed for two sequential frames. The four conditions of an object in the window are given in Table 4.1.

Table 4.1. Object detection and counting process

Fi-1	**Fi**	Object Detection
0	0	No object for two sequential frames
0	1	An object enters in Fi
1	0	An object leaves at Fi (Detect and count)
1	1	An object exists for two consecutive frames

In Table 4.1, F_{i-1} and F_i represent the previous and current frame, respectively if there is not any object for two sequential frames.

4.4 Object Classification

After the object, has been detected and counted by applying the segmentation method, some geometrical features are obtained to detect the size of the object in each frame. Geometric features give information about location, orientation, shape, and size of an object in an image. When an object has been detected, the boundary of this object will be driven Figure 4.3. shows the boundaries of the detected objects.

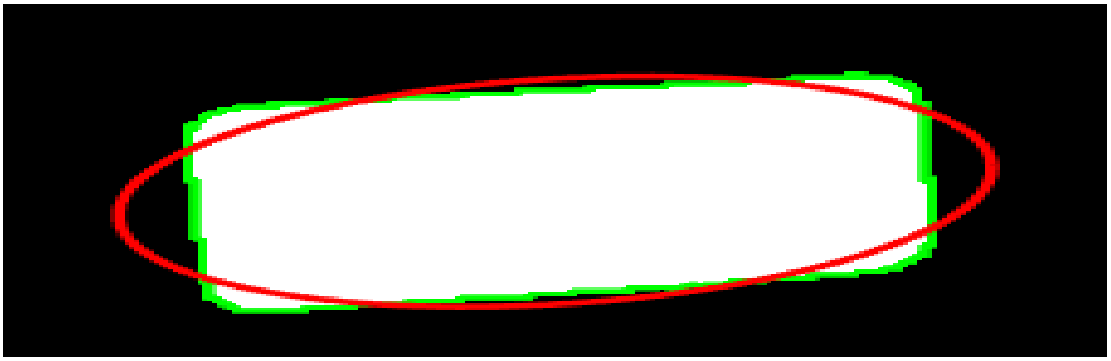


Figure 4.3. Object detection and drawing its boundaries

Some features are extracted from the detected objects in order to classify different objects. For this purpose, an ellipse is placed on the detected object and the features are estimated by using this elliptical shape. The obtained basic features are given in Figure 4.4.

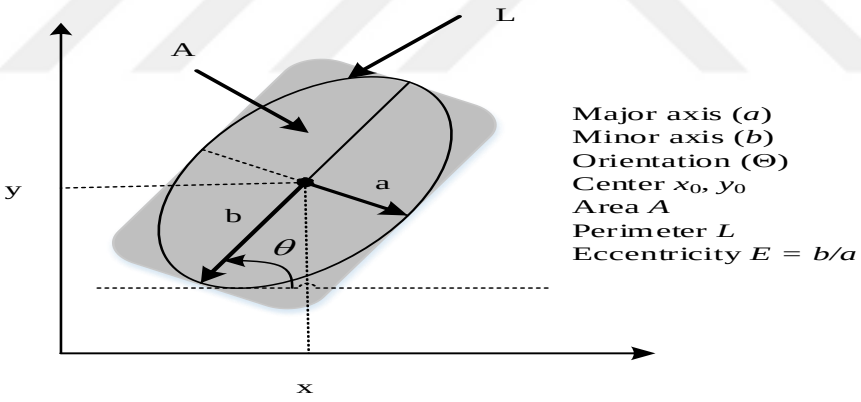


Figure 4.4. The obtained features from the detected object

In Figure 4.4, the major features of the object are extracted. The class of this object is determined according to the obtained features. Geometric features of the detected objects are determined by using the method given in Figure 4.5.

```
for each frame in video do
    I=read(video,frame)
    J=segmment(I)
    for i=1:size(J,1) do
        for j=1:size(J,2) do
            if (J(i,j)==1) do
                xr=[xr i]
                xc=[xc j]
            endif
        endfor
    endfor
    i_m=mean(xr)
    j_m=mean(xc)
    L8=find sum of 8-connected pixels
    L4=find sum of 4-connected pixels
    L = (3*L4+L8)/4
     A=find area of binary object
    roundness = 4*A*pi/L^2
    height     = max(xr)-min(xr)+1
    width      = max(xc)-min(xc)+1
endfor
```

Figure 4.5. The pseudo code of obtaining the geometric features

In Figure 4.5, the calculations of some features are depicted. Firstly, the coordinates of pixels, which belong to the detected object, are acquired in two arrays. Afterwards, gravity center, the area, perimeter, roundness, height and width of the objects are calculated. These features are used to classify the binary object.

4.5 Experimental Results

The proposed method was tested on two videos that were taken from a production line. The verification of the proposed method was made by two videos. Each video was taken from a high speed industrial camera. The main features of the camera are given in Table 4.2.

Table 4.2. The characteristics of the camera used in quality control system

Feature	Value
Resolution	1280x720 px
Frame rate	59 fps
Shutter type	Global
Sensor type	CCD
Mono/Colour	Color
Interface	GigE
Pixel bit depth	12 bits

In the proposed method, first they obtained colour image is converted to a high contrast image. This image is very useful to obtain a threshold value for segmentation. Some examples of the high contrast frame are given in Figure 4.6.

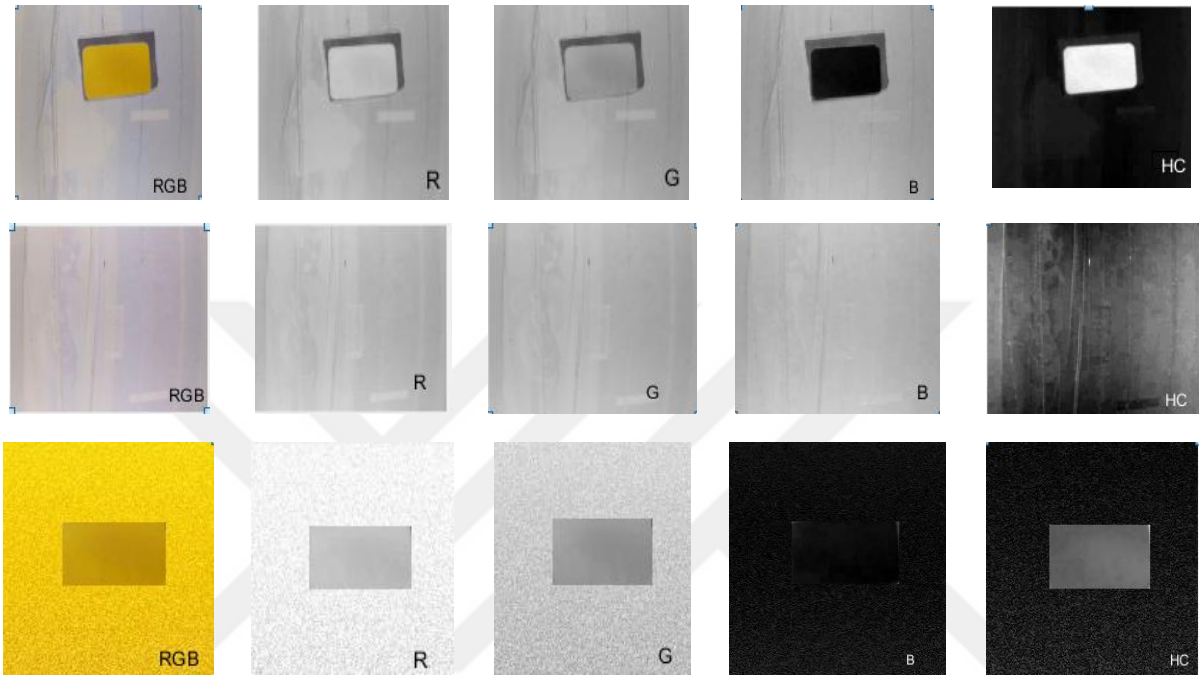


Figure 4.6. The image, its components (R, G, and B) and high contrast image (HC)

In Figure 4.7, the first row shows the image components and corresponding high contrast image for the current frame when an object enters into the scene. As shown in this row, blue component of the image is useful to separate the background and object. However, this component fails when the background and object have similar colour tone. This condition occurs in row 3. The high contrast image does not significantly change when there is not any object in the scene as seen in row 2. After the high contrast image, has been obtained, the segmentation process should be applied to the transformed image to obtain the threshold value. Figure 4.7. shows the histograms and segmented images of grayscale and high contrast images.

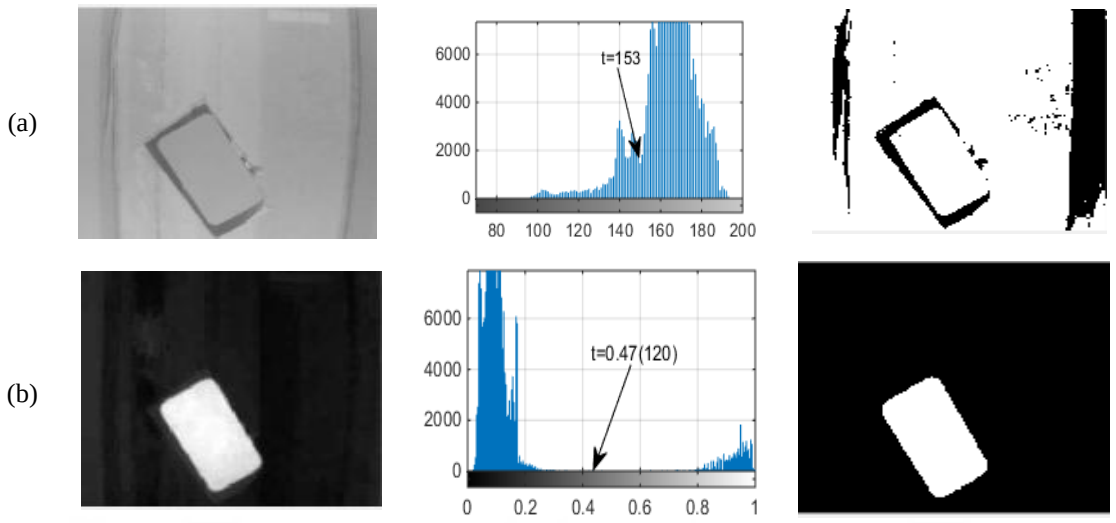


Figure 4.7. The histogram and segmentation results of two images (a) Grayscale image (b) Highcontrastimage

As shown in Figure 4.7, the histogram of the high contrast image is very useful to separate the object and background. When the grayscale image has been used, the segmentation process fails to separate object and background. The segmentation process is applied to the scene that has an object and this process is only applied once to determine the threshold value. If the scene has not any object, the pixels of the high contrast image are similar to each other. Therefore, the segmentation process fails. To solve this situation, if the number of white pixels in the segmented image exceeds a threshold value, there is no any object in the image. Thus, all pixels of the segmented image are set to black. The determination of the threshold value is made as offline. After the threshold value, has been obtained, this value is used to segment the current frame. The counting process is made according to the condition occurred in Table 4.1. Counting process is shown in Figure 4.8.

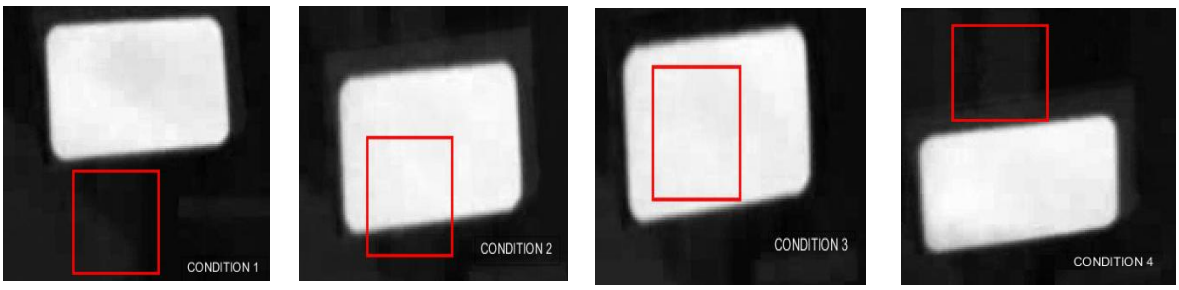


Figure 4.8. The counting process of an object

In Figure 4.8, the counting process is depicted. If there is not any object in the determined window for current and previous frames, the condition 1 will occur. If there is an object in the current frame and it does not exist previous frame the condition 2 will occur. If there is an object in two sequential frames, condition 3 will occur. If there is an object in the previous frame and it does not exist in the current frame, the counting process will be activated. After an object is counted, the size and other features of the related object will be obtained. If an object is detected, the boundary of the detected object will be drawn and its size and other features will be saved. Some example of the object detection and boundary drawing are given in Figure 4.9.

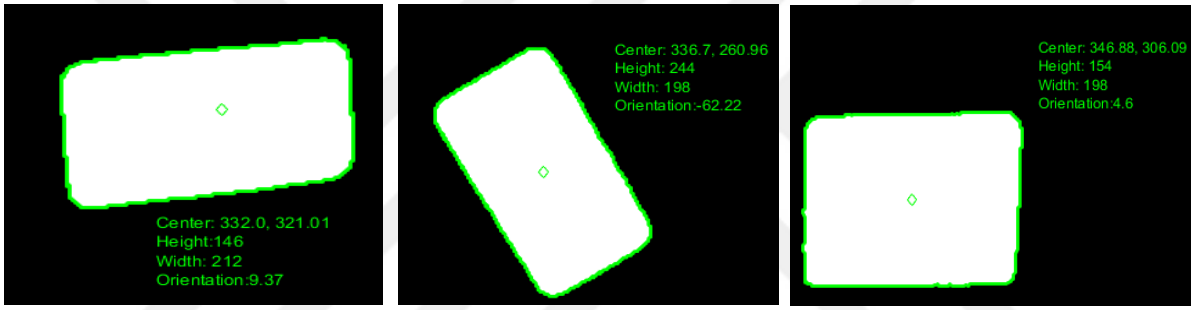


Figure 4.9. Measuring the size of the detected object

In Figure 4.9, the size, gravity center, and orientation of each object are calculated. The knowledge can be used to control and classify the size of the product. The performance of our method is based on sensitivity calculation. This calculation is given in (4.8).

$$S_n = \frac{TP}{TP + FN} \tag{4.8}$$

Table 4.3. The performance comparisons

The method	Sensitivity	Time (ms)
GMM	85.3+6.9	103.9±3.9
SIFT	84.6+5.3	105.4±2.6
SURF	87.7+4.5	96±4.1
MSER	76.6+2.3	108±4.2
Our Method	96.33±1.5	71.3±4.8

As shown in Table 4.3, the proposed method gives better result than SIFT, SURF, MSER and GMM. The proposed method accurately detects objects. The noise sensitivity is better than SIFT, SURF, MSER and GMM.

5. CONCLUSIONS

In this thesis, a new method has been proposed to detect moving objects. The proposed method converts a colour image into a high contrast image. Afterwards, a threshold value is determined in order to separate the object and background by using the Otsu method. In the testing stage, an image is converted into a high contrast image and the object and background are separated by using the threshold value. After the object, has been detected, the size and other geometric features are obtained for each object. The proposed method is robust and gives good results when compared to GMM. Also, an interactive segmentation based method is proposed for quality control. The user selects two scribbles for modeling the background and objects. Afterwards, the roundness of each object is calculated by using the area and perimeter of each object. Objects whose roundness are above a certain threshold are counted and the missing objects are detected. The proposed method is also fast and seven frames can be processed during one second. The correctness of the proposed method is experimentally proven. In any case, later we took note of that in the GMM method, the quantity of classes will diminish to genuine classes of image. At long last, GMM algorithm is a direct, so our strategy is reasonable for basic images.

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