UNIVERSITY OF GAZİANTEP
GRADUATE SCHOOL OF
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VIDEO ANOMALY DETECTION USING MORPHOLOGICAL PROCESSES

M. Sc. THESIS
IN
ELECTRICAL-ELECTRONICS ENGINEERING

BY
ABDÜLKADİR GÜMÜŞÇÜ

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M.Sc. Thesis
in
Electrical-Electronics Engineering
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Supervisor
Prof. Dr. Ergun ERÇELEBİ

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This is to certify that we have read this thesis and that in our consensus/majority opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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Abdülkadir GÜMÜŞÇÜ

ABSTRACT

VIDEO ANOMALY DETECTION USING MORPHOLOGICAL PROCESSES

GÜMÜŞÇÜ, Abdülkadir
M.Sc. in Electrical and Electronics Eng.
Supervisor: Prof.Dr. Ergun ERÇELEBİ
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One of the most important security problems in public places is an abandoned package. It is not practical method that security person is watching security cameras video in order to detect abandoned package. For this aim when public security becomes most important, abandoned package that threatening public security detection system is proposed in this thesis. The proposed method is based on video backgrounds. Objects added on current background are detected by comparing consecutive backgrounds. In proposed method, morphological processes are utilized for reducing noise.

Keywords: Detection Abandoned Package, Mathematical Morphology, Background Estimation

ÖZET

MORFOLOJİK İŞLEMLER KULLANARAK VIDEO ANOMALI TESPİTİ

GÜMÜŞÇÜ, Abdülkadir

Yüksek Lisans Tezi, Elektrik ve Elektronik Müh.

Tez Yöneticisi: Prof.Dr. Ergun ERÇELEBİ

Ağustos 2012, 66 sayfa

Halka açık yerlerde en önemli güvenlik sorunlarından birisi ise terk edilmiş paketlerdir. Terk edilmiş paketlerin belirlenmesi amacı ile ortamların güvenlik güçlerince izlenmesi pek pratik bir yöntem değildir. İşte bu amaçla bu tezde toplum güvenliği kavramının öneminin arttığı günümüzde, toplum güvenliğini tehdit eden şüpheli paketlerin tespiti ile ilgili problem ele alınmıştır. Önerilen yöntem video görüntülerinin arka planlarına dayanmaktadır Arka planlar kıyaslanarak arka plana eklenen nesneler tespit ediliyor. Önerilen yöntemde arka plan çıkarımı yapılırken oluşan gürültüleri azaltmak ve daha net sonuçlar alabilmek için morfolojik işlemler uygulanmıştır.

Anahtar Kelimeler: Terkedilmiş Paket Tespiti, Matematiksel Morfoloji, Arkaplan Çıkarımı

To my wife and daugter, who

contributed to my life with their lovely

supports and encouragements.

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NOMENCLATURE

F	Image Matrix
(x,y)	Coordinates of discrete matrix F
f(x,y)	Value of matrix F at point (x,y)
A	Binary set
B	Structuring element
$a \in A$	*a* is a set member of *A*
$a \notin A$	*a* is not a set member of *A*
$(A)_z$	*A* is translated by an amount of *z*
$\hat{B}$	Reflection of set *B*
$\oplus$	Dilation
Θ	Erosion
A^c	Complement of *A*
$\subset$	Subset
$\varnothing$	Empty set
$\neq$	Not equal
$\circ$	Opening
$\bullet$	Closing
max	Maximum operator
min	Minimum operator
T	Threshold value

CHAPTER I
INTRODUCTION

The main goal of this thesis was to make efficient and different research about video anomaly identification. In this section, some background topics are described.

Security systems are in great demand to safe guard human lives and property. Video surveillance is one of the fastest growing sectors in the software market. The projections of the compounded annual growth of this segment are 23%. The most important features of the video surveillance system are that it must be robust and intelligent.

The first generation of video-based systems consisted of CCTV systems which had a number of cameras connected to monitors through automated switches. Second generation systems consists of robust detection and tracking algorithms which constructs models of people's appearance in order to detect and track groups of people as well as monitor their behaviors . The third generation however, consisted of distributed and heterogeneous surveillance systems for wide area surveillance [1].

Millions of video surveillance cameras tracking our every move just about everywhere in the world. Video camera networks are ubiquitous. Over 30 milion cameras produce close to 4 bilion hours of video footage per week in the United States alone. [2].

With video surveilllance systems increase storage become big issue in video surveillance. The latest data from International Management Systems (IMS) Research forecasts the world market for video surveillance storage is that it will exceed US$5.6 billion in 2013. [3]. This cost is huge.

One of the most important security problems in public places is abandoned packages. When there is a suspicious event in camera vision, camera is going on recording video and in some cases, human supervision is not enough to detect and identify suspicious objects in security video. Therefore with processing video, video surveillance systems alerts automatically.

1.1 Problem Description

With the increasing demands for security and safety, vision-based surveillance technologies have received more and more attention. Practical surveillance systems deployed today are not yet capable of autonomous analysis of complex events in the field of view of cameras. This is a serious deficiency as video feeds from millions of surveillance cameras worldwide are not analyzed in real time and thus cannot help with abandoned package, accident, crime or terrorism prevention, and mitigation, issues critical to the contemporary society. In some cases, human supervision is not enough to detect and identify suspicious objects abounded at an unusual location for an extended period of time therefore we face the need to exploit new autonomous video analysis methods to protect public areas and natural infrastructures. Unlike human supervision, computer systems that is detecting anomalies automatically can help to protect public from abandoned package, accident, crime or terrorism prevention, and mitigation.

In this thesis we proposed a new method for video anomlay detection. The proposed method is based on video backgrounds. Object added on current background are detected by comparing past consecutive backgrounds. The proposed method was evaluated by exploitting i-lids video library where two different scenes exit. First scene is related to wrong parking detection whereas second one is dealing with detection of suspicious package. For both scenes there are three difficulty level. Figure 1.1 shows a part of detecting suspicious package scene.

Figure 1.1 Sample Scene of i-lids

1.2 Thesis Structure

This thesis is organized as follows: Section 2 describes all the related work done in video anomaly identification. In the section 3, video anomaly and enhancement are given in details. Section 4 presents the proposed method. In the section 5, the proposed method is compared with related works. Finally in the section 6, future works are discussed.

CHAPTER II

LITERATURE SURVEY

This part gives just an idea of all the research during this last ten years to resolve this complicated problem which is detect anomaly.

In recent years, many research has been done to design systems that automatically detect abandoned objects in public areas. Some of algorithms have been proposed to solve this problem. Benezeth et al. [4] has been designed a system that can detect abnormal events based on spatio-temporal co-occurences. The system has been tested on a lot of abnormal events. But abnormal events have been selected very comfortable to detect abandoned package. Video scenario has been selected very basic.

Lin and Wang [5] has been proposed a method that is based on the gaussian mixture model. Like Benezeth et al. [4], Lin and Wang [5] has been applied their algorithm to basic video database. Unlike real world, There are only a man and abandoning package. Like our proposed method, Lin and Wang [5] has been proposed algorithm that based on backgrounds. They have been estimated background by gaussian mixture model.

Lim and Davis [6] has been proposed abadoned package detection system that based on color properties of abandoned package using Hausdorff distance and simple quadratic histogram similartiy measure. This method has been applied to real world surveillance and result is effectively. Lim and Davis have been added to system Hausdorff distance and quadratic histogram similarity measure.

Bhargava et al. [7] has been designed a system that can detect abnormal events. His proposed method is based on background. In this method they has been proposed method that firstly searching bags. After found bag, next step is looking for bag's neighbour pixel for find human near bag. Eccentricity, orientation and size are classifier for decide that object is bag or not. Like our proposed method. Bhargava et al. [7] has been applied their method on i-LIDS video database and results are succesful.

Our proposed method has morphological processes in addition to Bhargava et al. [7] method.

Smith et al. [8] has proposed abadoned package detection technique that based on tracking objects. In this method, Smith et al. has selected luggage that doesn't move and is smaller than people criterias for decide to object is bag or not. In many researchers that works on detecting abandoned package should select bag criteria.

Many research is based on detection of people carrying objects. Haritaoglu et al. [9] has been presented method detecting people who carry objects.

Beynon et al. [10] has proposed method that detects abandoned packages in a multi-camera video surveillance system. This method is more stabile than one camera video surveillance systems. Because sometimes abandoned package can't be seen with one camera vision. Therefore alert time has increased. This method is based on background subtraction.

CHAPTER III
VIDEO ANOMALY AND ENHANCEMENT

3.1 Video Anomaly

Anomalies are patterns in data that do not conform to a well defined notion of normal behavior. Video anomaly is anomaly that in video sequence. Illegal U-turn, abandoned objects e.g. are video anomalies. Figure 3.1 shows suspicious package example. In figure 3.1(a), a man who is carrying luggage, is abandoning package. In figure 3.1(b) and figure 3.1(c), the man is leaving from security camera vision. In figure 3.1(d), There is only abandoned package in security camera vision.

a) b) c) d)

Figure 3.1 Example of suspicious package

3.1.1 Usage of Video Anomaly Detection Systems

World population and number of metropolis cities increased at last years. Like World population, terorist attacks increased. So global security become more of an issue. There are many security camera in metropolis cities. They are not smart device. Many researchers are working to develop public security cameras to smart cameras. In this thesis, we proposed a new method for detecting suspicious package. Public security cameras can change to smart devices with this development.

3.2 Video Enhancement

3.2.1 Digital Image

Digital image is a integer value matrix that every pixel are determined with integer value. Each distinct coordinate in an image is called a pixel, which is short of "picture element". The nature of the output of for each pixel is dependent on the type of image. Most images are the result of measuring a specific physical phenomenon, such as light, heat, distance, or energy. The measurement could take any numerical form. Digital image usually is digitized from camera or picture. Physically when someone pushs shutter button, camera is generating voltage for each pixels via sensors. After that camera converting pixel's analog value to digital value. For digitize image we must execute some process such as sampling and quantization of continous data. Block diagram that in figure 3.2 shows how to generate digital image step by step.

Figure 3.2 Generating Digital Image Process

Sampling is a process that select interval for taking sample. This process work with a sampling frequency. For digital image sampling frequency determines image resolution. Figure 3.3 shows that how changing image quality with resolution.

Figure 3.3 Images with different resolutions

For storage purposes, pixel values need to be quantized. Quantization is a process that converts analog values of intensity into discrete values. The discrete value is stored in bits. Quantization quality is bit's number. Figure 3.4 shows how quality is changing with bit's number.

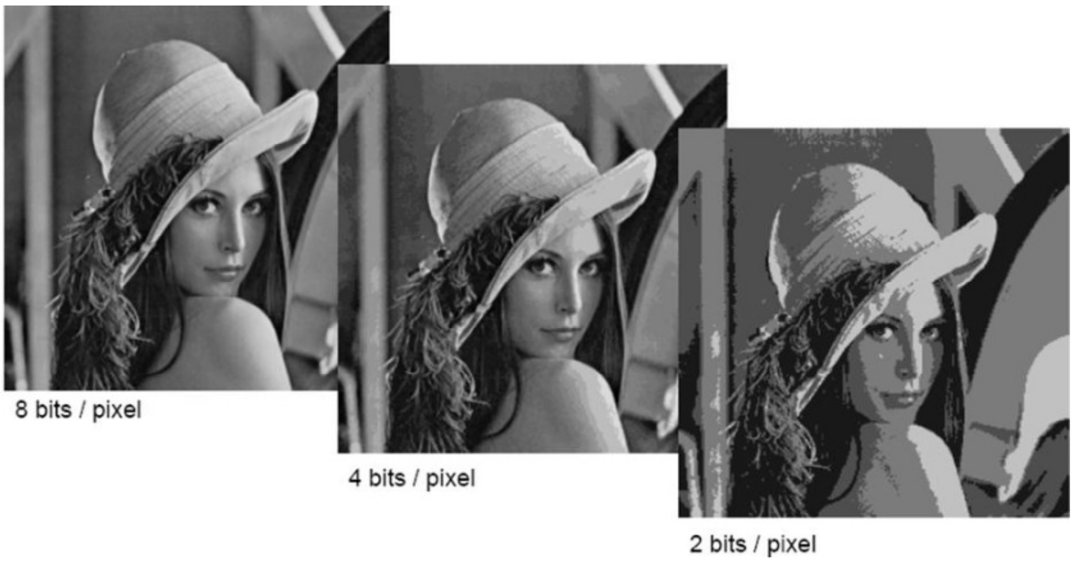


Figure 3.4 Images with different bits/pixel

Every sample of digitized image is referred to as pixel. Digitized image is represented as a discrete matrix I

$$I = \{I(x,y) \mid x = 0,\ldots..N-1,\ y = 0,\ldots\ldots M-1\} \quad (3.1)$$

where N is the total number of rows and M is the number of columns. An image matrix is shown in figure 3.5. Image matrix's elements can't take on negative value.

	0!	1!	.!	.!	.!	.!	M&2!	M&1!
0!	I(0,0)!	I(0,1)!	.!	.!	.!	.!	I(0,M&2)!	I(0,M&1)!
1!	I(1,0)!	I(1,1)!	.!	.!	.!	.!	I(1,M&2)!	I(1,M&1)!
.!	.!	.!	.!	.!	.!	.!	.!	.!
.!	.!	.!	.!	.!	.!	.!	.!	.!
.!	.!	.!	.!	.!	.!	.!	.!	.!
.!	.!	.!	.!	.!	.!	.!	.!	.!
N&2!	I(N&2,0)!	I(N&2,1)!	.!	.!	.!	.!	I(N&2,M&2)!	I(N&2,M&1)!
N&1!	I(N&1,0)!	I(N&1,1)!	.!	.!	.!	.!	I(N&1,M&2)!	I(N&1,M&1)!

Figure 3.5 Image matrix

In digital image processing, four different images such as binary, gray-level, RGB and indexed are considered.

3.2.1.1 Binary Image

Binary image can take on either binary values, 0 or 1. Therefore, binary images can have two colour white and black. "1" contains all frequency bands therefore described with white. "0" contains none frequency band therefore described with black. Figure 3.6 shows that example of binary image.

Figure 3.6 Binary Image

Thresholding generates binary images from gray-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one. If g(x, y) is a thresholded version of f(x, y) at some global threshold T,

$g(x,y) = 1, \text{ if } f(x,y) \geq T$ (3.2)

$g(x,y) = 0$ otherwise

3.2.1.2 Gray-level Image

A greyscale image measures light intensity only. All colours of gray-level image are between white and black. Each pixel is a scalar proportional to the brightness. The minimum brightness is called black, and the maximum brightness is called white. A typical example is given in Figure 3.7. Assume that we can describe one pixel with 8 bit. Therefore, pixels can get value 0 and 255. 255 is white in this gray level image. 0 is black in this gray-level image. Other values are other colour tones between white and black. If quantization bit number increases, gray level images quality increase. Because we can describe our pixel more bits and we can generate new gray levels. Many common greyscale images use 8 bits per pixel, giving 256 distinct grey levels. This is a rough bound on the number of different intensities the human visual system is able to discern.

Figure 3.7 Gray Level Image

3.2.1.3 RGB Image

The RGB (Red, Green, Blue) space is used most frequently in computer graphics and image processing applications. A color in this space is represented by a triplet of values typically between zero and one and is usually scaled by 255 for an 8-bit representation. RGB images have three same dimension matrice. A color pixel can be described with Red, Green, Blue. Base colours have different image matrice. Other colours can describe with compositon of this three base colours For example, yellow can describe with red and green colours. Figure 3.8 show how to present RGB images with matrice. Figure 3.9 shows RGB image. Like gray level image RGB image's quality depends on quantization. If quantization bit number increases, RGB images quality will also increase.

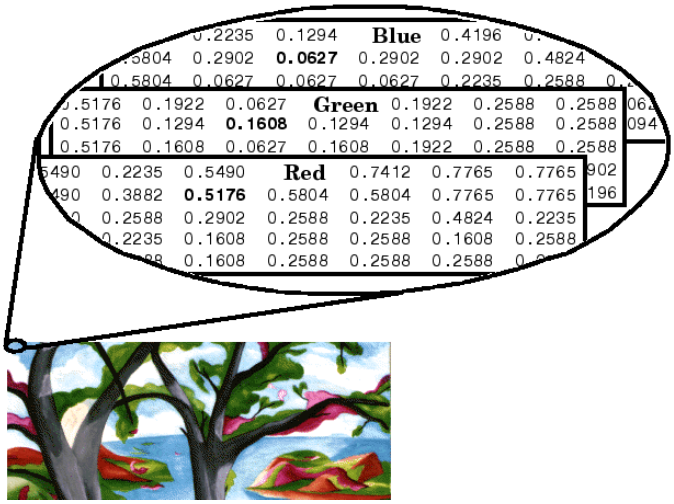


Figure 3.8 Presentation of RGB Images

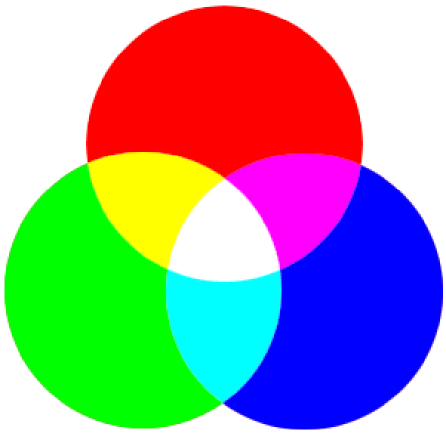


Figure 3.9 RGB Image

3.2.1.4 Indexed Image

Indexed images can be described with two matrice. First matrix is image matrix which contains all pixel values . Second matrix is index matrix that contains all colour values. First matrix describes pixel value that corresponding to row number in index matrix. For example third row describes white and we have 3 value at image matrix. This matrix describes in image white colour. Figure 3.10 shows example for indexed image.

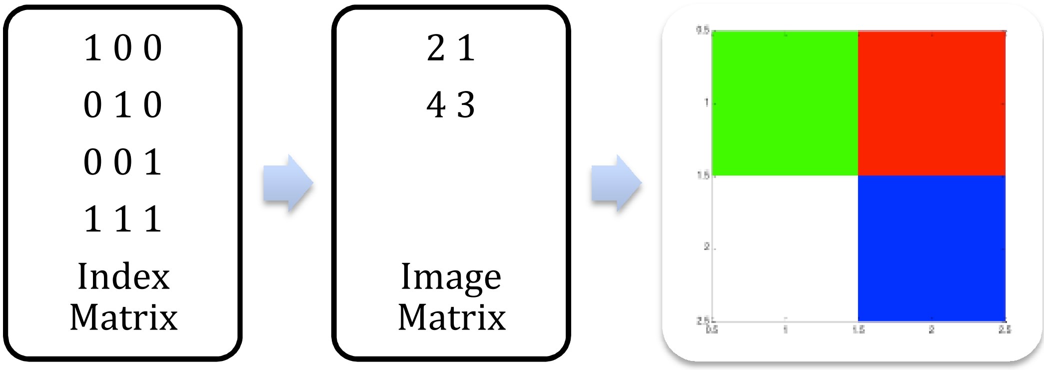


Figure 3.10 Indexed Image

3.2.2 Digital Video

Video that is sequence of digital images, quality depends on frame rate. For example, 40 frame/second is more quailty than 30 frame/second. Before process video we should mention about a few notion.

- Frame
- Shot
- Scene

3.2.2.1 Frame

Video is generated by images and every image is named as frame. When the moving picture is displayed, each frame is flashed on a screen for a short time (1/25 second, 1/30 second). Figure 3.11 shows video frame.

Figure 3.11 Frame

Frame frequency or frame rate expressed in frames per second, shows quality factor. Frame rate describe that how many frame is going on one second. This data is not convenient to process. The video datas that are considered in this thesis have 720*576 resolution and 25 frame rate. In this situtation, our processor must process 720*576*25 data in a second. If you work on video and real time application, video frame rate must be descreased. Because CPU or GPU can not process this huge data. Therefore in many aplication programmer is decreasing resolution or frame rate. In the computer program that we have designed in this thesis, video resolution is reduceed to 360*288 and quantization factor (bits/pixel) is reduceed 7 bits/pixel.

3.2.2.2 Shot

Video shots are important part of frames. When video content changes, coming frame is refered to as key frame. Therefore, frame between two key frames is called as shot. Shots are part of video.

3.2.2.3 Scene

Scene is background of video sequence. We can examine background and foregorund. Background or scene is a video frame that no action. Foreground is video frame having an action. Most academic researchers are going on estimating backgrounds. Background estimation is very crucial step in video anomaly detection. Figure 3.12 shows a scene. If some objects stay on background for a long time. They are considered as background objects.

Figure 3.12 Scene

3.2.3 Morpological Processes

3.2.3.1 Morphology in Image Processing

In general, morphological operators transform an original image into another image through the interaction with the other image of a certain shape and size, which is known as the structuring element. Morphological processes are often used in image processing research areas. These are edge detection, enhancement, segmentation, restoration. Rest of morphological processes are listed in below.

- Erosion process
- Dilation process
- Opening process
- Closing process
- Perimeter process
- The Hit or Miss Transformation

3.2.3.2 Structure Element Morphology

Before explaining basic operations of binary morphologic, structure element must be defined. All morphological processes form with structure element. Figure 3.13 shows example of structure element.

1	1	1
1	1	1
0	0	0

Figure 3.13 Example of Structure Elements

3.2.3.3 Binary Morphology

The theoretical foundation of binary mathematical morphology is the set theory [11].
In this section, Erosion, Dilation, Opening, Closing transformation topics will be mentioned.

3.2.3.3.1 Erosion

Let A and B are sets in $\mathbb{Z}^2$. Erosion of A by B denoted by $A \ominus B$, is defined as

$$A \ominus B = \{z | (B)_z \subseteq A\} \quad (3.3)$$

Erosion of A by B is a set that all points of covered by A of transform sets of B by z. Figure 3.14 depicts erosion process. There is image matrix and structure element matrix. Firstly, structure element is compared with image matrix part that circled element is centered. If all elements of image matrice part that circled element is centered and structure element is same, new circled element value is 1. If all elements of image matrice part that circled element is centered and structure element is not same, new circled element value is 0. At the end of process all new elements are joined and result image matrix is generated. Figure 3.15 shows result of binary image matrix

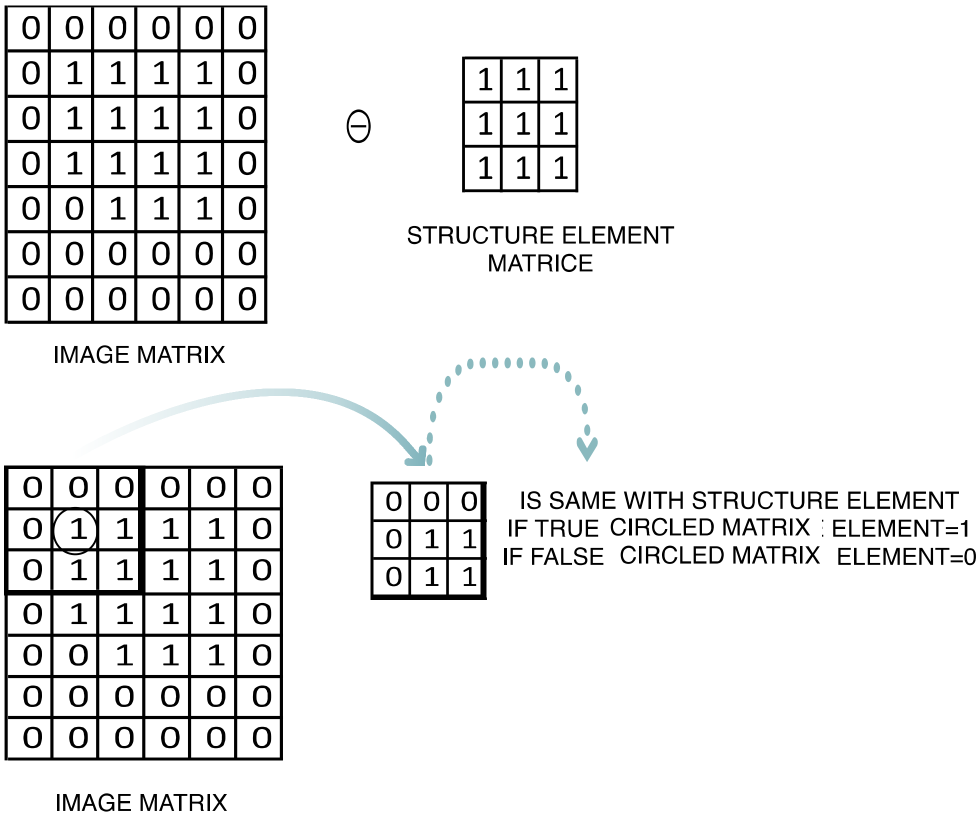


Figure 3.14 Erosion Process

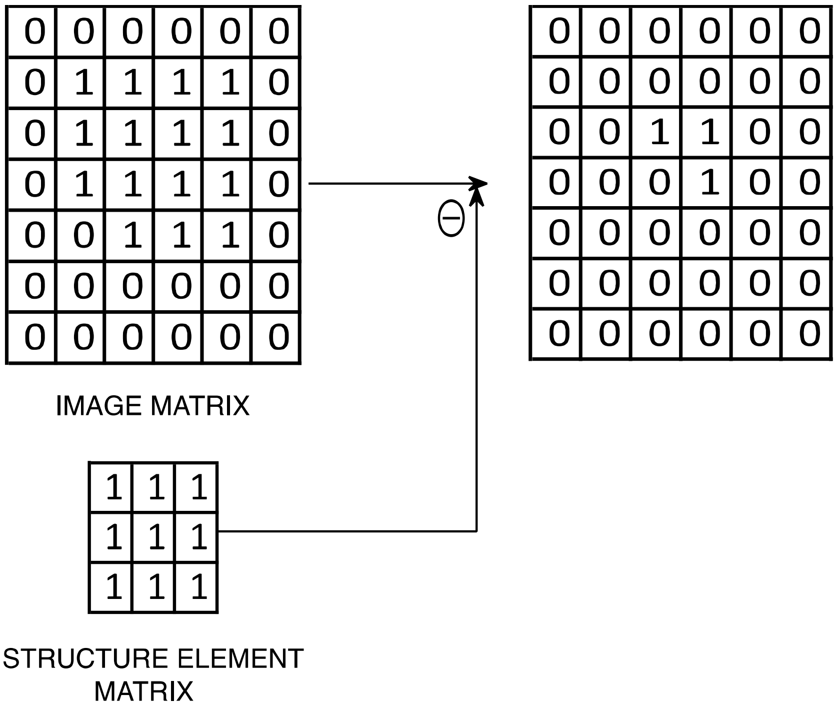
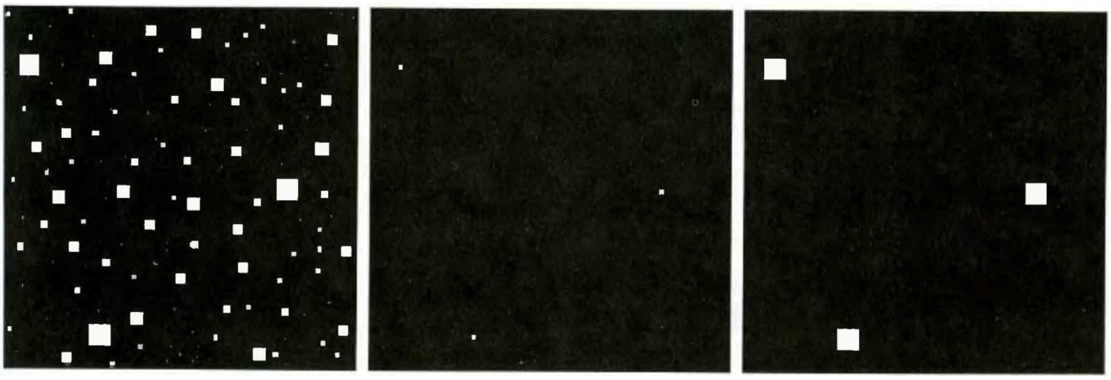


Figure 3.15 Result of Erosion process

Erosion method is used for binary image enhancement. Figure 3.16 shows how erosion method eliminate unwanted points. First image in Figure 3.16 (a) is orjinal image, This image is eroded by structure element that has bigger size than unwanted points. Second image in Figure 3.16 (b) is eroded image. But points that are in second eroded image are smaller than original image. Second image should be dilated for generating orginal size points. In this section structure element should be same size. Because if we determine structure elements size big for dilate. New points will be bigger than points that are in original image matrix. Last image in Figure 3.16 (c) is result of erosion and dilation processes.



(a) (b) (c)

Figure 3.16 Application of Erosion [12]

3.2.3.3.2 Dilation

Dilation is a morphological process that grows objects in a binary image. Growing specific controlled by structure element.

Let A and B are sets in $\mathbb{Z}^2$. Dilation of A by B denoted by $A \oplus B$, is defined as

$$A \oplus B = \{z|(B')_z \cap A \neq \emptyset\} \quad (3.4)$$

where A is image matrix and B is structure matrix.

This equation is based on obtaining reflection of B and conversion the result according to z. In this sense, dilation of A by B, is intersection of reflection of B on A and A. So according to (3.2)

$$A \oplus B = \{z|[(B')_z \cap A] \subseteq A\} \quad (3.5)$$

Like other all morphological process structure element is generally denoted by B.

Figure 3.17 depicts dilation process. There are image matrix and structure element matrix. First process is comparing structure element and image matrix part that circled element is centered. If circled element is '1' ,new 3x3 image part matrix is structure element. If circled element is '0',new 3x3 image part matrix will not change. At the end of process, all new elements are joined and result image matrix is generated. Figure 3.18 shows result of binary image matrix.

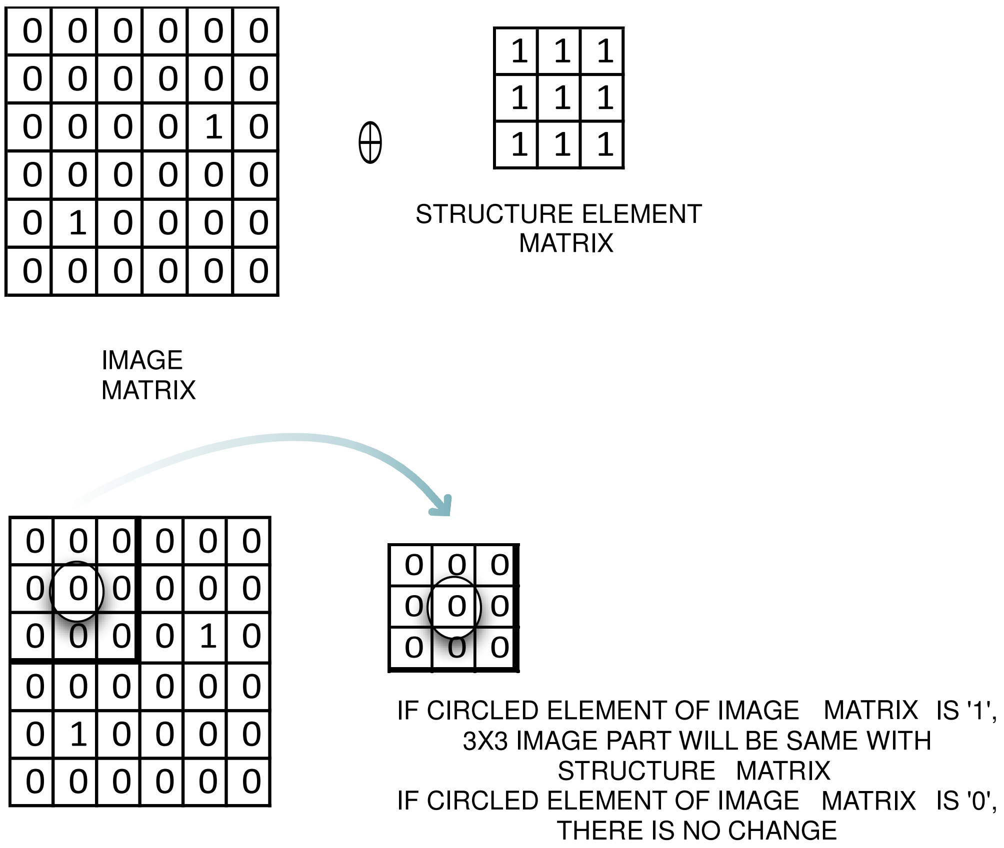


Figure 3.17 Dilation process

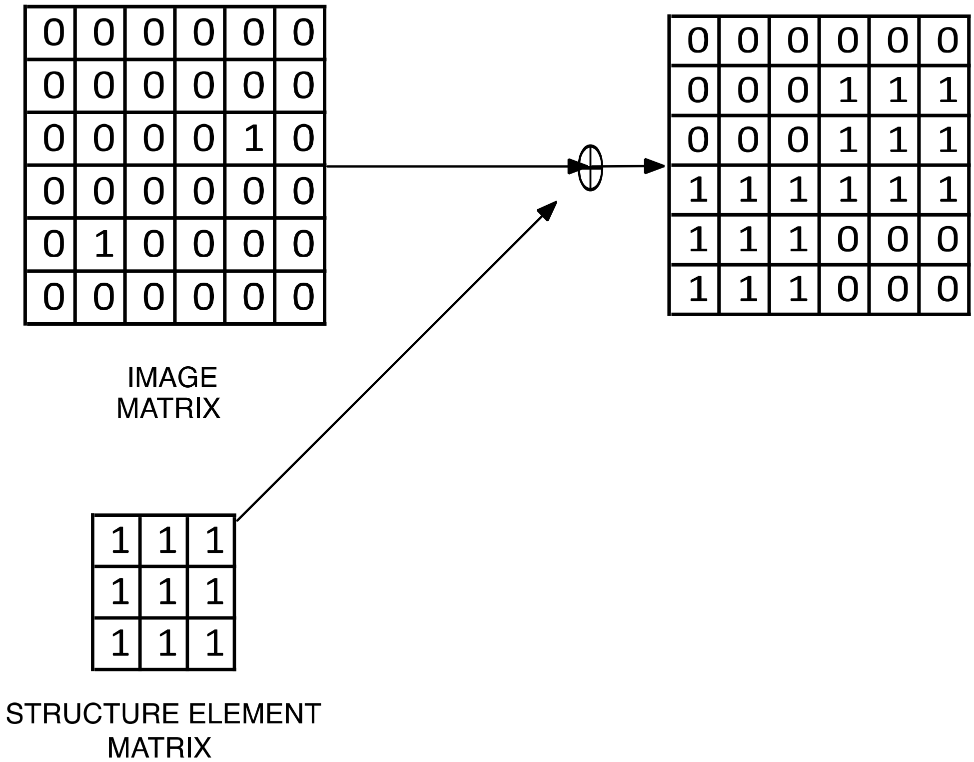


Figure 3.18 Result of Dilation process

Dilation is generally used for fill the blanks. Figure 3.19 and Figure 3.20 show how dilation method fill blanks. Figure 3.19 shows the image before dilation process, this image is dilated by structure element that has bigger size than unwanted points. Figure 3.20 denotes image after dilation process.

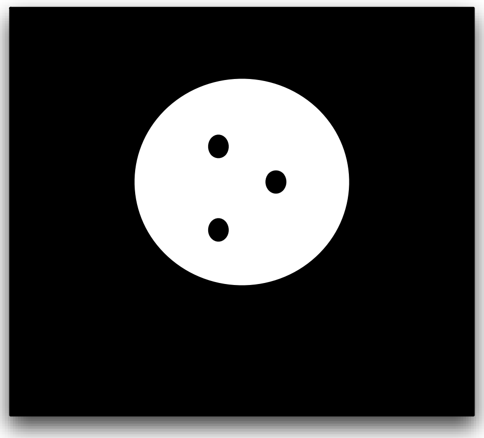


Figure 3.19 Image before dilation

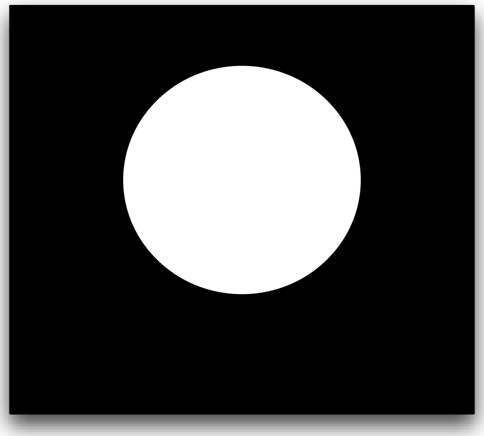


Figure 3.20 Image after dilation

3.2.3.3.3 Opening

As can be seen dilation is growing image and erosion is thining image. In this section other important morphological processes such as opening and closing are mentioned. Opening process softens boundaries, eliminates protrusions. The opening of a binary image A by the structuring element B denoted by $A \circ B$ is defined as;

$$A \circ B = (A \ominus B) \oplus B \quad (3.6)$$

Firstly image matrice A is eroded by structure element matrice B, then result matrice is dilated by B. This processes are named as opening.

In Figure 3.21, opening process is illustrated by geometrical method. Assume that structure element is circle that is in figure 3.20. Opened image matrix A by B is close shape that circle is turned.

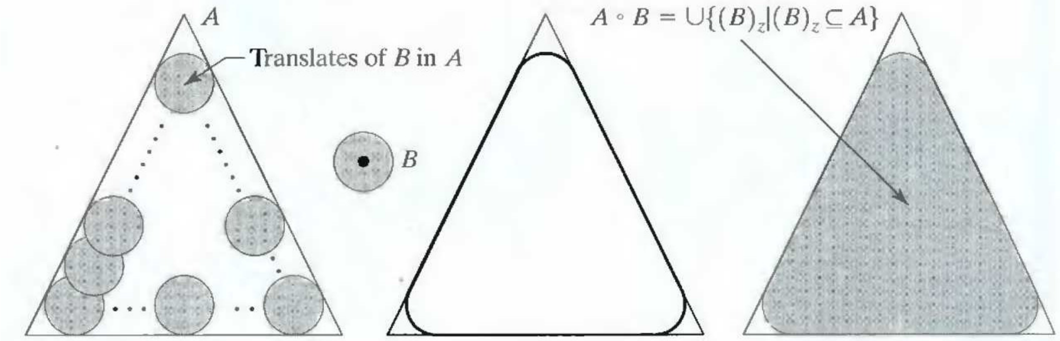


Figure 3.21 Binary Opening Process [12]

Figure 3.22 shows that generating opening process. Firstly, we dilate image matrix A with structure element matrix B, then result image matrix will be eroded with structure element matrix B. All this processes are named as opening. Opening is translation invariant, which is anti-extensive.

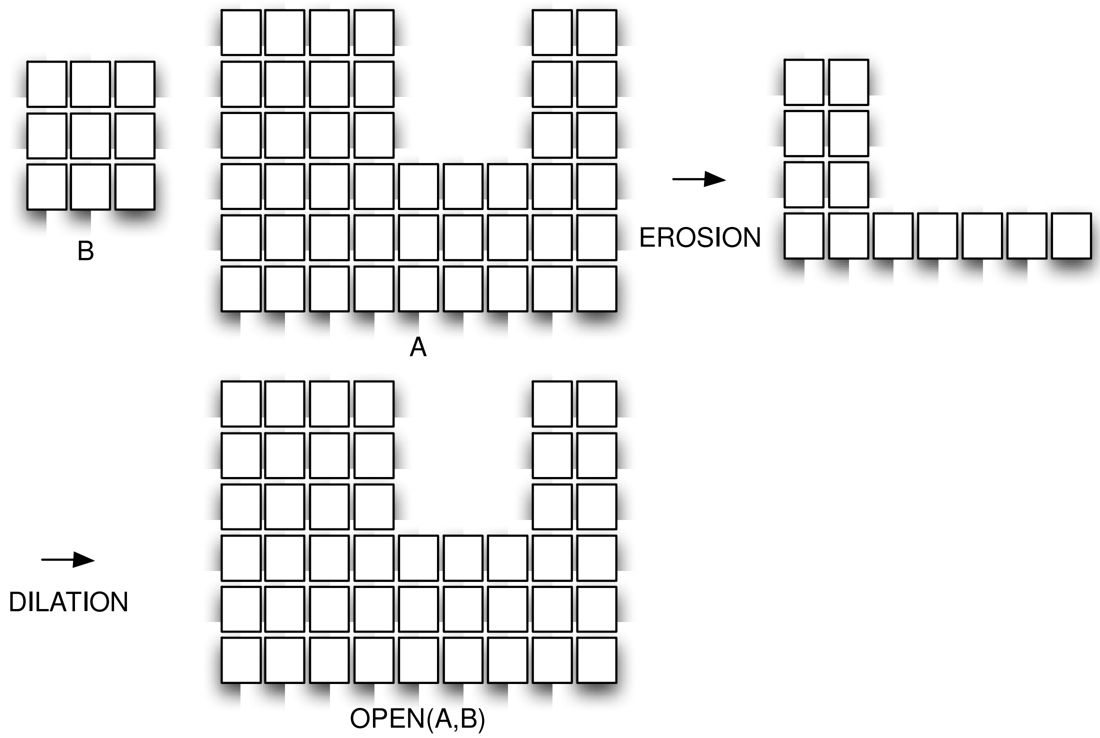


Figure 3.22 Illustration of binary opening process

3.2.3.3.4 Closing

The closing of a binary image A by the structuring element B denoted by $A \cdot B$ is defined as;

$$A \cdot B = (A \oplus B) \ominus B \qquad (3.7)$$

Firstly, image matrix A is dilated by structure element matrix B, then result matrix is eroded by B. This process is named as closing.

In figure 3.23, closing process are illustrated by geometrical method. Assume that structure element is circle that is in figure 3.23. Closed image matrice A by B is close shape that circle is turned.

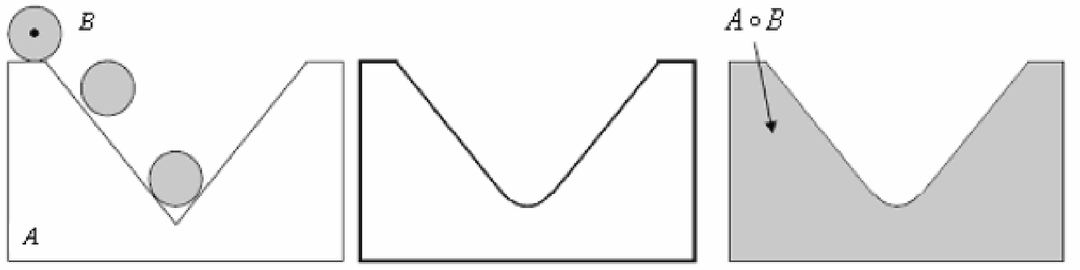


Figure 3.23 Binary closing process [12]

Figure 3.24 shows how closing process is performed. Firstly, image matrix A with structure element matrix B is eroded, then result image matrix will dilate with structure element matrix B. All this processes are named as closing. Opening and closing operations are translation invariant, closing is extensive, opening and closing are duals of each other. Opening and closing processes result only change first application, then if same processes are applicated. There will not no change.

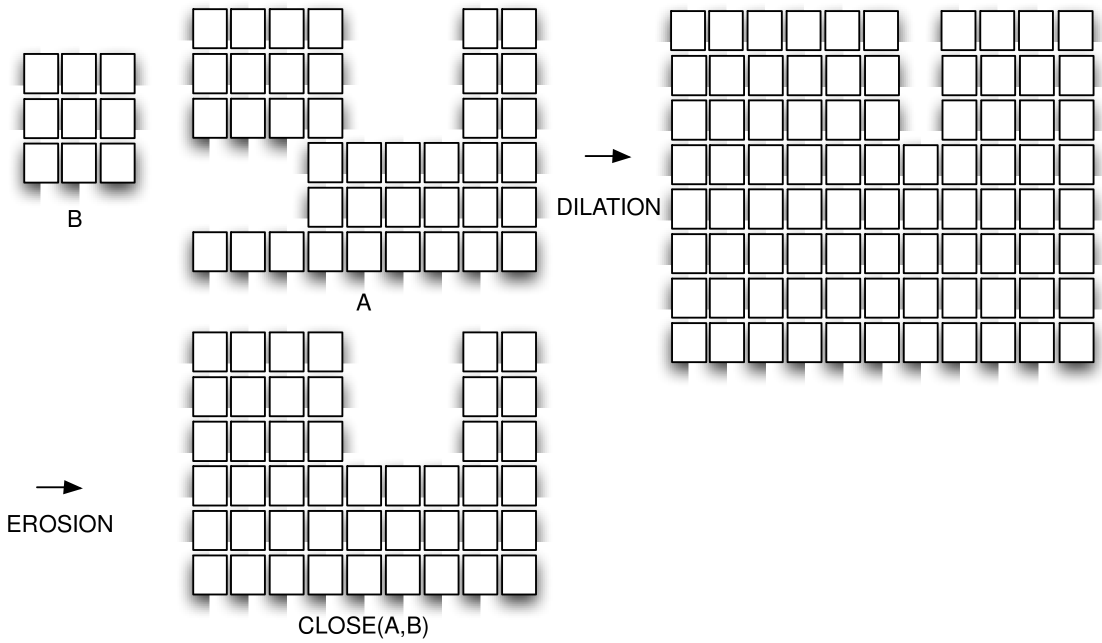


Figure 3.24 Illustration of binary closing process

CHAPTER IV
PROPOSED METHOD

4.1 Introduction

One of the most important security problems in public areas is abandoned packages. Therefore, we have proposed a method to overcome this issue. The proposed consider video backgrounds for video anomaly detection. Objects added on current background are detected by comparing current background with past consecutive backgrounds.

4.2 Background Estimation

Each pixel in the background detection method used in this study is based on background information.

Where f (x, y) is image matrix, g (x, y, n) is image archive matrice and k (x, y) is background image matrice, the background extraction can be expressed in the following equations.

$f(x, y) = n$;

$$g(x, y, n) = g(x, y, n) + 1 \qquad (4.1)$$

$$k(x, y) = max(g(x, y, :)) \qquad (4.2)$$

Figure 4.1 shows the proposed background estimation method. Firstly z array is generated for all pixel. z array is a histogram of pixel values that is in frames of 20 second part for a pixel. Therefore, for every pixel z array is produced. After this operation, pixel value that has maximum probability is selected as a background pixel value.

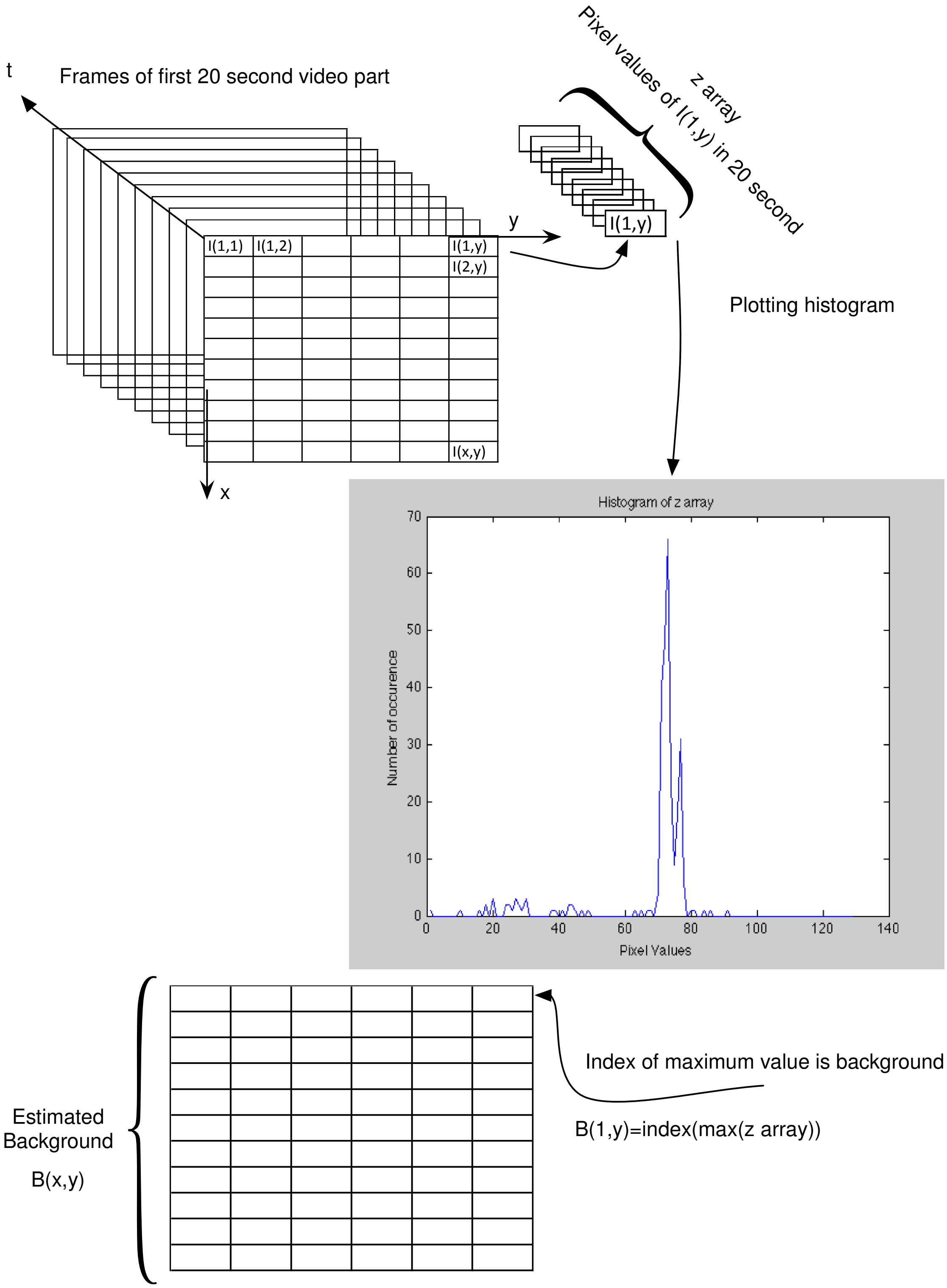


Figure 4.1 Proposed Background Estimation Method

Figure 4.2 Estimated Backgrounds

4.3 Proposed Method

In general, the proposed method is based on difference of two estimated background. Modeling of the background, all pixel intensity values of the frames that received from the camera and these values are compared to the same location is repeated the number of pixel intensity values for the pixels are stored in[13].

Videos that used for testing are taken from i-lids library. i-lids library has three abandoned packages videos easy, normal and difficult. Critical frames are given in appendix a, appendix b and appendix c.

Figure 4.3 shows the proposed method for the determination of an abandoned package. Subtracting current background with past consecutive background is image that describes added objects. Thus, throughout the expected duration of the image have been detected in any part of an object is stopped for a long time. For speed up processes, resolution and quantization factor (bits/pixel) are reduceed two times. Orginally resolution was 720*576 and resolution is reduceed to 360*288. Also orginally quantization factor (bits/pixel) was 8 bits/pixel and this value is reduceed to 7 bits/pixel. For eleminate the background noises morphological processes are used in proposed method. Sequence of morphological operations with the erosion and dilation applications. These two operations are repeatedly applied to an image size of the particles below the image is destroyed.

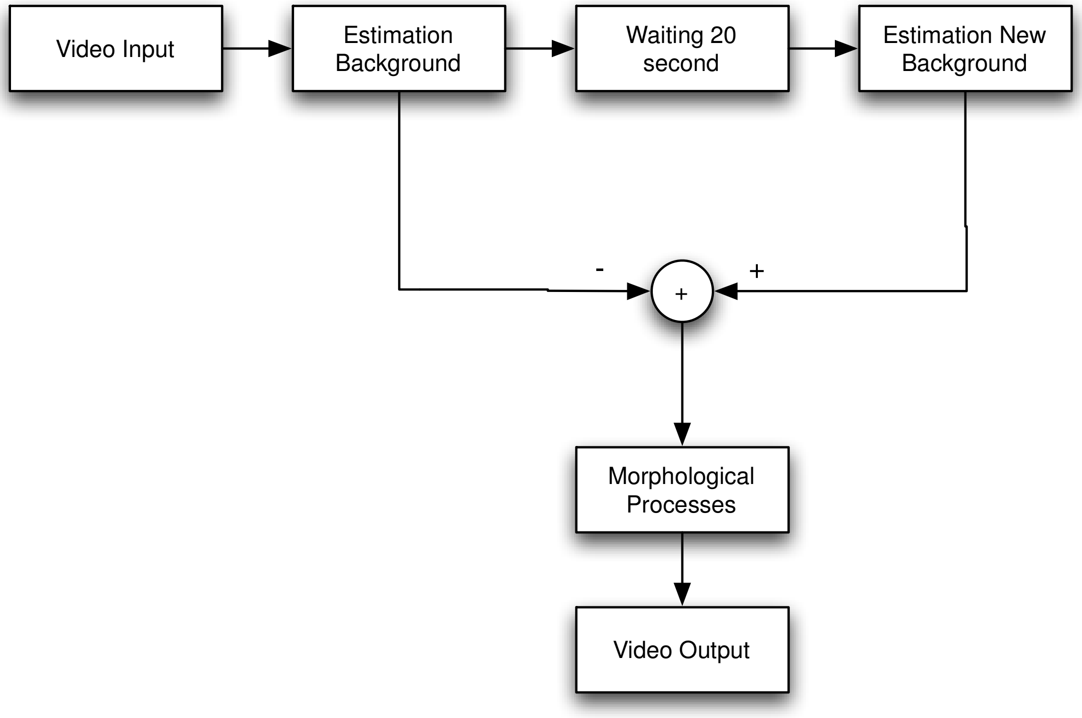


Figure 4.3 Model of Proposed Method

4.4 Experimental Studies

Figure 4.4, 4.5 and 4.6 show critical frames in i-lids easy,medium and hard abandoned package videos, respectively.

Figure 4.4 Critical frames in i-lids easy abandoned package video

Figure 4.5 Critical frames in i-lids medium abandoned package video

Figure 4.6 Critical frames in i-lids hard abandoned package video

Figure 4.7, 4.8, 4.9 denote estimated backgrounds for i-lids easy,medium,hard abandoned package videos, respectively.

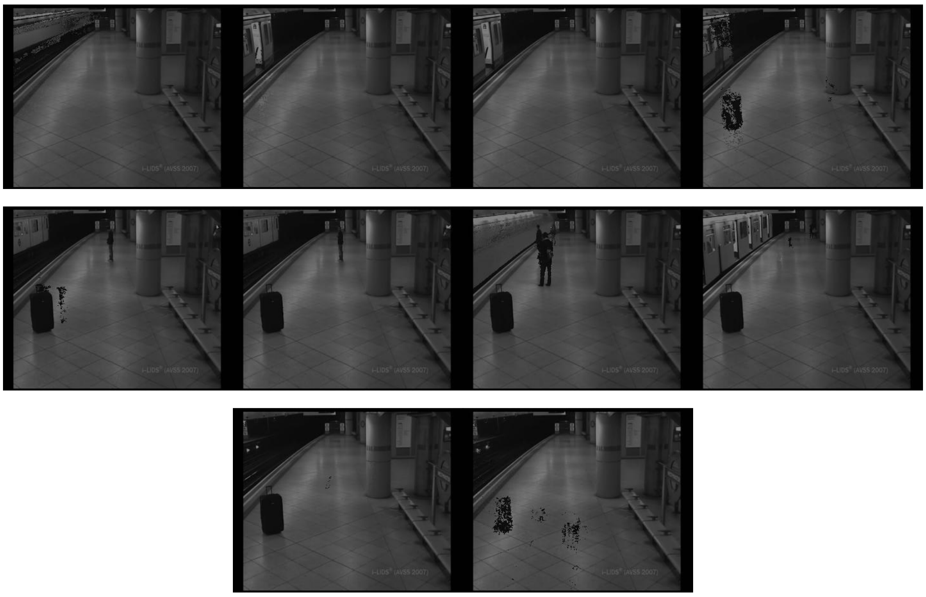
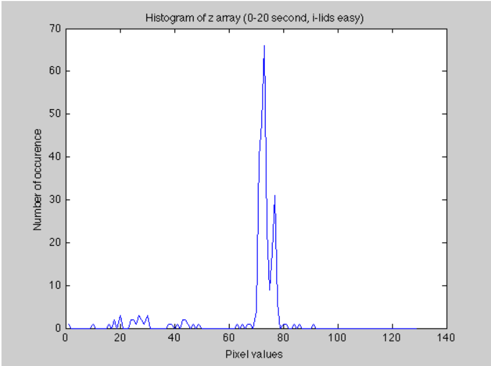


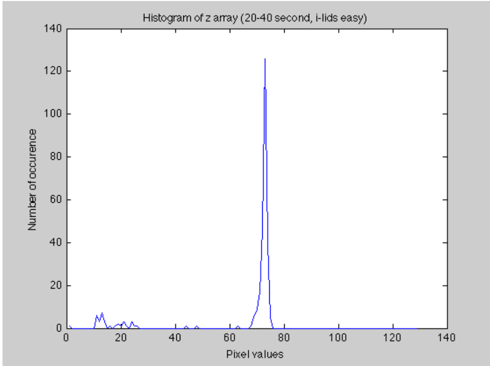
Figure 4.7 Estimated backgrounds in i-lids easy abandoned package video

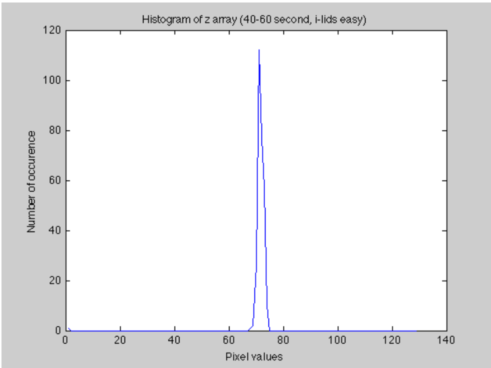
Figure 4.8 Estimated backgrounds in i-lids medium abandoned package video

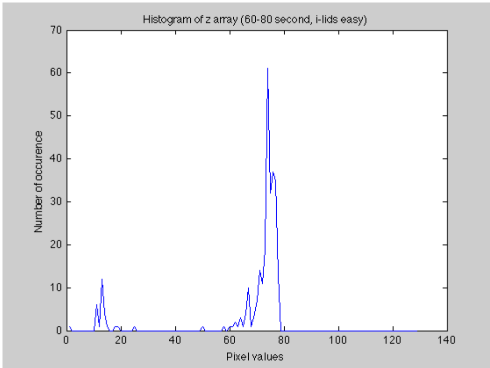
Figure 4.9 Estimated backgrounds in i-lids hard abandoned package video

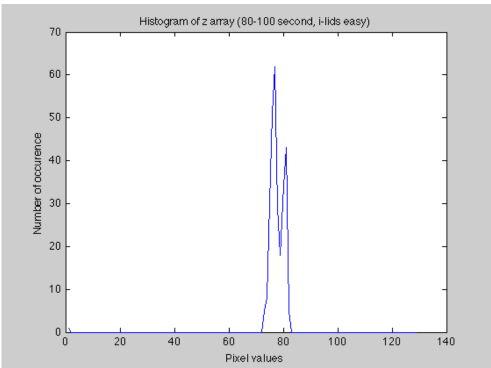
Z array is a histogram of pixel values that is in frames of 20 second part for a pixel.In figure 4.10, 4.11, 4.12 show histograms of z array for I(160,160) pixel.

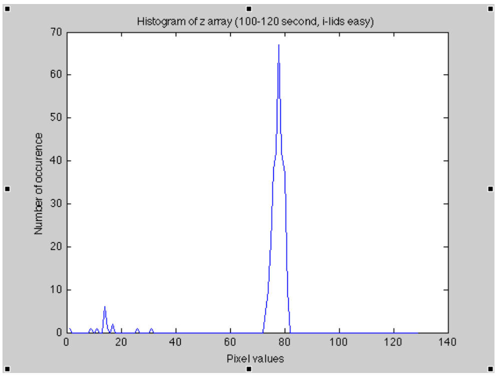

Histogram of z array (0-20 second, i-lids easy)
Number of occurence
Pixel values

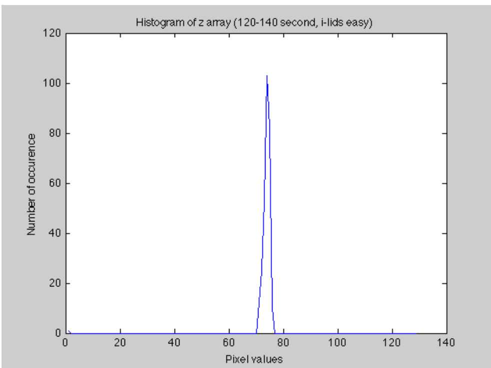

Histogram of z array (20-40 second, i-lids easy)
Number of occurence
Pixel values

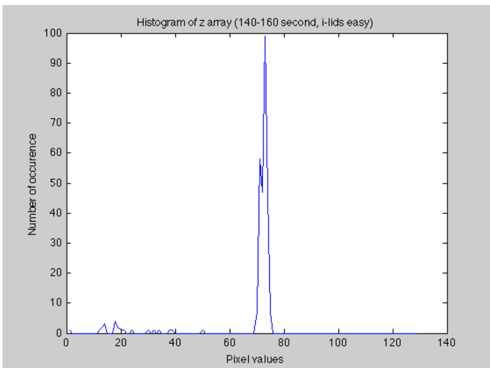

Histogram of z array (40-60 second, i-lids easy)
Number of occurence
Pixel values


Histogram of z array (60-80 second, i-lids easy)
Number of occurence
Pixel values


Histogram of z array (80-100 second, i-lids easy)
Number of occurence
Pixel values


Histogram of z array (100-120 second, i-lids easy)
Number of occurence
Pixel values


Histogram of z array (120-140 second, i-lids easy)
Number of occurence
Pixel values


Histogram of z array (140-160 second, i-lids easy)
Number of occurence
Pixel values

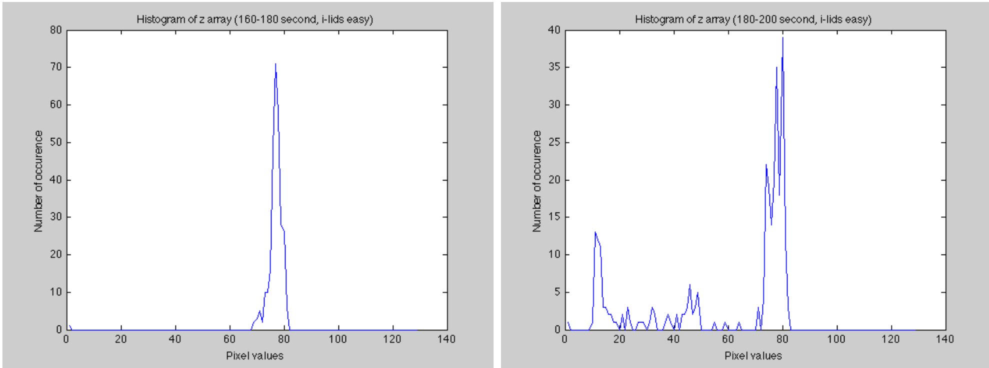
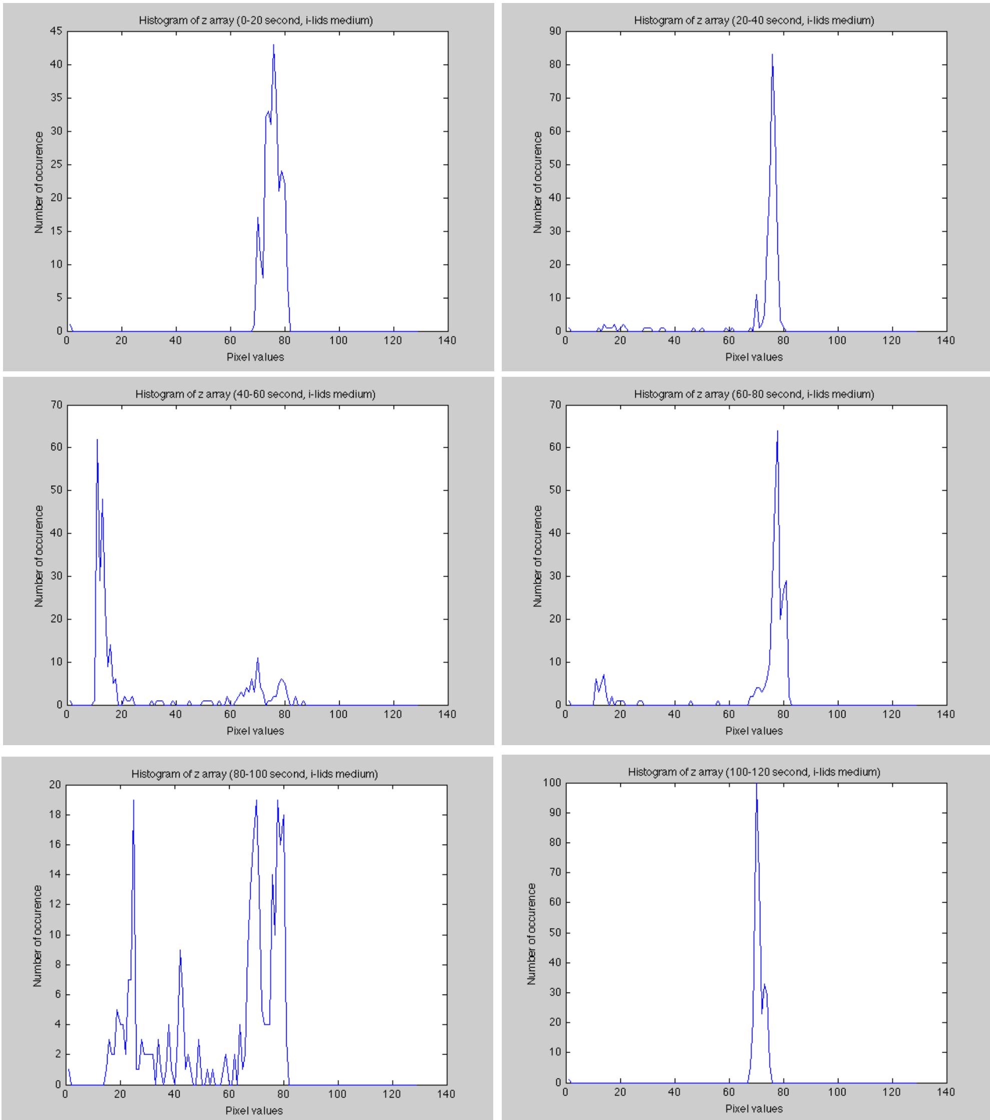


Figure 4.10 Histograms of z array for I(160,160) in i-lids easy abandoned package video



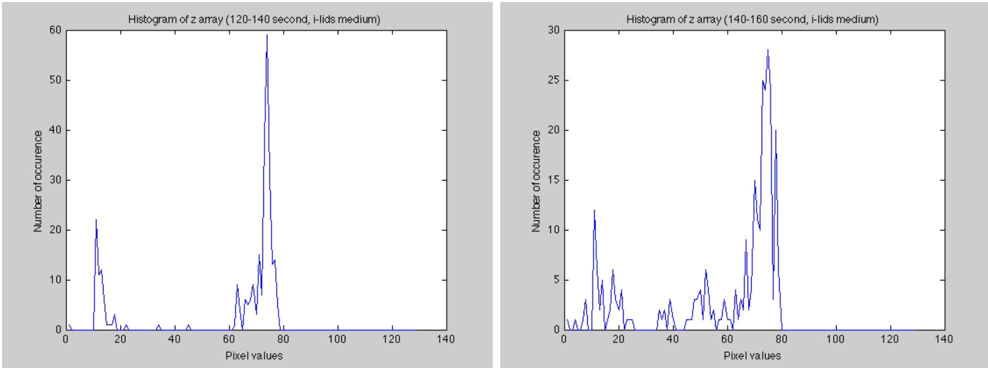
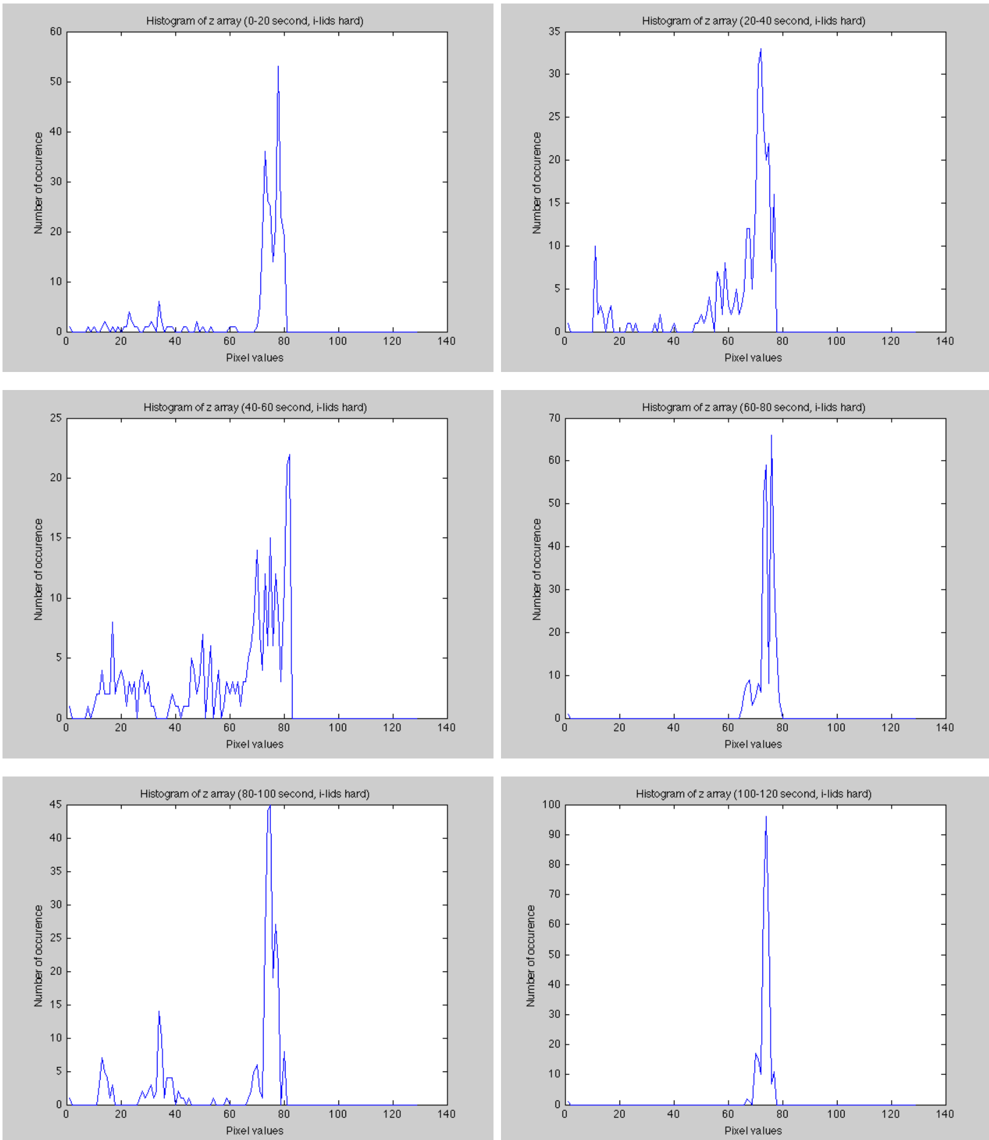


Figure 4.11 Histograms of z array for I(160,160) in i-lids medium abandoned package video



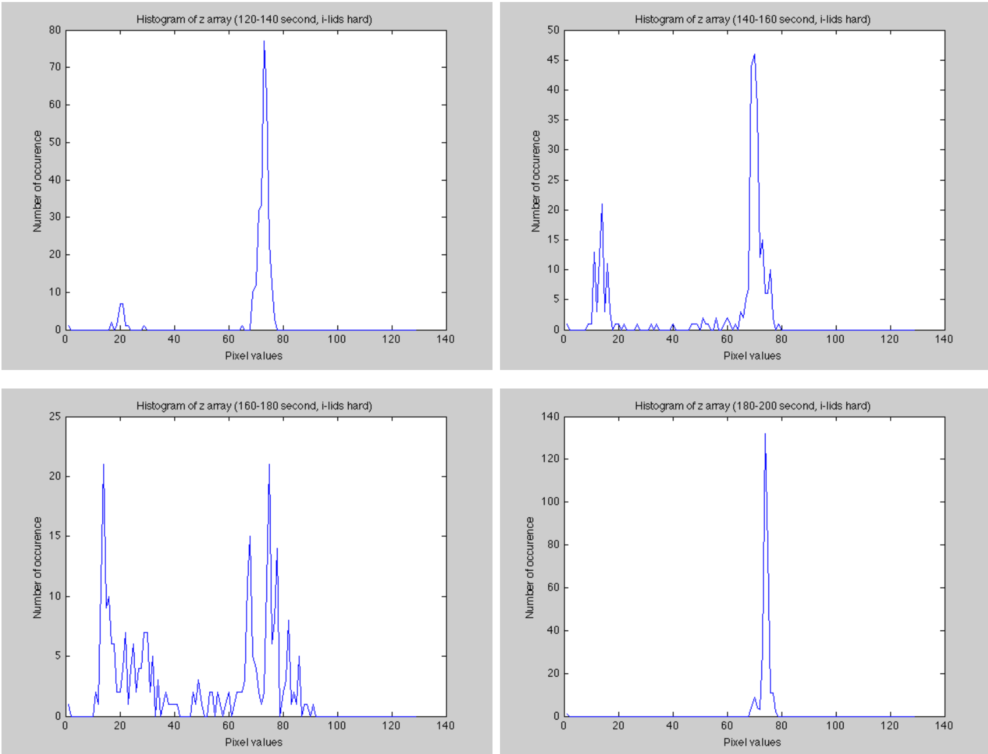
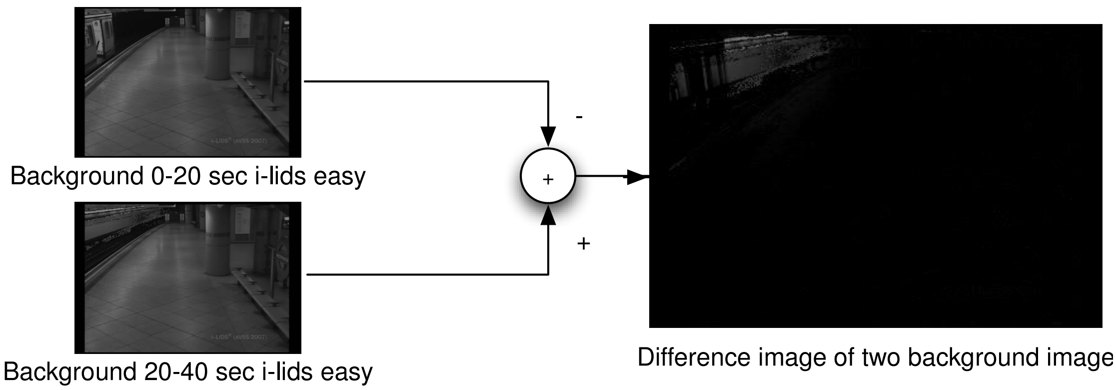
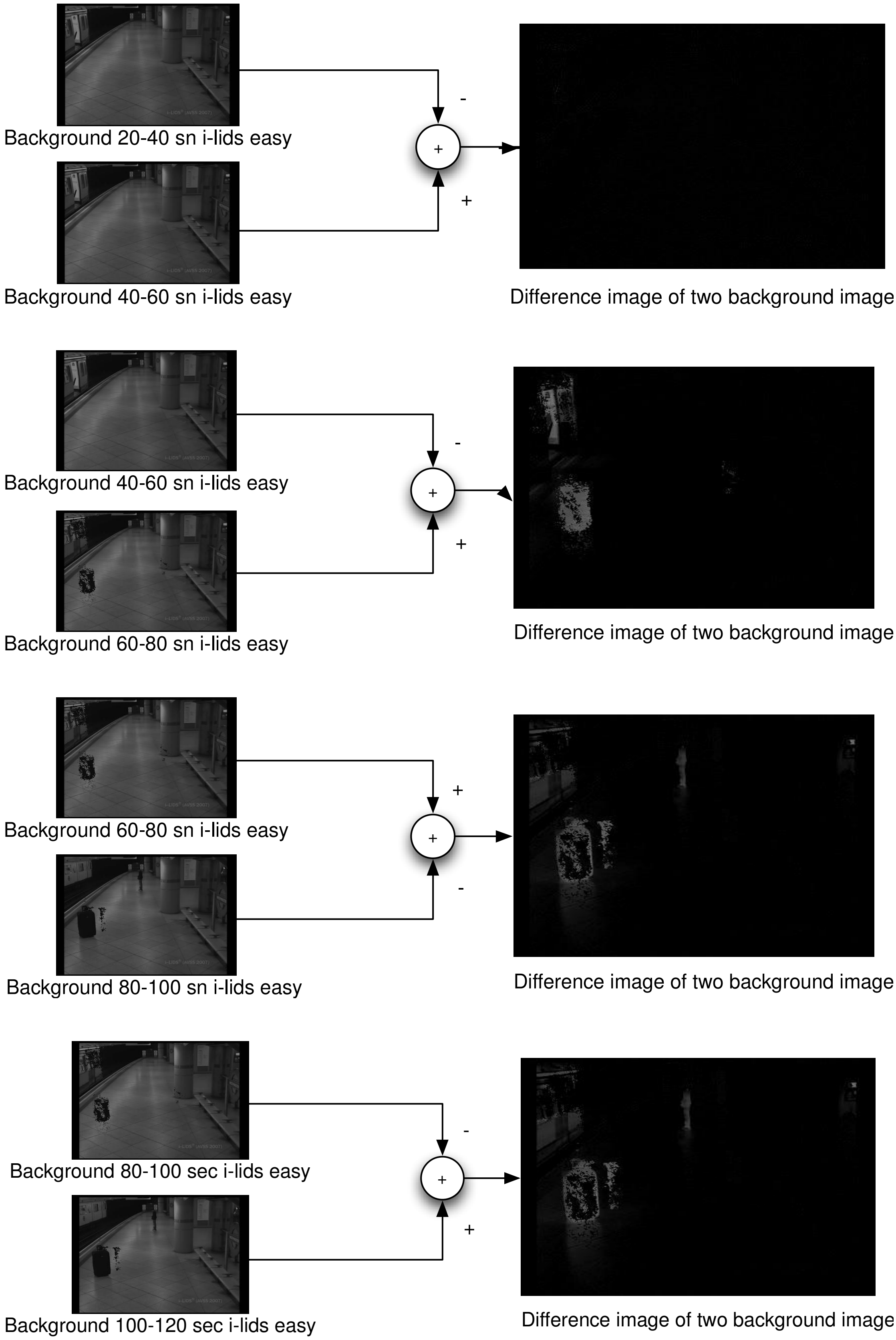
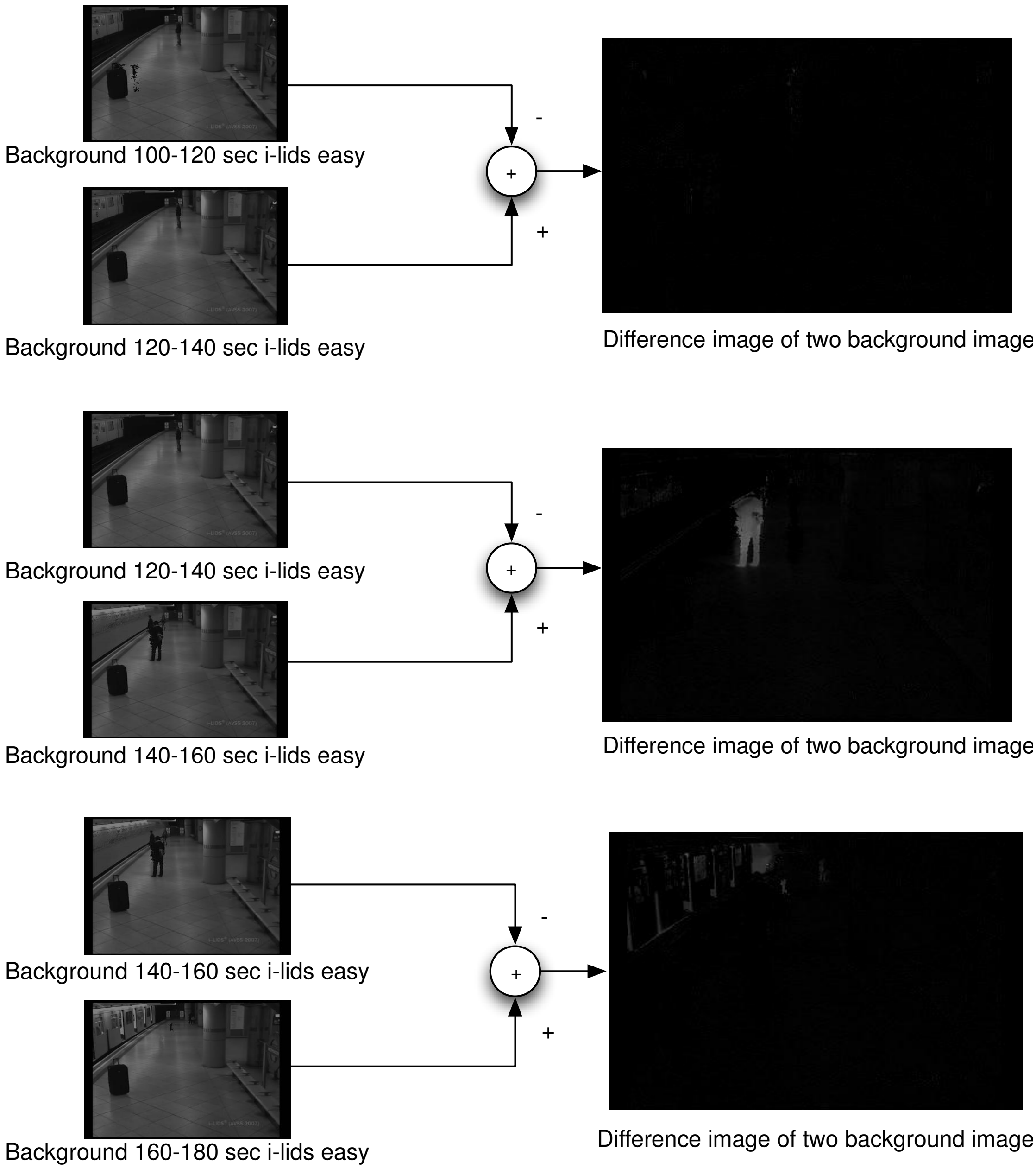


Figure 4.12 Histograms of z array for I(160,160) in i-lids hard abandoned package video

Considering algorithm for proposed method given in figure 4.3 the difference between estimated backgrounds is obtained for each of video datas. Figure 4.12, 4.13, 4.14 show the difference images between estimated backgrounds, respectively.




Background 20-40 sn i-lids easy
Background 40-60 sn i-lids easy
-
+
+
Difference image of two background image
Background 40-60 sn i-lids easy
Background 60-80 sn i-lids easy
-
+
+
Difference image of two background image
Background 60-80 sn i-lids easy
Background 80-100 sn i-lids easy
+
+
-
Difference image of two background image
Background 80-100 sec i-lids easy
Background 100-120 sec i-lids easy
-
+
+
Difference image of two background image


Background 100-120 sec i-lids easy
Background 120-140 sec i-lids easy
Difference image of two background image
Background 120-140 sec i-lids easy
Background 140-160 sec i-lids easy
Difference image of two background image
Background 140-160 sec i-lids easy
Background 160-180 sec i-lids easy
Difference image of two background image

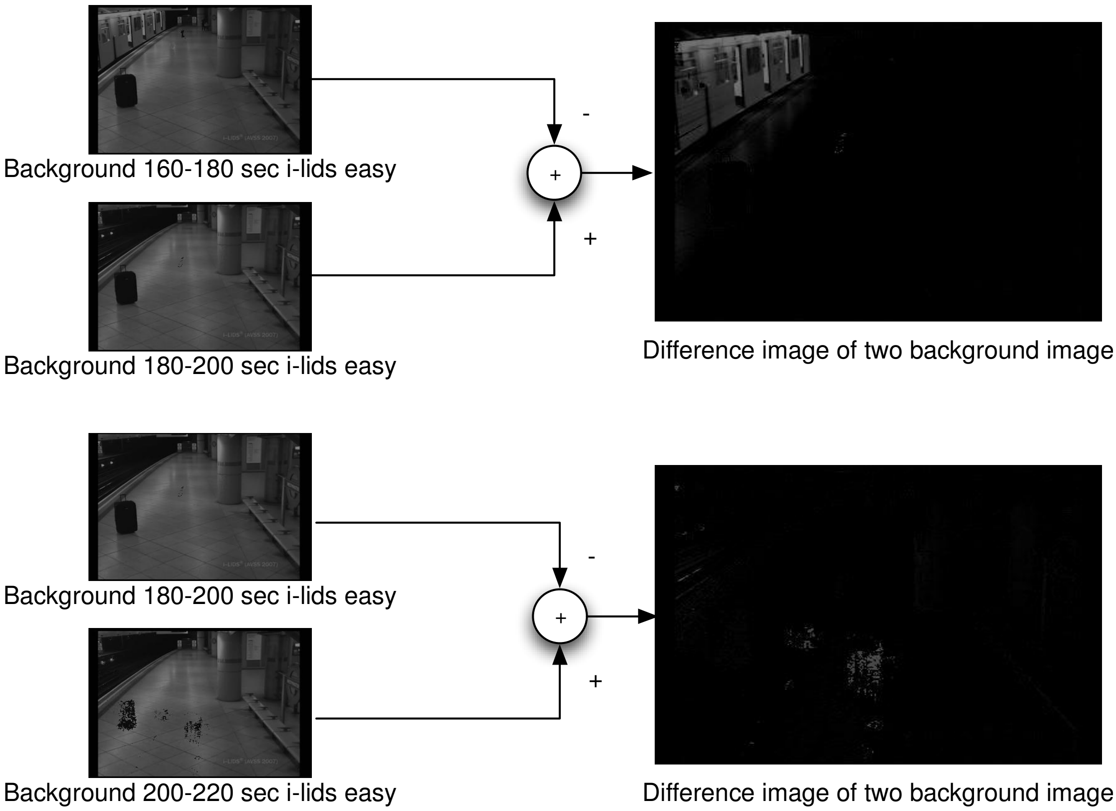
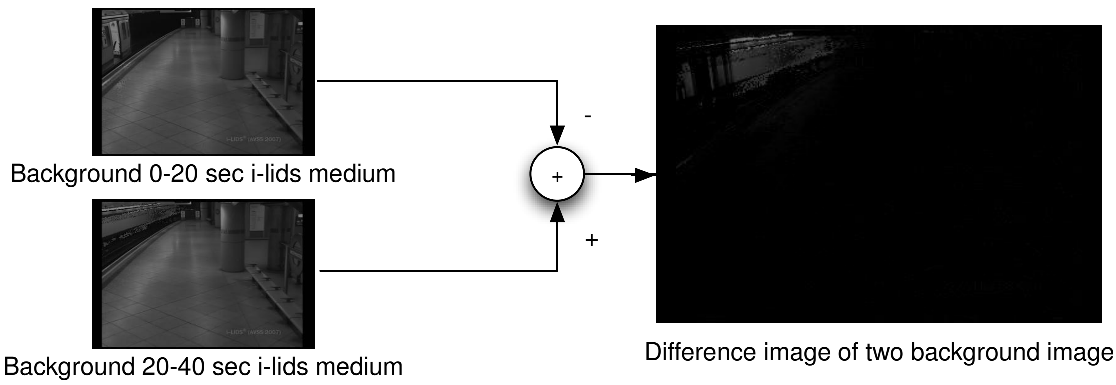
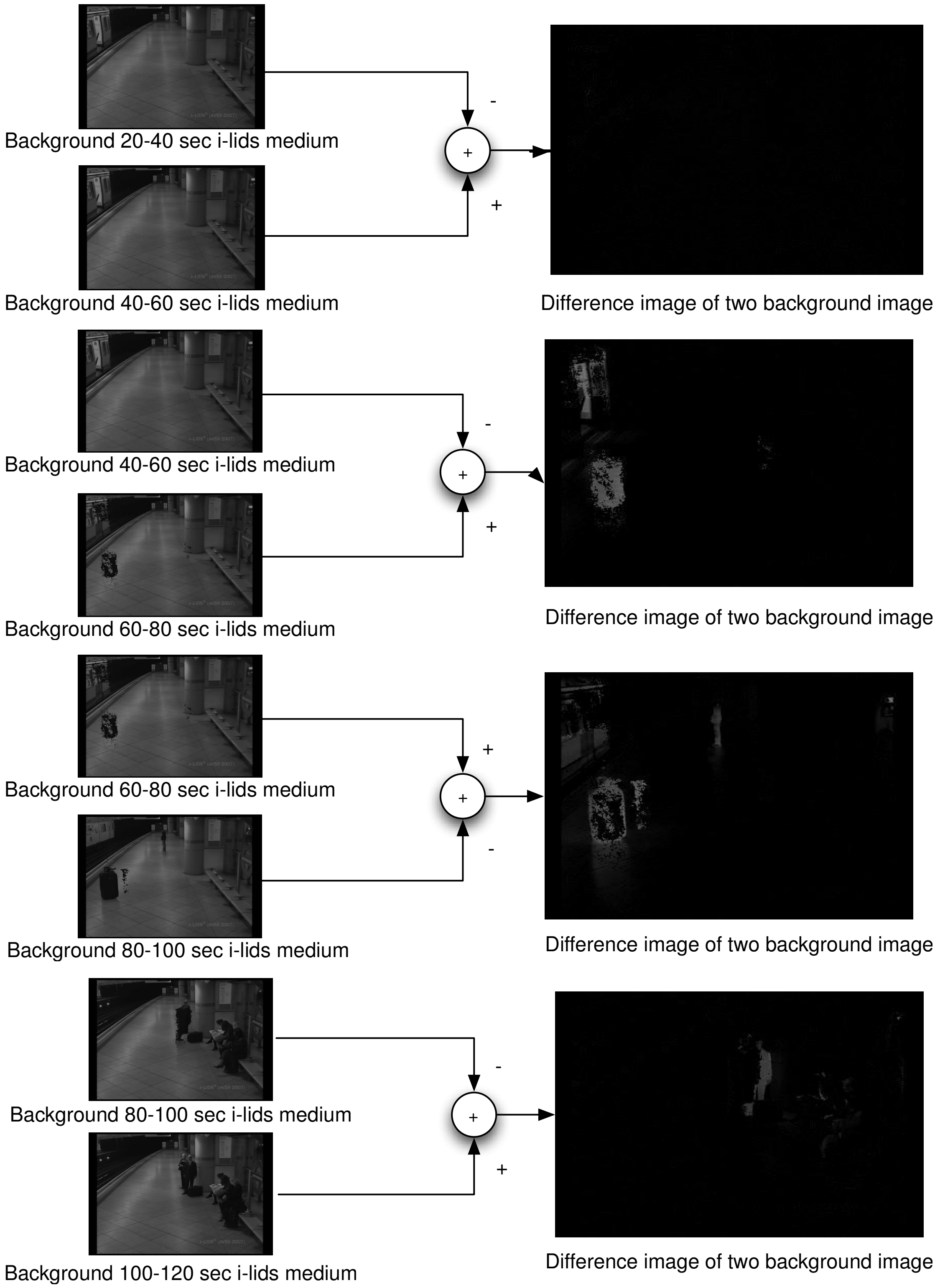


Figure 4.12 Difference of backgrounds (i-lids easy)




Background 20-40 sec i-lids medium
Background 40-60 sec i-lids medium
Difference image of two background image
Background 40-60 sec i-lids medium
Background 60-80 sec i-lids medium
Difference image of two background image
Background 60-80 sec i-lids medium
Background 80-100 sec i-lids medium
Difference image of two background image
Background 80-100 sec i-lids medium
Background 100-120 sec i-lids medium
Difference image of two background image

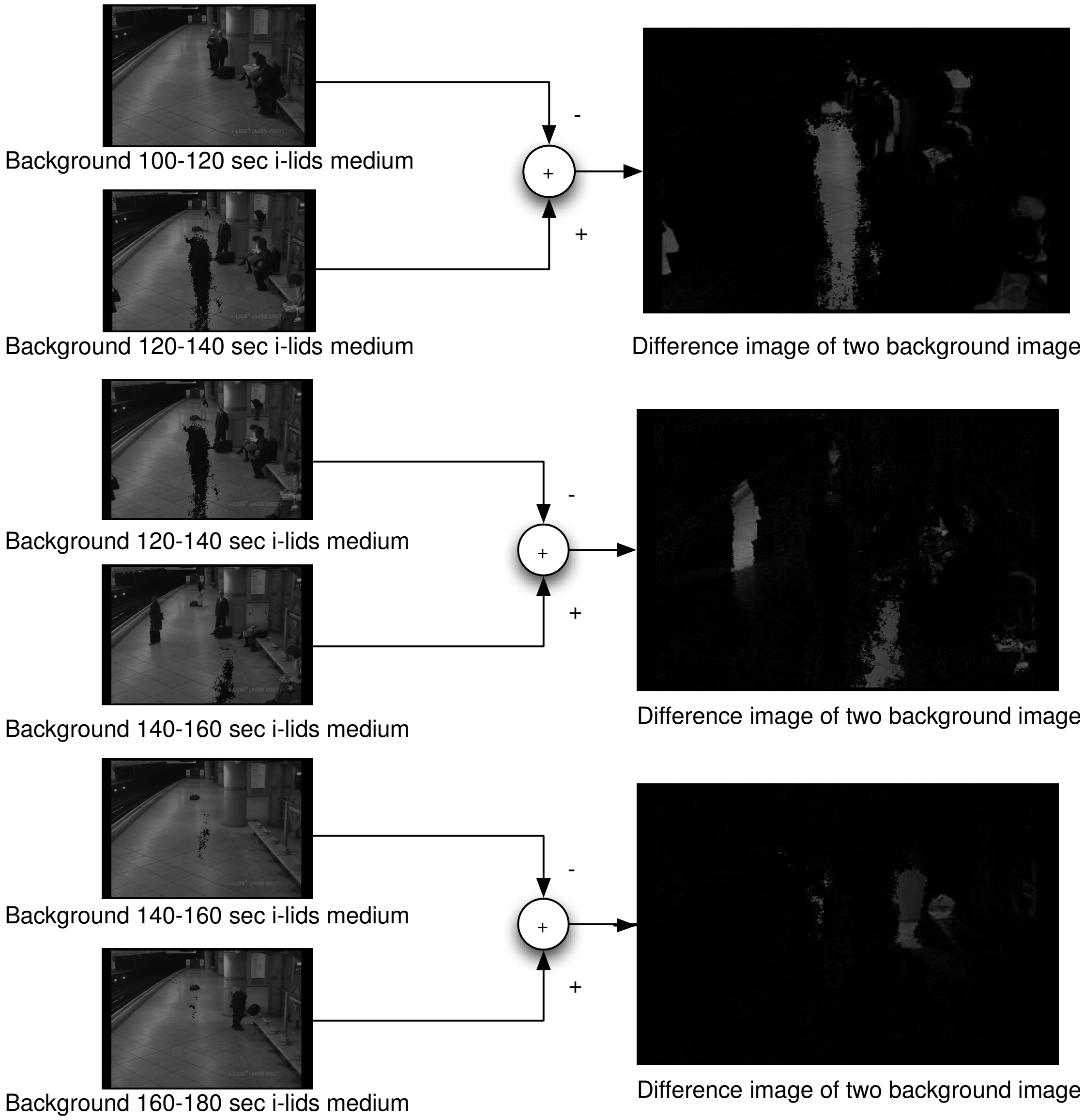
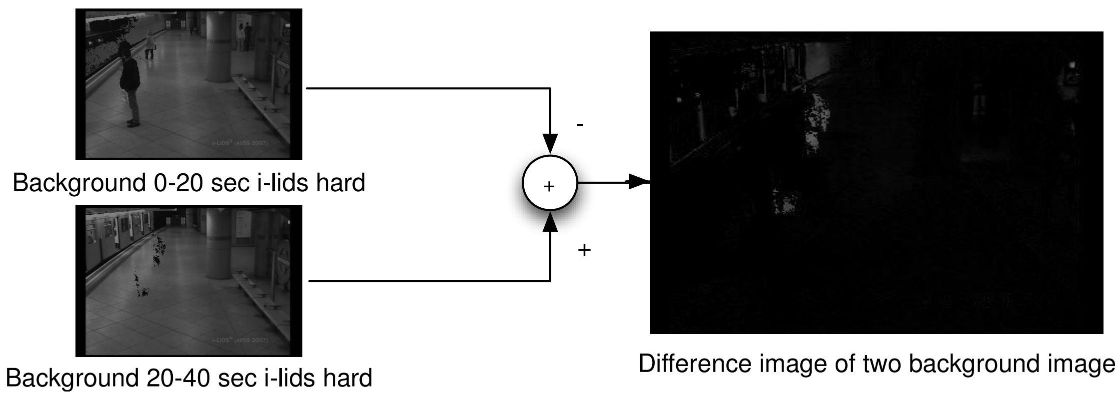
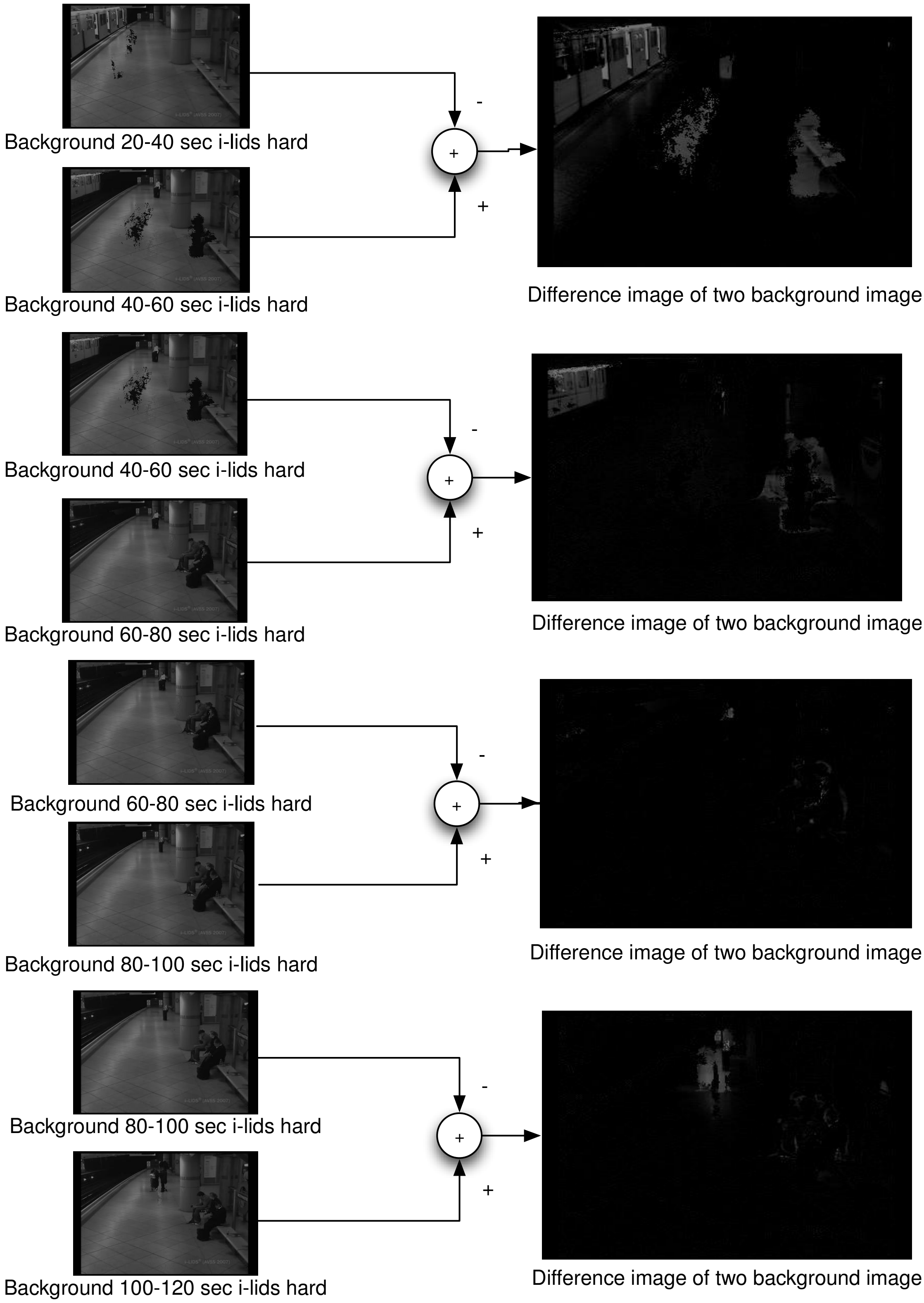


Figure 4.13 Difference of backgrounds (i-lids medium)




Background 20-40 sec i-lids hard
Background 40-60 sec i-lids hard
Difference image of two background image
Background 40-60 sec i-lids hard
Background 60-80 sec i-lids hard
Difference image of two background image
Background 60-80 sec i-lids hard
Background 80-100 sec i-lids hard
Difference image of two background image
Background 80-100 sec i-lids hard
Background 100-120 sec i-lids hard
Difference image of two background image

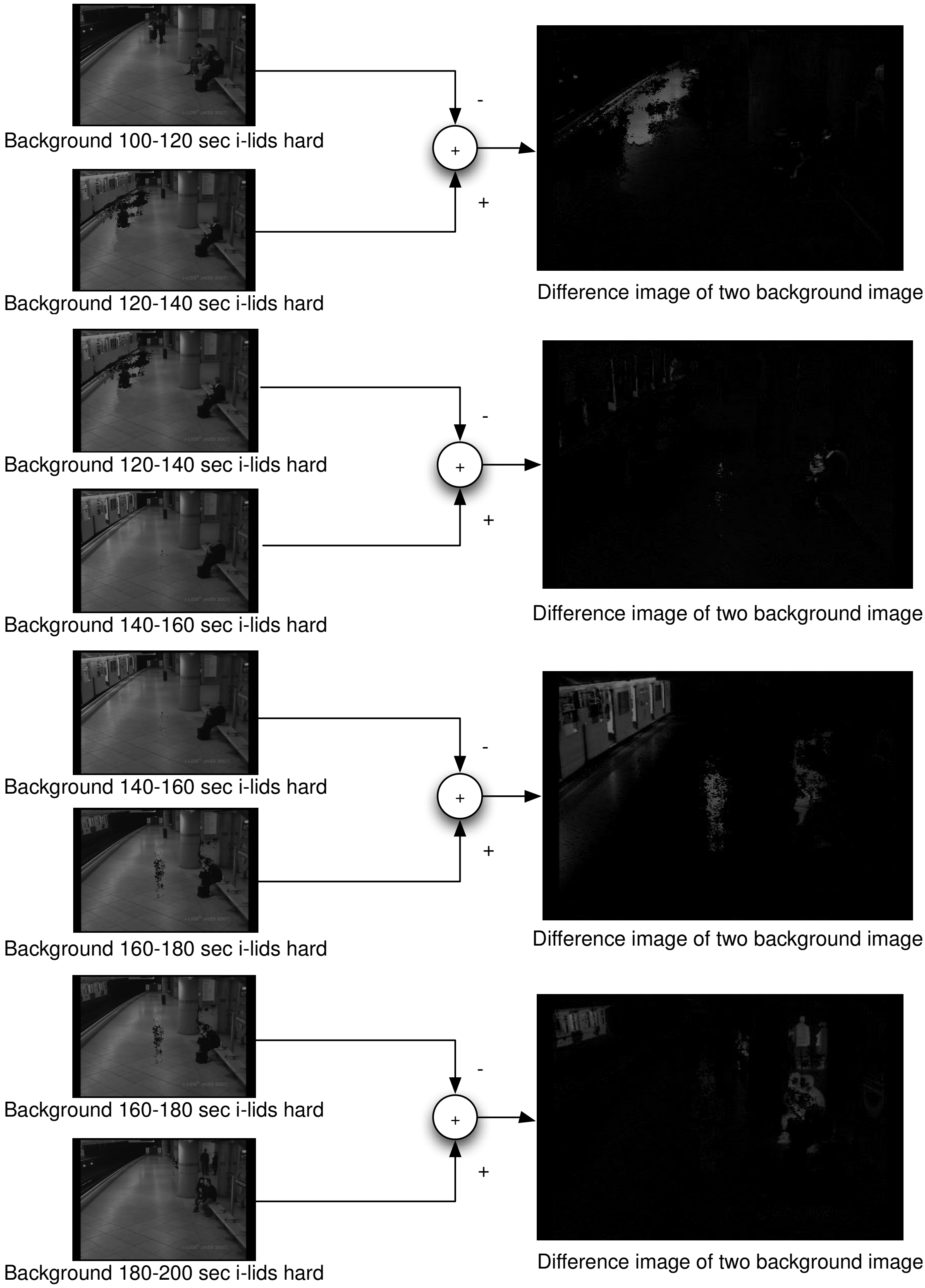
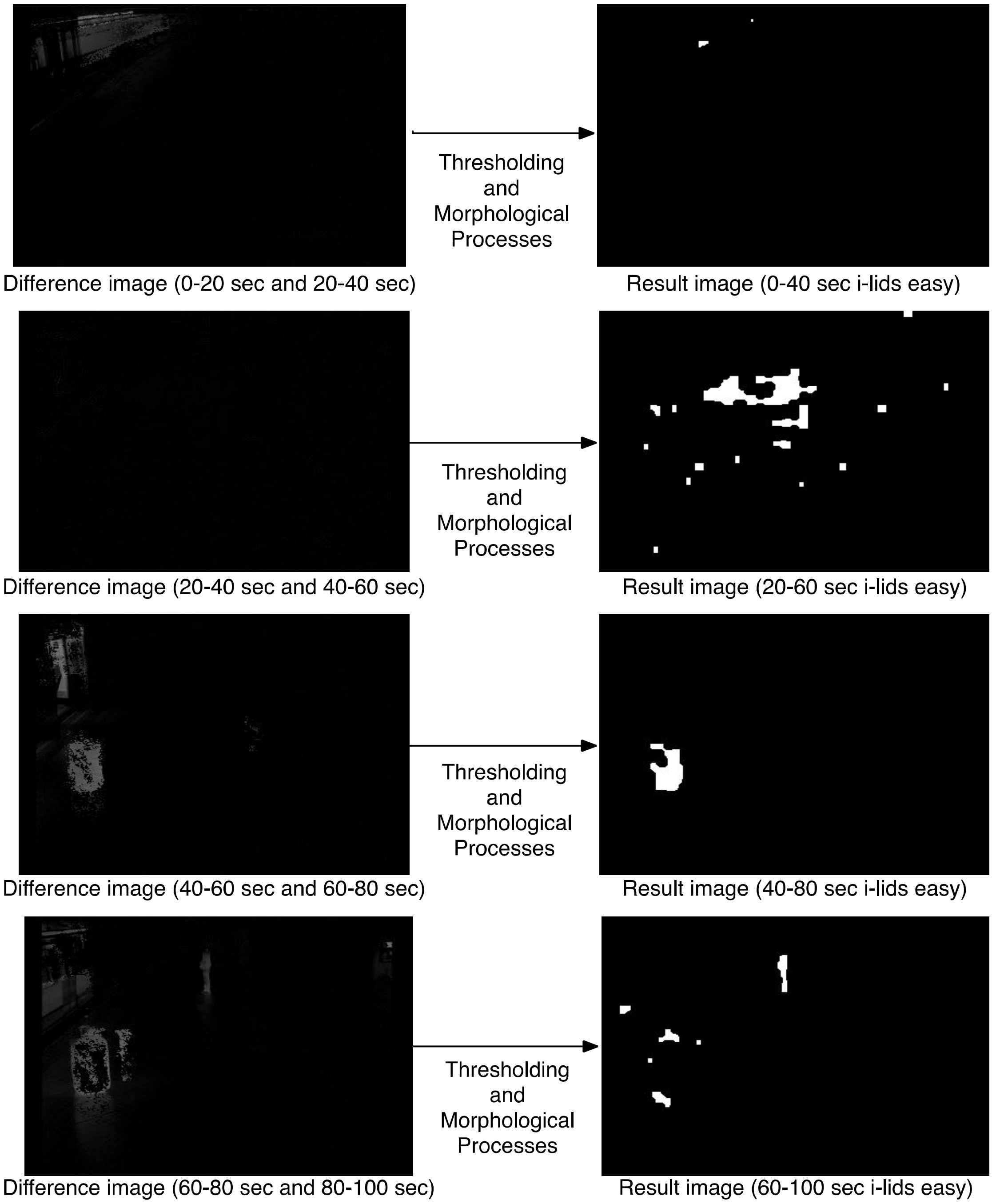


Figure 4.14 Difference of backgrounds (i-lids hard)

After estimate background difference, last step is theresolding and morphological processes. Figure 4.15, 4.16 and 4.17 is a result of proposed method. Thresholding is the simplest method of image segmentation. Morphological processes often are used for image enhancement. Erosion and dilation morphological processes are used for eliminate noises.



Thresholding and Morphological Processes

Difference image (80-100 sec and 100-120 sec)

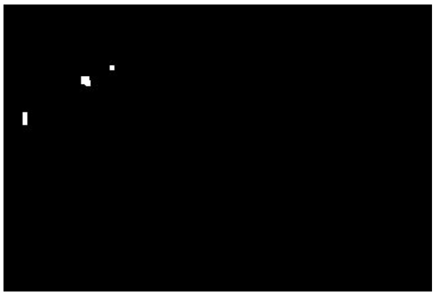
Result image (80-120 sec i-lids easy)

Thresholding and Morphological Processes

Difference image (100-120 sec and 120-140 sec)

Result image (100-140 sec i-lids easy)

Thresholding and Morphological Processes



Difference image (120-140 sec and 140-160 sec)

Result image (120-160 sec i-lids easy)

Thresholding and Morphological Processes

Difference image (140-160 sec and 160-180 sec)

Result image (140-180 sec i-lids easy)

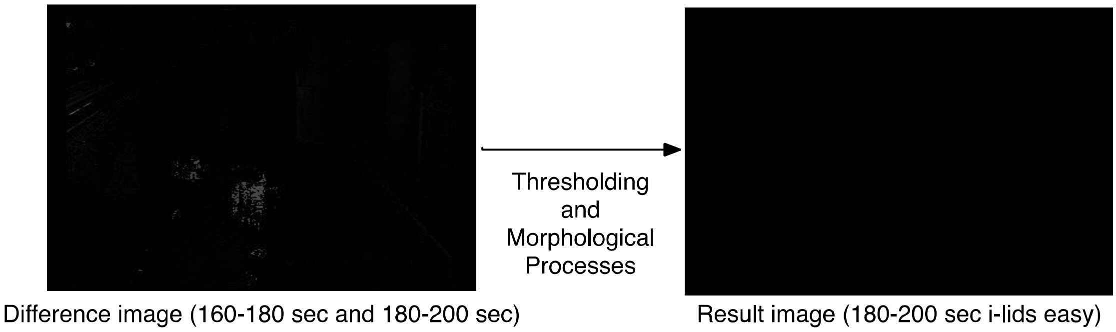
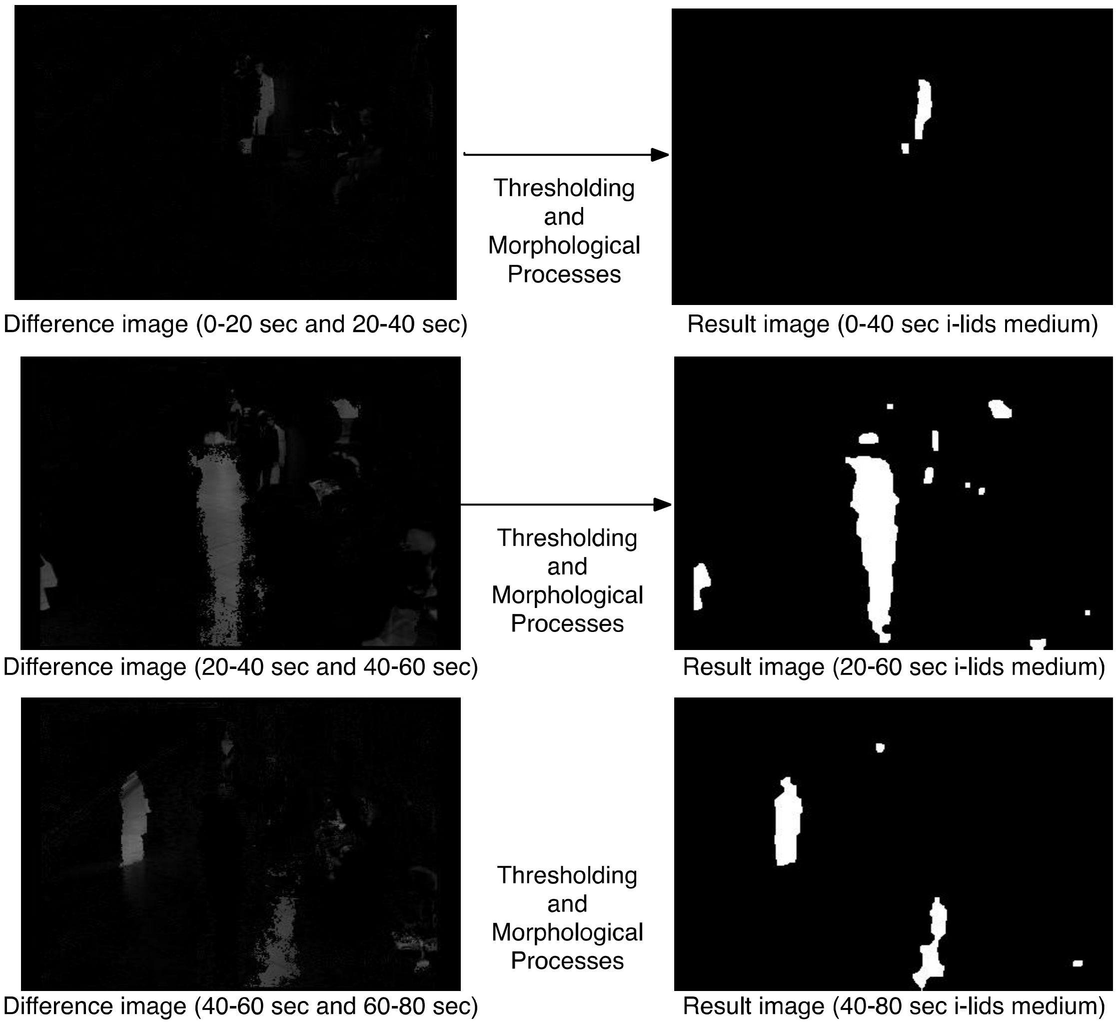
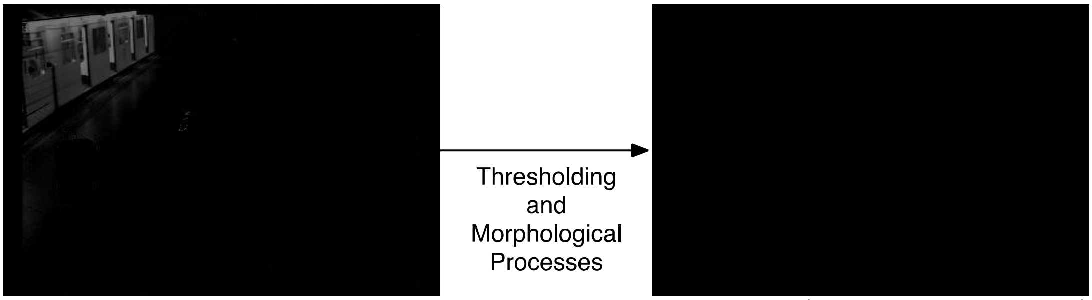
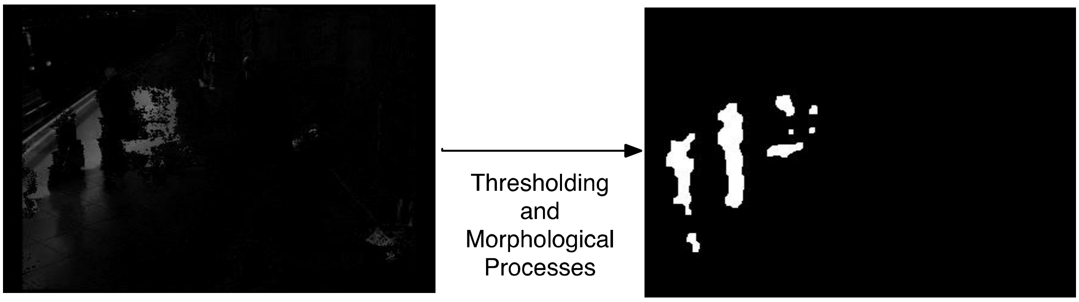


Figure 4.15 Results of proposed method (easy)

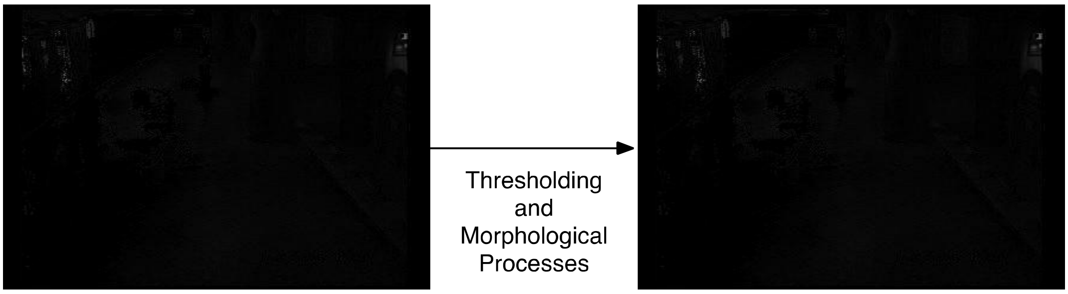




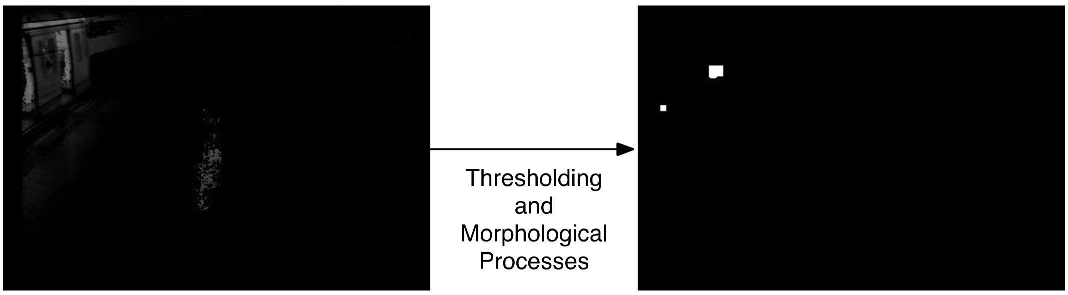
Difference image (60-80 sec and 80-100 sec) Result image (60-100 sec i-lids medium)



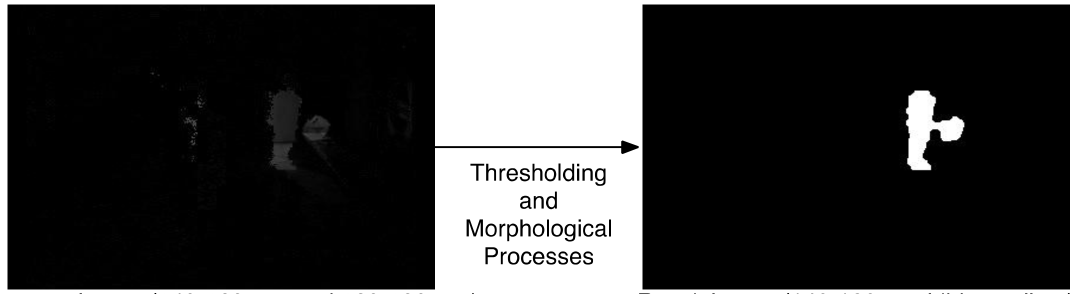
Difference image (80-100 sec and 100-120 sec) Result image (80-120 sec i-lids medium)



Difference image (100-120 sec and 120-140 sec) Result image (100-140 sec i-lids medium)

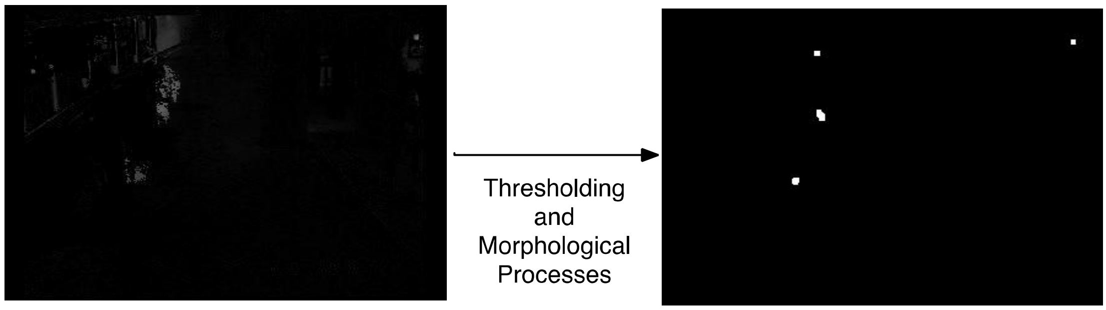


Difference image (120-140 sec and 140-160 sec) Result image (120-160 sec i-lids medium)

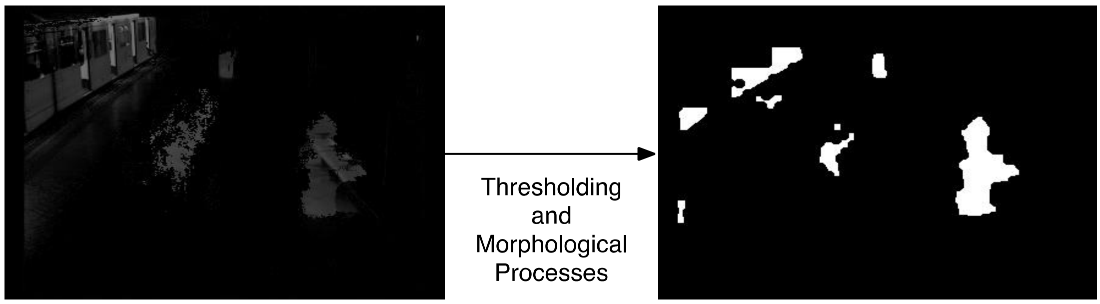


Difference image (140-160 sec and 160-180 sec) Result image (140-180 sec i-lids medium)

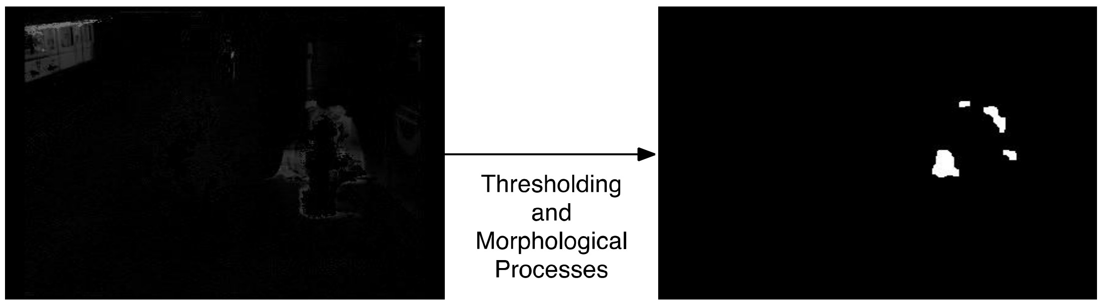
Figure 4.16 Results of proposed method (medium)



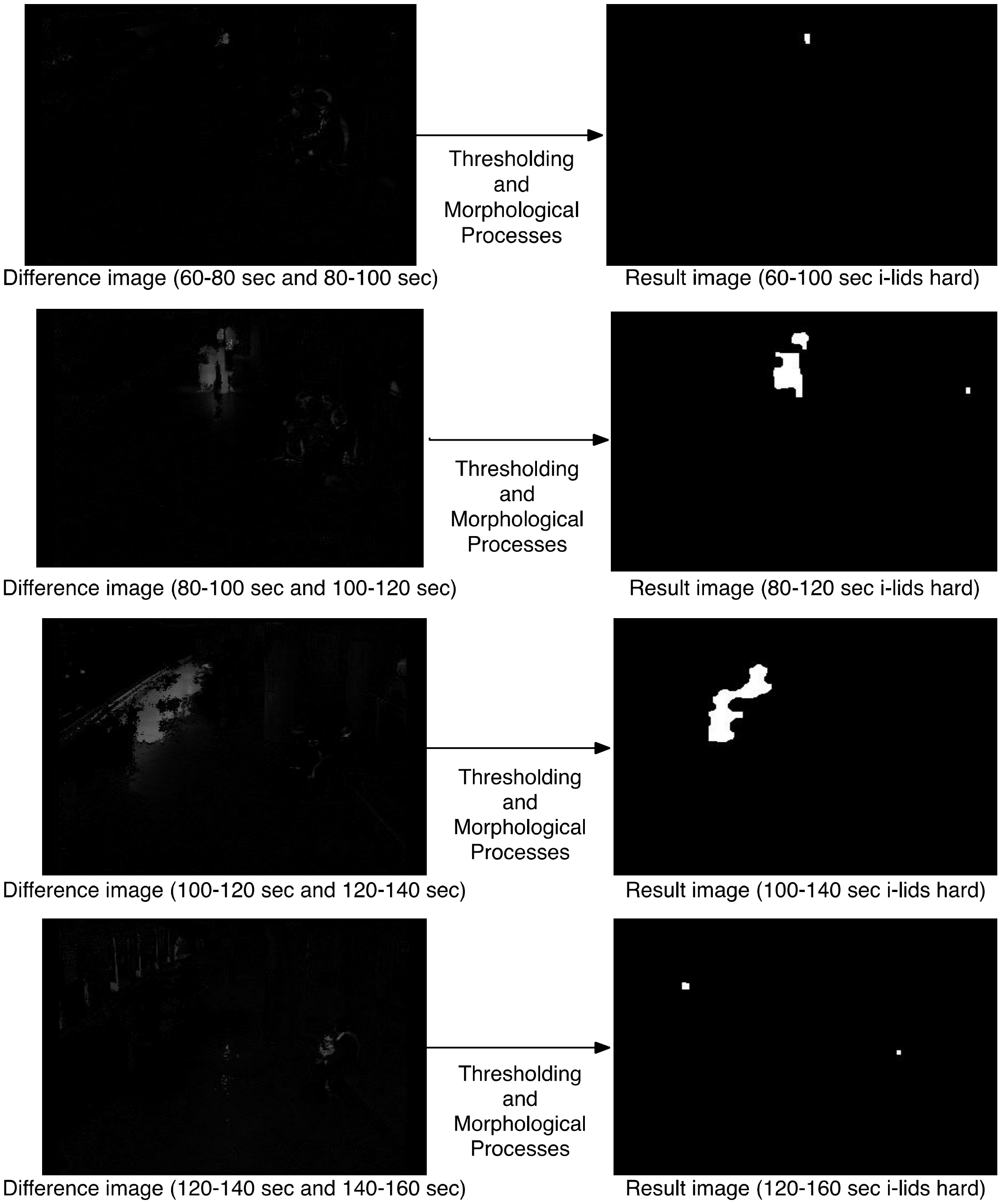
Difference image (0-20 sec and 20-40 sec) Result image (0-20 sec i-lids hard)



Difference image (20-40 sec and 40-60 sec) Result image (20-60 sec i-lids hard)



Difference image (40-60 sec and 60-80 sec) Result image (40-80 sec i-lids hard)


Thresholding
and
Morphological
Processes
Difference image (60-80 sec and 80-100 sec)
Result image (60-100 sec i-lids hard)
Thresholding
and
Morphological
Processes
Difference image (80-100 sec and 100-120 sec)
Result image (80-120 sec i-lids hard)
Thresholding
and
Morphological
Processes
Difference image (100-120 sec and 120-140 sec)
Result image (100-140 sec i-lids hard)
Thresholding
and
Morphological
Processes
Difference image (120-140 sec and 140-160 sec)
Result image (120-160 sec i-lids hard)

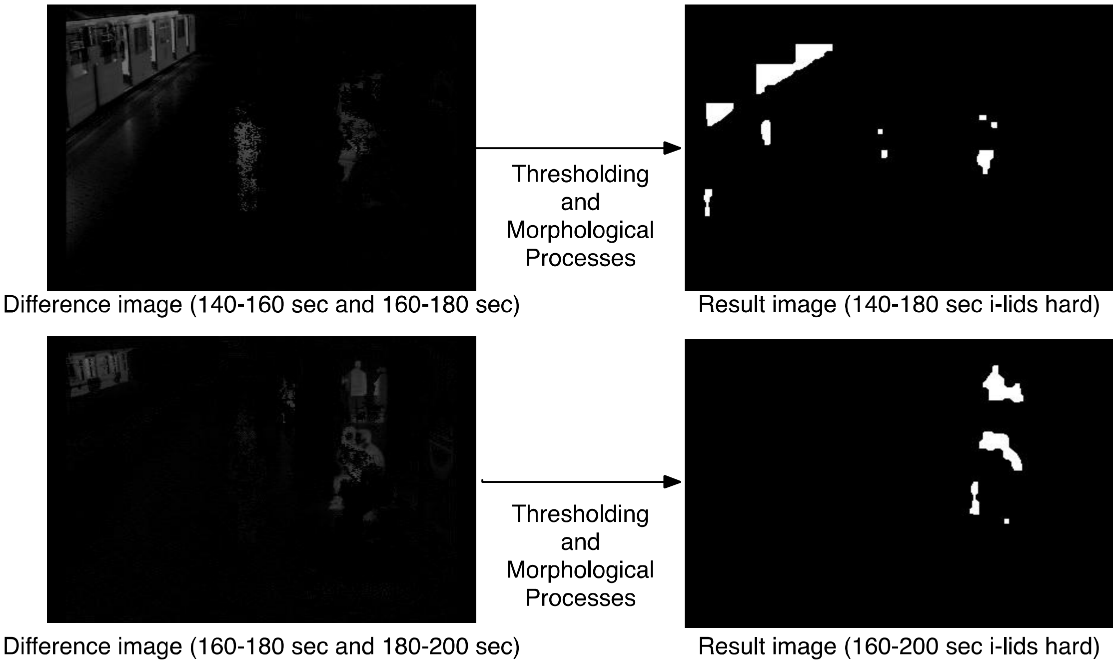


Figure 4.17 Results of proposed method (hard)

CHAPTER V
COMPARATIVE ANALYSIS

In this section abandoned package detection method using morphological processes will be compared with abandoned package detection method.

5.1 Proposed Method Analysis

In this study, morphological operations improved method of background extraction method is presented that detects abandoned packages. Proposed method is analysied i-lids library. I-lids [14] library has three option in abandoned object detection. There are easy,medium and hard diffuculty levels.

Data Set	True Pixel Ratio with Morphological Processed (Proposed Method)
i-lids Hard	%35.95
i-lids Medium	%52.38
i-lids Easy	%99.02

Table 1. True Pixel Ratio with Morphological Processed

5.2 Detecting Abandoned Package Background Estimation Method

In this study, Detecting Abandoned Package Background Estimation Method is modulated. This apporach is developed by adding morphological processes.

Data Set	True Pixel Ratio without Morphological Process
i-lids Hard	%29.62
i-lids Medium	%37.87
i-lids Easy	%93.70

Table 2. True Pixel Ratio without Morphological Processed

5.3 Comparative Analysis

Data Set	True Pixel Ratio without Morphological Process	True Pixel Ratio with Morphological Processed (Proposed Method)	Difference
i-lids Hard	%29.62	%35.95	%6.33
i-lids Medium	%37.87	%52.38	%14.51
i-lids Easy	%93.70	%99.02	%5.32

Table 3. Comparative Analysis

Morphological operations as shown in Table 1 provided improvements in the existing method. Morphological processes provide most improvements in medium difficulty level video data set. In general, required performance of the method didn't perform in hard and medium difficulty levels. But in easy difficulty level successful outcome was obtained with the proposed method. In hard difficulty level video data set package size is most small so our method couldn’t eliminate noises.

CHAPTER VI

CONCLUSION and FUTURE WORK

In this thesis abandoned package detection method using morphological processes was applied. According to the method used in this study gave better results than without morphological operations. In further studies with the thermal cameras separation can be done living and nonliving. So with this method human and package can be seperated. When we think processor ability. We can accelerate the application with graphics processors.

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[14] i-LIDS dataset for AVSS 2007

APPENDIX A I-LIDS EASY ABANDONED PACKAGE VIDEO FRAMES


i-LIDS® (AVSS 2007)


i-LIDS® (AVSS 2007)

APPENDIX B I-LIDS MEDIUM ABANDONED PACKAGE VIDEO FRAMES


i-LIDS® (AVSS 2007)

APPENDIX C I-LIDS HARD ABANDONED PACKAGE VIDEO FRAMES


i-LIDS® (AVSS 2007)


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