International Review on Computers and Software (I.RE.CO.S.), Vol. 10, N. 10
ISSN 1828-6003 October 2015

Automatic Moving Objects Segmentation Enhancement Based on Fuzzy C-Means with Gabor Filter and Minkowski Distance

M. A. Soeleman[1, 2], M. Hariadi[1], Eko M. Yuniarno[1], Mauridhi H. Purnomo[1]

Abstract – *The low intensity of several pixels can be a crucial problem for the segmentation of moving object because the object cannot be separated perfectly from the background. This paper proposes Gabor filtering to enhance the intensity of foreground in automatic segmentation of moving object.*

The experiments evaluate the application of Gabor filter and Fuzzy C-Means (FCM) clustering for segmentation of moving objects showing that FCM with Gabor filter is able to perform a good differentiation process of foreground and background which is better than FCM with no Gabor filter. In the work, several distance metrics have been evaluated. The result shows that Minkowski distance is more accurate than the other distances. ***Copyright © 2015 Praise Worthy Prize S.r.l. - All rights reserved.***

Keywords: *Fuzzy C-Means, Gabor Filter, Distance Measure, Segmentation for Moving Object*

I. Introduction

Nowadays, segmentation for moving objects isa challenging problem in some video application areas such as automatic visual surveillance, content-based video analysis, video object labeling, and human-computer interaction. The results of video segmentation process are important for further analysis such as feature extraction, recognition, and classification.

The basic goal of moving objects segmentation process in video is to divide an image sequence into mutually distinctive regions which can subsequently enclose meaningful labels, with a set of decompose regions with identical and homogeneous attributes such as pixel intensity, color, motion. Accordingly the segmented objects are often as the foreground and the rest of image frame is the background. Many researchers have been conducted on various problems found in the segmentation of moving objects, that can be classified into three categories according to their primary approaches: temporal differencing [1]; motion optical flow [2], [3]; and background subtraction.

The segmentation of semantic video object is an ill-imposed problem [4]. The human can only understand the meaning of semantic video segmentation.

The common approach in the first process for analyzing the image sequence in video is by applying background subtraction in [5]. This method consists in maintaining an update model of foreground objects from the background components. The benefit of background subtraction is its ability to segment object foreground in video streams from its background.

Compared to other approaches, such as optical flow in [6], this approach is computing the reasonable for real-time applications.

Jianwei et al. [6] proposed a customized Gabor filter for image improvement in fingerprint identification by applying parameter selection such as standard deviation called adaptive parameter. The author in their proposed method, discarded the prior sinusoidal wave to overcome the shortcoming wave. However the modified Gabor filter is still having problems when region of image contains many heavy noises.

Linden Baum et.al in [7] proposed a method for enhancement in deburring image by applying modified Gabor filter. The approach method demonstrated that the result of Gabor filter have better performance than the Laplacian methods. Besides, the value of Gabor methods showed that the signal noise ration value of signal noise is better than the Laplacian result.

Tudor in [8] proposed a feature extraction technique for detecting video cut by applying 2D Gabor filtering. The technique is applied in the feature vectors computation of tridimensional image for video frames. Frequently, most detection for shot cut applies threshold technique to distinguish the inter-frame difference and video identity.

The basic goal of object segmentation improvement is to process the segmented object, which can view and assess the contained visual information with better clearness. The main condition for moving objects segmentation is that the extracted information extracted must exist in the image.

In many clustering problems, the choice of metric distance is the key for the success in the clustering technique. The widely used metric is the Euclidean distance because of its simplicity. This metric is based on the hypothesis that data are uncorrelated in the space of features, and clusters have the same super spherical shapes.

However, this hypothesis is not always true, especially in many image segmentations. Gustafson and Kessel [9] proposed the fuzzy covariant matrix and applied the modified Mahalanobis distance. Liu et al. [10] proposed an algorithm of fuzzy c-means for image segmentation which is derived from different Mahalanobis distance.

Jayasudha [11] in proposed fuzzy c-means for image enhancement. The proposed methods were based on median filtering for helping to remove the noisy and unwanted pixels from input image. After employed median filter the proposed method has been extracted RGB colors form the color image transformation. The proposed method could enhance image better than the existing OSGFB approach in terms of MSE, PSNR, contrast and homogeneity.

Shao et al. [12] proposed a method for the decision threshold in video segmentation. The proposed algorithm works properly, thus this method is good to determine a dynamic background conditions, though there is no user input. Furthermore, this method successfully prevents the possible error in propagations which is based on a different mechanism of pixel background subtraction.

Furthermore, Shao [12] proposed also a method for histogram matching color by diffusion distance. This method, for a moving object with no rigid character, can perform a robustly tracking, though it is under drastic illumination changes. In addition, it is the most suitable in realization of parallel and hardware implementation.

The FCM algorithm based on the Euclidean distance is sensitive to noise and weighting exponent in objective function is suboptimal [13]. For the reason, authors propose to evaluate the other distance measures, i.e. Euclidean, City Block, Canberra, Chebyshev, Minkowski, Bray Curtis and Jensen Shannon.

Based on background subtraction advantages in [14], in this study was decided to apply temporal frame difference in segmentation process for moving object.

Although FCM is widely used for object segmentation, the low intensity of pixels in an image may reduce the performance of FCM. The solution to enhance the intensity of the pixels is by applying Gabor filter. Here, the Gabor filter is applied to improve the performance of FCM in distinguishing the pixels of foreground and background.

II. Related Works

A robust foreground segmentation algorithm had been proposed in [3]. It's aim to categorize the background and foreground using a multiple threshold and refining the color information by applying morphological process.

Meanwhile, the reliable foreground segmentation approach has been proposed in [2].

The authors combined the analysis of temporal image to the background image reference in order to overcome the trouble occurred in outdoor daylight scenes causing change intensities on the background of reference image for moving object segmentation.

A binary image of model proposed by Meier and Ngan in [15] performed the automatic segmentation and tracking of moving objects. This method used the edge detection method of an image that would generate the binary models. The method was performed on each frame renewal process in order to have steadyshape of objectand spatial position in a convinced time. Process of moving object detection was performed by matching two frames which based on the model of binary-based distance Housdoff.

Arch and Kaup [14] proposed statistical approach for segmentation method in video sequence, the method was applied on two frames to get Gaussian distribution of pixel characteristics in background frame difference. The result of two frames difference showed significant value to the threshold that was producing the change detection limit (CDM).

In the proposed method, the result of segmentation depended on the intensity difference frames, which were affecting the segmentation results when there was slow move or a little movement.

Colonnese and Russo [16] proposed a semi-automatic segmentation method, in which the user could interact withthe region segmentation process. It was performed by determining the region of interest (ROI) to describe boxboundaries ofsegmented object.

The method controlled the segmented object of all pictures having frame from restriction ROI. This method was applied to define the limits of object measured in the segmentation process of important parameters such as intensity, texture, motion and color. Gu and Lee [17] proposed the method of semiautomatic video segmentation toward the interaction of user (I-frame segmentation) and object tracking (P-frame tracking).

A guard band was defined for the beginning of an object boundary which contained real object boundary. Meanwhile, the marker was the pixels on inner and outer edges of the guard band applied as a seed for developing area. A watershed having multi-valued was applied to detection process of object boundary working for color images. Objects tracking meant for ridge motion have the models of parametric motion only in P-frame tracking process. However this method repeatedly failed to be consistent in tracking the object with non-rigid motion.

Thus, in this case, a frequent intervention of user was necessary to improve the result of segmented objects.

III. Methodology

This section describes the process of moving object segmentation by applying clustering techniques. Moving object segmentation in each frame is performed by several steps described in the following subsections.

III.1. Image Subtraction

This proposed methods, firstly applies image subtraction approach for moving objects detection, by applying frame difference.

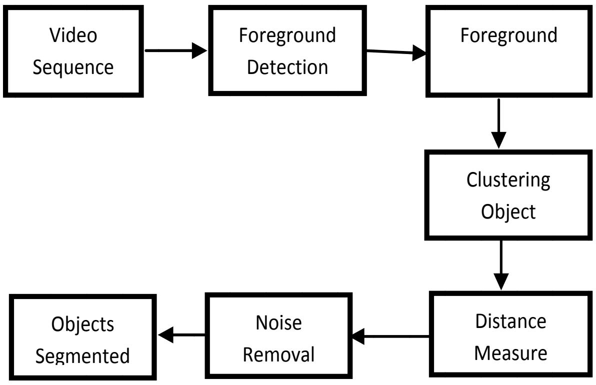


Fig. 1. Proposed Method

It is applied on the three succeeding frames of frame between fb_i to fb_{i-1} and fb_{i+1} to fb_i.

It's aim is to detect moving object and to find the current and the background image difference [14]:

$$fb_{i-1} = \left| fb_i - fb_{i-1} \right| \quad (1)$$

$$fb_{i+1} = \left| fb_{i+1} - fb_i \right| \quad (2)$$

(a) (b)

(b)

Figs. 2. Result of background model: (a) Original frame, (b) computed frame different, (c) background model

III.2. The Design of Gabor Filter

Gabor filter is a very robust method, not only in texture analysis, object tracking and face recognition, but also appropriate for character recognition [18].

The main step for segmentation process of high resolution image is to apply Gabor filter for removing the noise from query image.

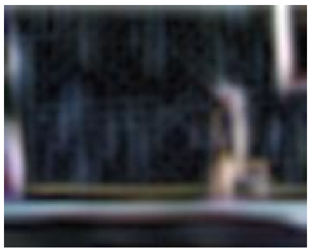
The universal function form of 2-D Gabor filter has been specified in (3) and (4), regarding the response of space domain impulse to function $g(x, y)$ and associated 2-D Fourier transform $G(x,z)$:

$$g(p,q) = exp\left(-\left(\frac{p^2+q^2}{2\sigma_{pq}}\right)\right)cos\left(2\pi\left(u_0 p + v_0 q\right)\right) \quad (3)$$

$$G(c,e) = A \cdot \left\{ \begin{array}{l} exp\left(-\frac{1}{2}\left(\frac{\left(c-c_0\right)^2}{\sigma_{ce}^2} + \frac{\left(e-e_0\right)}{\sigma_{ce}^2}\right)\right) + \\ + exp\left(-\frac{1}{2}\left(\frac{\left(c+c_0\right)^2}{\sigma_{ce}^2} + \frac{\left(e+e_0\right)^2}{\sigma_{ce}^2}\right)\right) \end{array} \right\} \quad (4)$$

where, $\left(c_0, e_0\right)$ is particular 2-D frequency of interest, σ_u and σ_v are the filter scaling parameters and determining the adequate size of a vicinity pixel in which the bias summation occurred.

(a) (b)



(c)

Figs. 3. Image enhancement using Gabor filter

III.3. Clustering Moving Objects using Fuzzy C-Means

Fuzzy C-Means isa popular soft clustering technique that generates a connection matrix.It containsa pixel connection degree to all clusters. FCM attempted to reduce the sum of square error (SSE):

$$SSE = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^m \left\| x_i - c_j \right\|^2, 1 \le m \le \infty \quad (5)$$

In which u_{ij} represented the connection of pixel x_i in the j^{th} cluster, and c_j is the j^{th} cluster center:

$$\sum_{i=1}^{c} u_{ij} = 1, \quad 1 \le j \le n \quad (6)$$

$$u_{ij} \ge 0, 1 \le i \le c, 1 \le j \le n$$

$$\sum_{i=1}^{n} u_{ij} = 1, \quad 1 \le i \le c \tag{7}$$

The FCM algorithm has been arranged in the following:

1. Collect the input data from image.
2. Decide the sum of cluster and value of ε ($\varepsilon > 0$).
3. Compute the partition matrix by applying

$$u_{ik} = \frac{1}{\sum_{j=1}^{c}\left(\frac{d_{ik}}{d_{jk}}\right)^{\frac{2}{m-1}}} \tag{8}$$

4. Update cluster center by applying:

$$c_j = \frac{\sum_{k=1}^{n} u_{ik}^{m} x_k}{\sum_{k=1}^{n} u_{ik}^{m}} \tag{9}$$

5. Redo step 3 to 4 where $\left\| c^k - c^{k+1} \right\| < \varepsilon$.

Let $X = \{x_i : i = 1, 2, N\}$ be the observed image, where i is in responding the pixel index, $x_i = (x_{i1}, x_{i2}, x_{id})V$ is pixel feature vector, i, d is the pixel dimension, and N is number of pixels in image X.

The objective function of FCM algorithm is formulated in:

$$J_{FCM} = \sum_{i=1}^{N}\sum_{j=1}^{c} u_{ij}^{m} d_{ij} \tag{10}$$

in which c is the number of clusters, and j is the cluster index, $U = [u_{ij}]N \times c$ is the connection matrix expressing fuzzy segmentation, u_{ij} represented m degree of connection in which x_i belongs to the jth cluster and convinced $\sum_{j}^{i} = 1$, $u_{ij} = 1$. The fuzzy factor was the contemplating exponent of u_{ij} and described the algorithm fuzziness degree. $d_{ij} = \left\| x_i - \mu_j \right\|^2$ presents the Euclidean distance measuring dissimilarity of pixel vector xi and mean vector of the j^{th} cluster $\mu_j = (\mu_{j1}, \mu_{j2} ... \mu_{jn})^T$.

III.4. Distance Analysis

The basic concept of cluster analysis is the concept of distance measurement or similarity. Distance is the separation space measure among objects; the data measurement is the metric; the similarity is measured by computing the proximity size of the qualitative suitability data.

Distance metrics [19] were applied to determine the similarity or dissimilarity between two objects. Distance had crucial role in clustering data objects.

The distance between two objects x_i and x_j was denoted by $d(x_i, x_j)$. The measured distance is named as a metric distance measure when it contains folowing properties.

III.4.1. Euclidean Distance

Euclidean distance is extensively applied in computer vision area, even in the supervised and unsupervised learning algorithm machine. It is estimated by Eq. (8):

$$d(x_i, z_j) = \sqrt{\sum_{k=1}^{d} \left| x_{i,k} - z_{j,k} \right|^2} \tag{11}$$

III.4.2. City Block Distance

It is the so called the Manhattan distance. The metric of city block distance has robustness to the outliers.

It is computed by the sum of definite differences among feature vectors of image and estimated by Eq. (9):

$$d(x_i, z_j) = \sum_{k=1}^{d} \left| x_{i,k} - z_{j,k} \right| \tag{12}$$

III.4.3. Canberra Distance

The city block distance metric presents a large value for two similar images which consider the dissimilarity within. Therefore, the normalization process of each feature pair difference can be divided by summing a pair of features. This metric is applied for distance numerical measurement between query and database feature vectors and it is estimated by Eq. (10):

$$d(x_i, z_j) = \sum_{k=1}^{n} \frac{|x_{ik} - z_{ik}|}{|x_{ik}| + |z_{ik}|} \tag{13}$$

The value is arranged in ascending order so that the upper shows high similarity. It has similarity with city block distance metric.

III.4.4. Chebyshev Distance

It is so called maximum value distance, which is applied to obtain the largest value of absolute differences in paired features of feature vectors and estimated by Eq. (14):

$$d(x_i, z_j) = \max_{i=1,2,..n} \left| x_{i,k} - z_{j,k} \right| \tag{14}$$

The distance value is the maximum features difference in pair of images, which shows the maximum dissimilarity of the two images.

III.4.5. Minkowski Distance

The generalized form of distance is defined as:

$$d\left(x_i, z_j\right) = \sqrt[p]{\sum_{k=1}^{d} \left|x_{i,k} - z_{j,k}\right|^p} \quad (15)$$

in which p is a positive integer. It offers other distance metrics for positive values of p, for example p =1 presents the city block and p= 2 for the Euclidean distance. Moreover, p =3 as the Minkowski distance on comparison of distance metrics.

III.4.6. Bray Curtis Distance

Bray Curtis Distance is similar to Manhattan distance. The formula is defined as the absolute difference divided by the summation as shown in Eq. (16):

$$d\left(x_{i,}, z_j\right) = \frac{\sum_{i=1}^{n} \left|x_{ik} - z_{ik}\right|}{\sum_{i=1}^{n} \left(\left|x_{ik}\right| + \left|z_{ik}\right|\right)} \quad (16)$$

III.4.7. Jensen Shannon Divergence

Jensen Shannon Divergence (JSD) is a popular method to measure the similarity between two probability distribution. This distance measure is based on Kullback–Leibler divergence. JSD is defined as:

$$JSD\left(x, y\right) = \frac{1}{2}\left(\sum_{i}^{N} x_i ln x_i + \sum_{i}^{N} y_i ln y_i\right) + \\ - \frac{x_i + y_i}{2} ln\left(\frac{x_i + y_i}{2}\right) \quad (17)$$

where x and y are the object of x and y .

III.5. Noise Removal

When background subtraction is processed by frame differencing from image sequence, the moving object as foreground, are not obviously perceptible from the background frame. In the operations of morphological opening and closing, it engaged in the performance of foreground from noisy.

In this section, a morphology operation has been engaged to modify the attribute in images based on the external form or appearance characteristic.

There is a basic operation morphology engaged such as erosion, dilatation, opening and closing. It was stated in [20] that the purpose of opening was to remove unwanted pixel, so it was able to refine and simplify images by estimating or trapping derived objects.

The opening operation [21] was applied for the process of objects smoothing contour. The present research denotes it with opening operation of set X by structuring element of Y *as:*

$$X \circ Y = \left(X \odot Y\right) \oplus Y \quad (18)$$

The impact of opening operation is to remove small and isolated objects from the foreground of image sequence and to place them in the image background.

Alongside with opening operation in performing the foreground, a closing operation has been engaged to the morphological operation of dilation followed by erosion of the same structuring element. The closing of set X by element composition Y, are defined as following:

$$X \bullet Y = \left(X \oplus Y\right) \odot Y \quad (19)$$

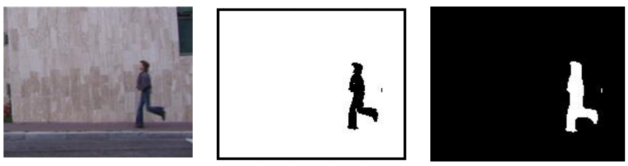
when the object foreground is successfully detected, it seems that only view of objects foreground segmented having good connectivity, such as holes in object foreground.

To overcome the problem, dilation and erosion operation morphology has been engaged iteratively, so that the foreground of the objects is totally segmented from image background. Officially, morphological operation of erosion would remove pixels on frontier objects from image X by structuring element Y defined as:

$$X \odot Y = \bigcap_{y \in Y} \left(X\right)_{-y} \quad (20)$$

Dilation add pixels to the boundaries from image by structuring element defined as:

$$X \oplus Y = \bigcup_{y \in Y} \left(X\right)_{y} \quad (21)$$



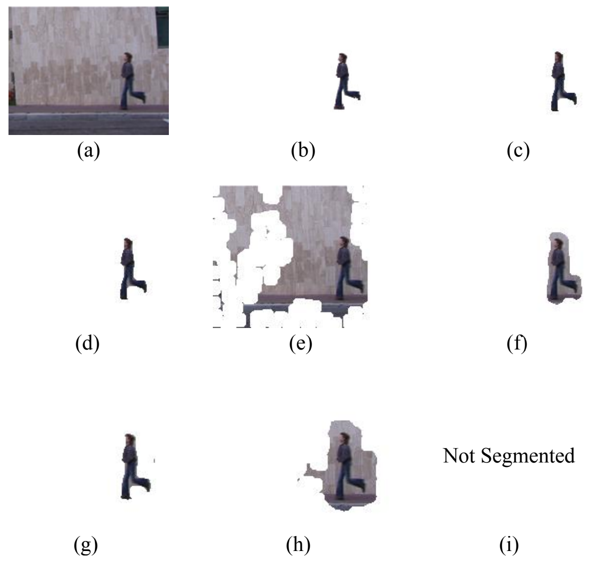
(a) (b) (c)

Figs. 4. Morphology Operation (a) frame original, (b) segmented objects, (c) Morphology operation

IV. Experimental Results

This experiment used a series video clips of Weizmann[1] dataset comprise 50 frames of low-resolution (180×144) at a frequency of 25 fps. For comparison purpose, we recounted the segmentation moving object by using two different FCM with distance and FCM with Gabor filter and Distance.

[1]http://www.ecse.rpi.edu/~cvrl/database/Activity_Datasets.htm



Figs. 5. Segmented moving object on 11th frame usingFCM+Gabor and variance distance. (a) Frame original (b) Ground truth (c) Euclidean (d) City Block (e) Canberra (f) Chebyshev (g) Minkowski (h) Bray Curtis (i) Jensen Shannon

The evaluations are performed by applying Mean Square Error (MSE) in the performance of method proposed for clustering moving objects on the segmentation process [22]. MSE is the mean squared error among the original images to the image processing results. Here, the image processing result is the image of moving object segmentation of image sequences.

The results are lower MSE value indicating better performance of the method. Performance of MSE is formulated as follows:

$$MSE(G,F) = \frac{1}{VY}\sum_{u=1}^{V}\sum_{t=1}^{Y}\left[G(u,t) - F(u,t)\right] \quad (22)$$

In which G is the ground truth image, F is the segmentation image of size $V \times Y$ and max is the maximum possible pixel value of the image. Performance evaluation of Gabor filter isdescribed in Fig. 7. It is compared only to FCM (Fig. 6). Beside, the application of Gabor filter is compared in different distance metric methods.

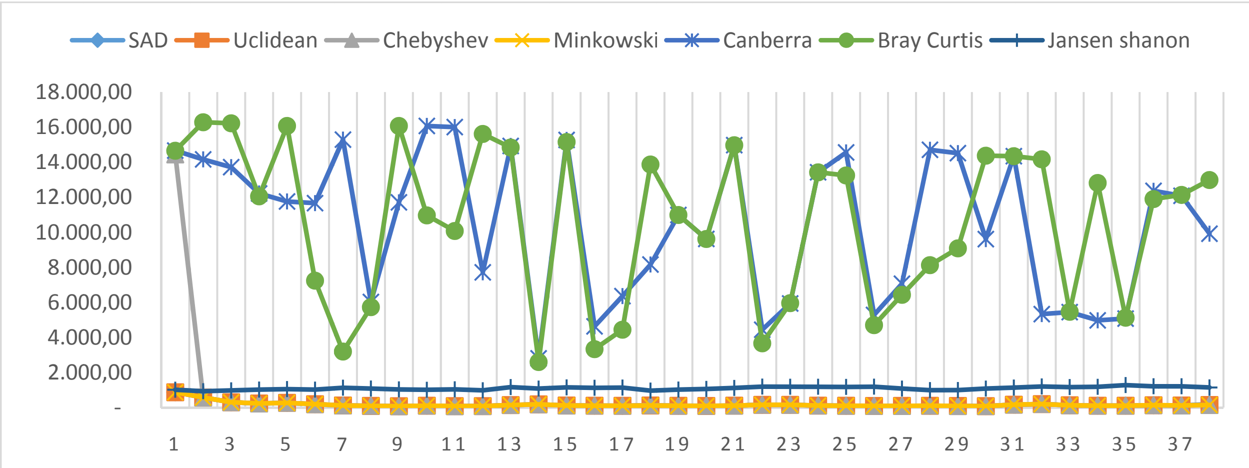


Fig. 6. MSE of Segmentation using FCM

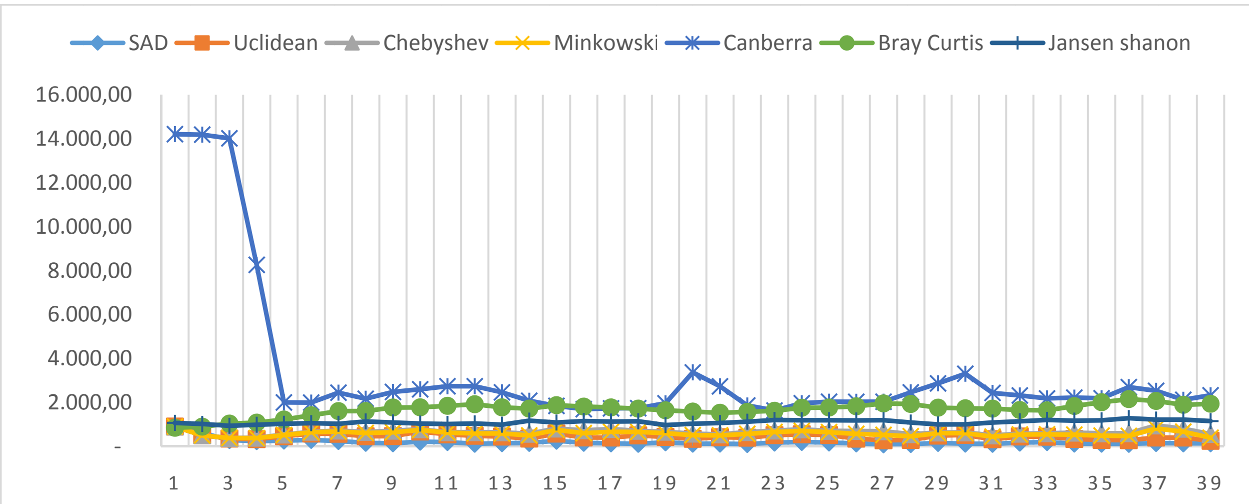


Fig. 7. MSE of Segmentation using FCM+Gabor

The result showed that it produces small MSE compared to the clustering method only. Derived from Fig. 6, the MSE of FCM are unstable. From the figures, Minkowski distance showed the best performance.

V. Conclusion

In this work, an automatic image of moving objects segmentation has been built by applying FCM and Gabor filter. It can be noted that Gabor filter is able to reduce the segmentation error of FCM. In the distance comparison, Minkowski distance shows the best segmentation result. In conclusion, the applied method has given a satisfactory result.

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Authors' information

[1]Electrical Engineering Department, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia.

[2]Computer Science Department, Dian Nuswantoro University, Semarang, Indonesia.

M. A. Soeleman received bachelor and master degree in 1999 and 2004 respectively from Computer Science Department Dian Nuswantoro University, Semarang, Indonesia. Since 2010, he has been studying at the Electrical Engineering of Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia as a doctoral student. He works as a lecturer of Computer Science Faculty, Dian Nuswantoro University, Semarang, Indonesia. His research interest includes image processing, computer vision and video processing.

Mochamad Hariadi graduated from Electrical Engineering Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia for his bachelor in 1995 and received MSc and PhD degree in 2003 and 2006 respectively from Graduate School of Information Science (GSIS) Tohuku University, Japan. He is currently lecturer of Electrical Engineering Departmen ITS. His research interest include multimedia processing and artificial intelligence. He is IEEE member and IEICE member.

Eko Mulyanto Yuniarno graduated from Electrical Engineering Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia for his bachelor in 1995 and received his Master and Doctor degree in 2005 and 2013 respectively from Graduate School of Electrical Engineering ITS Surabaya. He is currently lecturer of Electrical Engineering Department ITS. His research interest include computer vision, image processing and multimedia processing.

Mauridhi Hery Purnomo received bachelor degree from Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia in 1985. He received his M.Eng and Ph.D degree from Osaka City University in 1995 and 1997 respectively. He joined ITS in 1985 and has been a Professor since 2004. His research interest include intelligent system application, electric power system operation, control and management. He is an IEEE member.