Advances in Optics and Computer Vision

Journal homepage: http://www.aocv.ir

AOCV

Image features matching using two methods of GLCM and Morphology

Morteza Meschi
Kambiz Rahbar*

Department of Computer, South Tehran Branch, Islamic Azad University, Tehran, Iran
Corresponding Author, Email: k_rahbar@azad.ac.ir

ARTICLE INFO

Article history:

- *Received: 2017-10-10*
- *Revised: 2017-11-25*
- *Accepted: 2017-11-28*
- *Available online: 2017-12-3*

Keywords:
Image matching
Geometric feature
Statistical features
Feature extraction
Morphology
Gray Level Co-occurrence Matrix

ABSTRACT

Image matching is one of the significant fields of image processing as the process is recognized as a step of pre-processing which contributes to identification of changes, combination and mosaic of images. Image matching is referred to as a process of overlaying of two or more images of the same scene which were taken under different photographic conditions (i.e. different angles, different times, different sensors and type and nature of the photographed area) and this process registers the reference and perceived images geometrically. The result could be used for registering a wider range of images based on existing features. The innovation in this research is dedicated to separate analysis of texture and color properties and their combination afterwards. Sensitivity study of the introduced matching method is among the major contributions of this innovation as noisy and distorted inputs are applied and then the stability of the introduced matching method applied on this type of data is determined.

1. Introduction

Matching an image is a basic process of computer vision which involves finding two-dimensional features that represent the main feature in the observed scene. Matching the image is the first step towards visual computation. Since matching the image is related to the efficiency and accuracy of the subsequent processes, most researchers put their efforts in this area. Likewise, today, image matching is one of the common issues in medicine, technology, etc., with the growing range of research and new findings in this area. In other words, the goal of image matching is the uniformization of the geometric space of two images. Therefore, due to the various applications of image matching in different fields, many researchers have focused on this method of image processing and significant advances have been achieved. However, despite its specific applications and problems, it still exists as an active branch of image processing. In general, the image matching process, based on the techniques used to determine similar situations in the images, can be categorized into two general categories of area-based methods and feature-based methods. Feature-based methods are more reliable than area-based methods and have better performance in terms of geometric and radiometric distortions. Essentially, there are two goals in this discussion, Recognition and Alignment of objects under various geometric transformations [1-2]. In order to meet the needs of the first objective, it is often enough to find constant descriptors in some geometric transformations [3-4]. For the second target, the patterns need to be matched and the transformation parameters must be estimated. Different ways to achieve these goals are as follows:

1-1. Methods for Photometric Based Matching

Photometric-based matching is designed to deal with grey level images: in this case, the algorithm tries to match every pixel of both images, assuming the corresponding points and their neighbors have similar intensities [5]. These methods may be classified in three groups, following what is done in [6].

1-1-1. Correlation methods

The similarity of two sub-images is measured by a correlation (usually normalized cross-correlation). Given a sub-image of the first image, i.e. a part of it, correlation methods search for the most similar sub-image of the second image. The higher is the correlation value, the higher the probability that the two sub-images are matched. However, the traditional cross-correlation *measure is only applicable to short base-line motion, small image rotation and similar image scales. Some researchers introduced a scale-space method to handle the last two problems, but the first problem remains unsolved.*

1-1-2. Relaxation methods

In these methods, a few matches are first guessed. Some constraints derived from these first matches are then used to compute other ones. This process is repeated until no new match can be found. Such algorithms were proposed by Marr and Poggio [7-8], with further improvements by Grimson [9-10], and Pollard et al. [11-12].

1-1-3. Dynamic programming methods

Dynamic programming (also known as dynamic optimization) is a method for solving a complex problem by breaking it down into a collection of simpler subproblems, solving each of those subproblems just once, and storing their solutions. The next time the same subproblem occurs, instead of recomputing its solution, one simply looks up the previously computed solution, thereby saving computation time at the expense of a (hopefully) modest expenditure in storage space. (Each of the subproblem solutions is indexed in some way, typically based on the values of its input parameters, so as to facilitate its lookup.) The technique of storing solutions to subproblems instead of recomputing them is called "memoization." Examples of such algorithms may be found in [13-14]. Additionally, [15-16] is also falls in this category.

1-2. Methods for Geometric Based Matching

In the field of geometric feature matching, higher level features in images, such as edge points or line segments, are used for matching. The main purpose is to find a correspondence between subsets of data features in different images that are geometrically consistent. This is achieved by finding a transformation of each data object in one image (say the first image) which geometrically aligns it with the subset of the data features in other images corresponding to an instance of the data object. There are two main classes of methods for geometric based matching:

1. Transformation space searching.

2. Correspondence space searching.

1-2-1. Geometric hashing

method based on the indexing approach that originated in the work of Schwartz and Sharir [17]. Schwartz, Wolfson, and Lamdan applied the idea for model-based visual recognition and developed a new geometric hashing technique applicable to arbitrary point sets under various geometric transformations [18-20]. Additionally, [21-22] is also falls in this category.

1-2-2. Proximity matrix matching

An algorithm which matches two 2D point patterns was proposed by Scott and Longuet-Higgins [23]. Point patterns are described by their inter-image distances in the form of a proximity matrix. Then eigenvector decomposition is carried out. Matching is done by comparing the distances between the eigenvectors of the proximity matrices.

1-2-3. Geometric invariants

A geometric invariant is a measure to characterize a feature such as line configurations in an image, which does not change under any geometric transformation. Thus, projective invariants are invariant under a projective transformation while affine invariants are invariant up to an affine transformation. For images obtained by perspective projection, projective invariants can be computed to characterize and hence match point and line configurations [24-25]. Additionally, [26-27] is also falls in this category.

2. Matching the image using Morphology and Gray Level Co-occurrence Matrix

In all of the image processing methods, the first step involves receiving images that are being processed. In the matching process of proposed images, as shown in Figure 1, after extracting the image, in the next step feature extraction is performed. The RGB color model is an additive color model. Because the red, green, and blue colors are combined in different combinations and make a wide range of colors, this color model is one of the most well-known and most used color models. Therefore, for the feature extraction step, the RGB color image is used for the proposed work. In the proposed method of RGB color-based quality, for each red, green, and blue component, normally eight bits are considered, with a total of 24 bits showing 16777216 different colors for each image. Feature extraction follows the characteristics by which they can describe the image well. Characteristics are divided into two general categories of color-based properties and texture-based properties.

The extracted properties of the image are determined according to the intended application. Suppose, white and red boxes are supposed to be separated from each other in a production line.

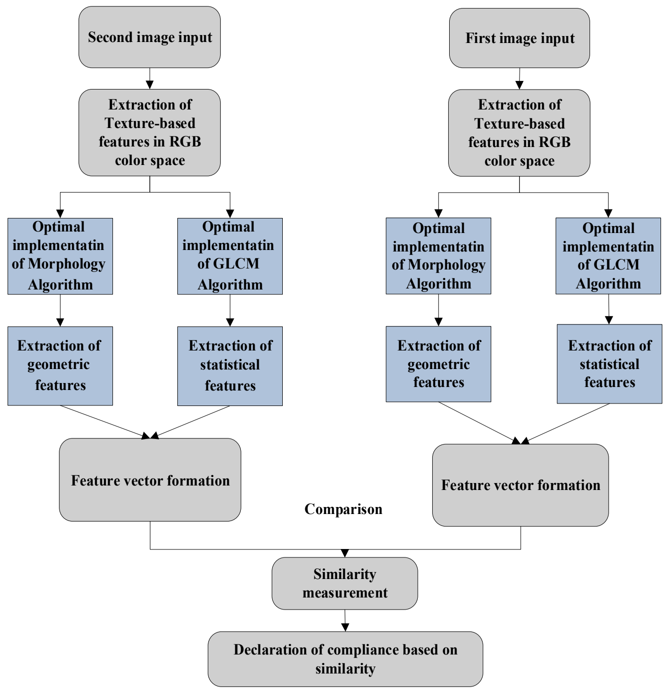


Figure 1 - Diagram of proposed solution

In this example, because of the difference in color, it is possible to separate the boxes from each other by extracting the color descriptor properties. But the color property alone cannot solve all the existing issues. Hence, in solving most of the machines visual issues, along with the color-based properties, the texture-based properties are also used. Therefore, in the proposed algorithm, the color and texture properties are used separately and then in combination. The moments used in the proposed method are the first and second order statistical properties and geometric properties. The geochemical properties of the images were extracted using the GLCM feature extraction method and morphological method was used to extract the geometric properties of the images.

The result of this extraction is 24 features for each image. All of these extraction features are presented in Table 1.

These characteristics can be evaluated individually as a similarity criterion in the images, so that they can be used to calculate the matching between the images based on the percentage of similarity.

The next step is to create a feature vector. All of the extracted features are linked together, and for each image, a feature vector is obtained that corresponds to the same image. In the end, by using the feature vectors obtained from the previous step, the similarity is performed by comparing the vectors of each image. Each image has a feature vector that represents that image. By comparing the feature vectors of two images, the similarity of these two vectors (actually two images) is determined. In this study, the correlation between two images is based on the percentage of similarity.

Table 1 - All properties extracted from images

difference Variance	*Correlation*	*Informaiton correlation*
Contrast	*Dissimilarity*	*Energy*
Homogeneity	*Normal Homogeneity*	*Maximum probability*
Sum average	*Sum Variance*	*Sum entropy*
Difference entropy	*Inverse difference normalized*	*Inverse difference moment*
Sum of squares Variance	*Cluster Shade*	*Cluster Prominence*
Autocorrelation	*Entropy*	*Opening*
Closing	*Rubbing*	*Expansion*

3. Laboratory results

The proposed method is evaluated on a challenging database called symbench_v1 [28], which includes pairs of images with significant appearance variations. In this database, there are 46 image pairs (two images in a folder), some of which are photographed over long distances, and some have a strong difference in brightness. Therefore, the data used for the implementations include different images in different dimensions and formats. In Figure 2, a few examples of this pair of images are shown.

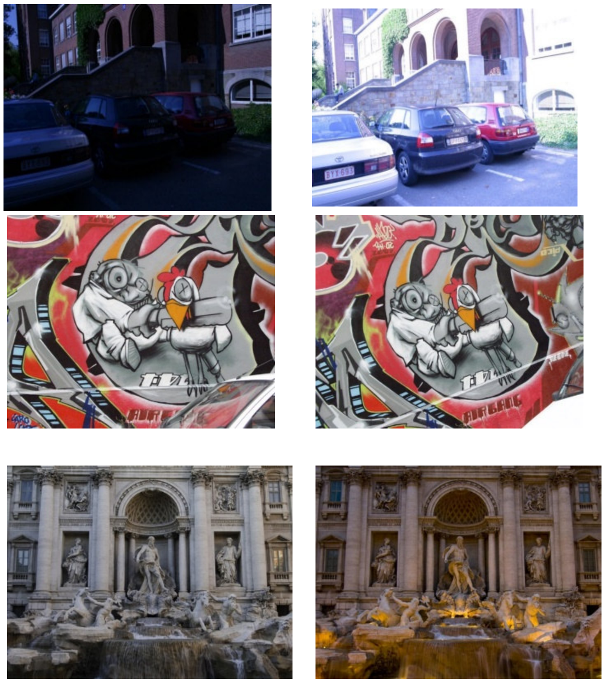


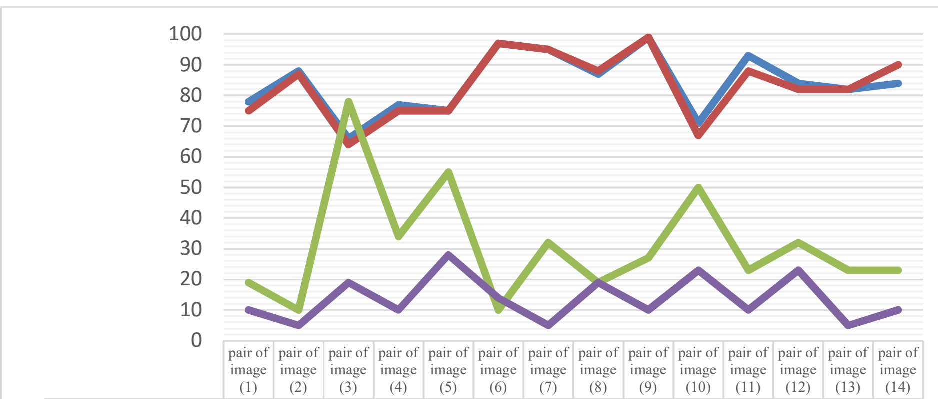
Figure 2 - Multiple examples from dataset

3-1. Evaluation of proposed method based on noise criterion

To evaluate the proposed method, the proposed algorithm is firstly evaluated based on the comparison of the previous results with the percentage of similarity and extraction characteristics in case of noise variations. The evaluation process is performed in such a way that the first input image is firstly obtained by the algorithm and then the second input image is given to the algorithm as a matching image after applying the salt & pepper noise (0.2). In order to evaluate the proposed algorithm based on the noise impact on the matching similarity percentage, the results of the 14 pairs of input images were compared in two noisy and noise-less states.

In Diagram 1, the results are shown on 14 pairs of images separately for geometric and statistical properties extracted from the images. These results show that geometric properties versus noise variations differ much less than the statistical characteristics and the proposed method has been able to achieve good results in this regard. Therefore, by weighing these geometric properties, more favorable results can be obtained in image matching after applying noise in total fusion.

In Diagram 2, the overall results are shown in noise application mode after weighing geometric properties with a 1.5-fold effect on all of the calculated characteristics. As shown in Diagram 2, these results are closer to each other in both Noise-less and Noisy states and can provide the analyzer with a more favorable percentage as output. It is worth noting that the process of weighting features has been carried out with the presumption of the existence of noisy images.



	pair of image (1)	pair of image (2)	pair of image (3)	pair of image (4)	pair of image (5)	pair of image (6)	pair of image (7)	pair of image (8)	pair of image (9)	pair of image (10)	pair of image (11)	pair of image (12)	pair of image (13)	pair of image (14)
Geometric	78	88	66	77	75	97	95	87	99	71	93	84	82	84
Geometric - Noisy	75	87	64	75	75	97	95	88	99	67	88	82	82	90
Statistical	19	10	78	34	55	10	32	19	27	50	23	32	23	23
Statistical - Noisy	10	5	19	10	28	14	5	19	10	23	10	23	5	10

Diagram 1 - Comparison of the results of the similarity percentage by geometric and statistical characteristics in the case of applying noise

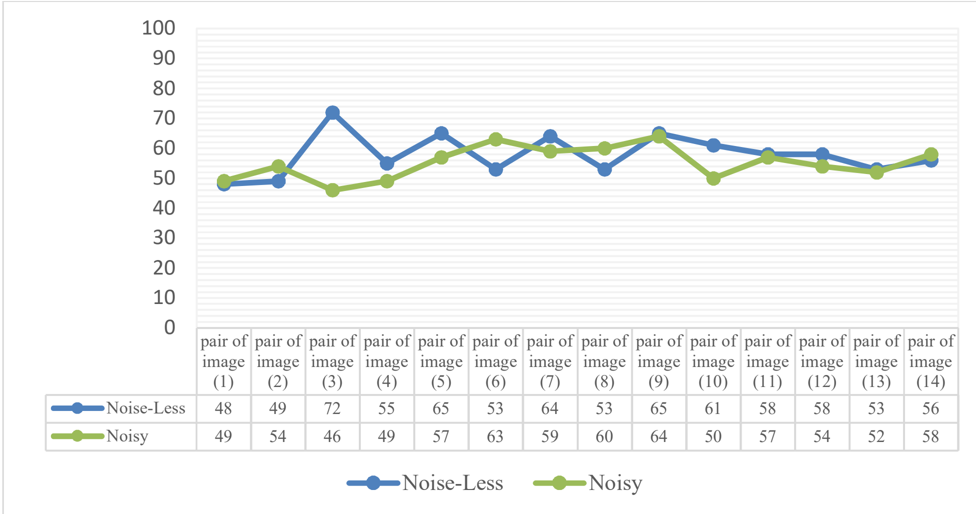


Diagram 2 - Comparison of the results of the similarity percentage of noisy and noise-less images after weighing the geometric properties

	pair of image (1)	pair of image (2)	pair of image (3)	pair of image (4)	pair of image (5)	pair of image (6)	pair of image (7)	pair of image (8)	pair of image (9)	pair of image (10)	pair of image (11)	pair of image (12)	pair of image (13)	pair of image (14)
Noise-Less	48	49	72	55	65	53	64	53	65	61	58	58	53	56
Noisy	49	54	46	49	57	63	59	60	64	50	57	54	52	58

3-2. Evaluation of proposed method based on distortion criterion

In the following, the proposed algorithm is evaluated on images with a certain percentage of distortion (deformation). For this purpose, the comparative images are rotated 5 degrees clockwise and bilinear is used (crop argument is used to maintain the output image size) to evaluate the effect of these changes on the output results. Then, in order to evaluate the proposed algorithm based on the criterion of distortion impact on the matching similarity percentage, the results of the 14 pairs of input images in two distortion-free and distorted modes were compared. Therefore, according to Diagram 3, the relatively low impact of the proposed algorithm against distortion variations is clearly visible, except in one case. In Diagram 4, the results are presented with 14 pairs of images to separate the geometric and statistical features extracted from the images. These results show that the statistical characteristics against the distortion variations differ much less than the geometric characteristics and the proposed method has been able to achieve the desired results in this regard. Therefore, without having to worry about these statistical properties, more favorable results could be obtained in matching images after applying distortion in total fusion. Of course, according to Diagram 3, indicating the results are in two distorted and non-distorted modes, one can consider the average of the fluctuations in all the features and consider the proposed method to be relatively resistant to the distortion variations.

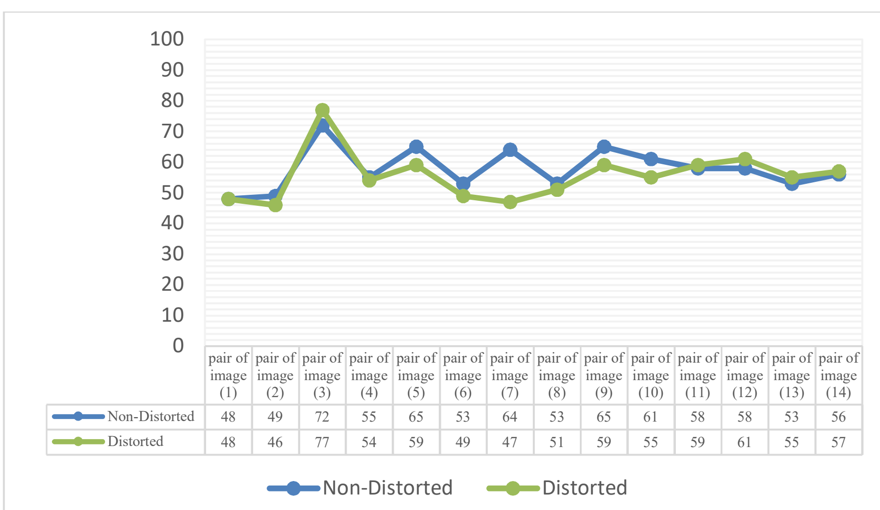
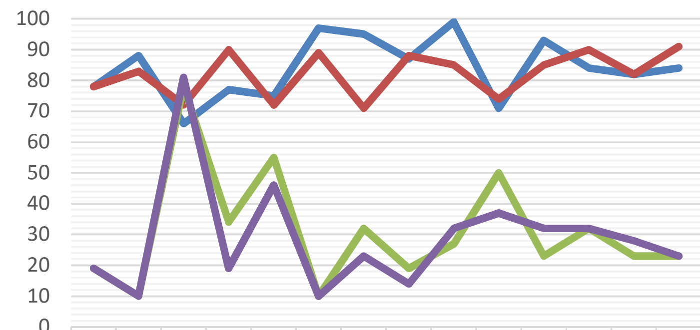


Diagram 3 - Comparison of the results of similarity percentage of distorted and non-distorted images

	pair of image (1)	pair of image (2)	pair of image (3)	pair of image (4)	pair of image (5)	pair of image (6)	pair of image (7)	pair of image (8)	pair of image (9)	pair of image (10)	pair of image (11)	pair of image (12)	pair of image (13)	pair of image (14)
Non-Distorted	48	49	72	55	65	53	64	53	65	61	58	58	53	56
Distorted	48	46	77	54	59	49	47	51	59	55	59	61	55	57



	pair of image (1)	pair of image (2)	pair of image (3)	pair of image (4)	pair of image (5)	pair of image (6)	pair of image (7)	pair of image (8)	pair of image (9)	pair of image (10)	pair of image (11)	pair of image (12)	pair of image (13)	pair of image (14)
Geometric	78	88	66	77	75	97	95	87	99	71	93	84	82	84
Geometric - Distorted	78	83	72	90	72	89	71	88	85	74	85	90	82	91
Statistical	19	10	78	34	55	10	32	19	27	50	23	32	23	23
Statistical - Distorted	19	10	81	19	46	10	23	14	32	37	32	32	28	23

Diagram 4 - Comparison of the results of similarity percentage of geometric and statistical characteristics in case of distortion

4. Summary

This report presents a new approach based on the process of extracting and analyzing geometric properties along with other statistical characteristics of the image for innovation in separate analysis of texture and color properties and their combination afterwards to achieve a method of matching image characteristics, and to match a more varied range of images based on existing features by taking advantage of this achievement. The results show that the proposed algorithm is applicable to images with different complexity, size and quality, and provides suitable analysis results. Also, the results obtained in noisy and relative distorted state indicate the stability of the proposed algorithm against such changes in the images. So that the proposed algorithm can maintain geometric properties against noise variations in order to be able to achieve a higher percentage of conformance by weighting these characteristics. Also, the proposed method is resistant to distortion variations and has been able to control the fluctuations of the extracted parameters from the statistical properties of the images, and even in general, the proposed method calculated close results in case of distortion in the comparative image.

Reference

[1] C. Harris, M. Stephens, "A combined corner and edge detector," 4th Alvey Vision Conference, p. 147–151, 1988 .

[2] J. Ben-Arie, Z. Wang, "Pictorial recognition of objects employing affine invariance in the frequency domain," Pattern Analysis and Machine Intelligence, vol. 20, p. 604–618, 1998 .

[3] J Heikkila, "Multi-scale autoconvolution for affine invariant pattern recognition," Pattern Recognition. Proceedings. 16th International Conference on, 2002 .

[4] T. Wakahara, Y. Kimura, A. Tomono, "Affine-invariant recognition of gray-scale characters using global affine transformation correlation," Pattern Analysis and Machine Intelligence, vol. 23, no. 4, p. 384–395, 2001 .

[5] M Sonka, V Hlavac, R Boyle, Image processing analysis and machine vision, 2014, p. 480 – 481.

[6] Faugeras, Three-Dimensional Computer Vision - A Geometric Viewpoint. Artificial intelligence, M.I.T. Press, Cambridge, MA, 1993 .

[7] D. Marr; T. Poggio, "Cooperative computation of stereo disparity," American Association for the Advancement of Science., vol. 194, p. 283 – 287, 1976 .

[8] D. Marr, T. Poggio, "A computational theory of human stereo vision," Proceedings of the Royal Society of London, p. 301 – 328, 1979 .

[9] WEL Grimson, "A computer implementation of the theory of human stereo vision," Philosophical Transactions of the Royal Society of London, p. 217 – 253, 1981 .

[10] WEL Grimson, "Computational experiments with a feature based stereo algorithm," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 7, p. 17 – 34, 1985 .

[11] S.B Pollard, "Identifying Correspondences in Binocular Stereo," PhD thesis,University of Shefield, 1985.

[12] SB Pollard, JEW Mayhew, JP Frisby, "PMF: A stereo correspondence algorithm using a disparity gradient constraint," Perception, vol. 14, no. 4, p. 449 – 470, 1985 .

[13] Baker, Henry Harlyn, "Depth from edge- and intensity- based stereo," Proceedings of the 7th International Joint Conference on Artificial Intelligence, p. 631 – 636, August 1981 .

[14] Y Ohta, T Kanade, "Stereo by intra and inter-scanline search using dynamic programming," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 7, p. 139 – 154, 1985 .

[15] H. Zhang, G. Kong, L. Ren, J. Jin, "An Inter-Projection Interpolation (IPI) Approach with Geometric Model Restriction to Reduce Image Dose in Cone Beam CT (CBCT)," Computational Modeling of Objects Presented in Images. Fundamentals, Methods, and Applications, 2014

[16] S. Haque, S.M. Rahmana, D. Hatzinakosc, "Gaussian-Hermite moment-based depth estimation from single still image for stereo vision," Journal of Visual Communication and Image Representation, Vol. 41, November 2016, p. 281-295

[17] Jacob T. Schwartz, Micha Sharir, "Identification of partially obscured objects in two dimensions by matching of noisy characteristic curves," The International Journal of Robotics Research, p. 29 – 44, 1987.

[18] Y. Lamdan, J. Schwartz, and H. Wolfson, "On recognition of 3D objects from 2D images Proc," IEEE Int'l Conf. robotics and Automation, IEEE Computer Soc., Los Alamitos, Calif., p. 1407 – 1413, 1988.

[19] Y. Lamdan, J. Schwartz, and H. Wolfson, "Object Recognition by affine invariant matching," Proc. IEEE Computer Vision and Pattern Recognition Conf. IEEE Computer Society, p. 335 – 344, 1988.

[20] Y. Lamdan, J. Schwartz, and H. Wolfson, "Affine invariant model-based object recognition," IEEE Trans. Robotics and Automation, vol. 6, no. 5, p. 578 – 589, 1990.

[21] V. Pătrăucean, M. Ovsjanikov, "Affine invariant visual phrases for object instance recognition," Machine Vision Applications (MVA), 2015 14th IAPR International Conference on, 18-22 May 2015

[22] H. Fu, J. Han, M. Ran, Z. Tian, "Affine-invariant registration using orthogonal projection matrices for object-based change detection," Signal Processing, Communications and Computing (ICSPCC), 2014 IEEE International Conference on, 5-8 Aug. 2014

[23] Guy L. Scott, H. Christopher Longuet-Higgins, "An algorithm for associating the features of two patterns," Proceeding of Royal Society London, p. 21 – 26, 1991.

[24] C.A Rothwell, "Hierarchical object descriptions using invariants," Proceeding of the DARPA-ESPRIT workshop on Applications of Invariants in Computer Vision, Azores, Portugal, p. 287 – 303, October, 1993.

[25] L. Morin, P. Brand, and R. Mohr, "Indexing with projective invariants," Shape, Structure and Pattern Recognition (D. Dori and A. Bruckstein, Eds.), World Scientific, Singapore, 1995.

[26] C. Liang and C. Juang, "Moving object classification using local shape and HOG features in wavelet-transformed space with hierarchical SVM classifiers," Applied Soft Computing, Vol 28, March 2015, p. 483-497

[27] C. Yang, O. Tiebe, K. Shirahama, M. Grzegorzek, "Object matching with hierarchical skeletons," Pattern Recognition, Vol 55, July 2016, p. 183-197

[28] Daniel Cabrini Hauagge, Noah Snavely, "Image Matching using Local Symmetry Features," IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2014.