Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A GENERAL FISH CLASSIFICATION METHODOLOGY USING META-HEURISTIC ALGORITHM WITH BACK PROPAGATION CLASSIFIER

[1]USAMA A. BADAWI AND [2]MUTASEM K. ALSMADI

[1,2]Department of Management Information Systems, Collage of Applied Studies and Community Service, University of Dammam, Kingdom of Saudi Arabia
Email: [1] ubadawi@ud.edu.sa, [2] mksalsmadi@ud.edu.sa

ABSTRACT

Problem statement: One challenging research area nowadays is pattern recognition. Many applications lay under the field of pattern recognition such as face and iris recognition, speech recognition, texture discrimination and optical character recognition. A system that recognizes isolated pattern of interest is called pattern recognition. The pattern under consideration could be an image. During the process of image recognition, many problems could occur such as noise, distortion, overlap, errors in the segmentation results and obstruction of objects in the image. Several approaches to handle and solve pattern recognition problems have been developed. Examples of such approaches are neural networks (NN), Contour matching, texture and color signature. **Approach**: The aim of this study is to develop a system to recognize isolated fish object in the image based on a combination between significant extracted features using anchor points, texture and statistical measurements. A generic fish classification could then be performed using a hybrid meta-heuristic algorithms (genetic algorithm with iterated local search) with back-propagation algorithm (GAILS-BPC), to classify the images of fish into dangerous and non-dangerous families, and to recognize the dangerous fish families into Predatory and Poison fish family, and recognize the non-dangerous fish families into garden and food fish family. **Conclusion and Results**: A prototype to deal with the problem of fish images classification is presented in this research work. The proposed prototype has been tested based on 24 fish families, each family contains different number of species. The proposed prototype has performed the classification process successfully. The experimental tests have been performed based on 320 distinct fish images. The 320 distinct fish images were divided into 220 images for training phase and 100 images for testing phase. An overall accuracy recognition rate is 80.5% that was obtained using the proposed GAILS-BPC.

Key words: *Feature Extraction, Anchor Measurements, Gabor filter, statistical measurements, Fish Images, Back Propagation Classifier, Iterated Local Search and Genetic Algorithm.*

1. INTRODUCTION

Previously, image recognition process based on human skills and senses. This has made the recognition process not accurate and insufficient. Therefore, as computers gained their place in the research area, it was obvious to think of using them in such important process. There are many approaches that are used for image processing and pattern recognition [1-7, 14, 17, 18 and 19]. In this research work, a prototype for image recognition using anchor points, texture and statistical measurements is introduced. The focus of this study is on fish images classification. This should benefit many fields such as agriculture, industrial and marine field. The system input is to be a fish image of specific size and format. Then the features of the fish images will be extracted using the anchor points, texture and statistical measurements in order to be classify using the meta-heuristic algorithm into dangerous and non-dangerous, and to recognize the dangerous fish families into Predatory and Poison fish family, and recognize the non-dangerous fish families into garden and food fish family.

2. PROBLEM STATEMENT

A number studies have been performed and conducted in the field of image recognition,

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

nevertheless; it is still an active area of research, due to many problems such as distortion, errors in the segmentation results, overlap and obstruction of objects in digital images [1-8, 13, 14, 17, 18 and 19]. Based on recent studies the developed fish recognition systems still have many limitations such as the low ability in detection and classification of fish. Moreover; a high number of deaths occur every day due to undifferentiating between dangerous and non-dangerous fishes [2-5].

3. RELATED STUDIES

To detect and identify fish in natural, underwater environments, Anderson et al in [6] has introduced a way to apply image processing techniques in the context of gray-level images. To achieve accurate segmentation, automatic image thresholding methods are explained, implemented, and applied - in conjunction with bac subtraction. One method to improve segmentation is by using a thinning edge procedure. To extract feature data, biometric principles such as WARP and Gabor filters are applied. Machine learning techniques such as Boltzmann machines, convolutional neural networks, and deep belief networks are trained to perform the classification.

The Gabor filter is used in several image processing applications. The output from the filter allows the location of any identification edges in an image. The process of feature extraction and classification is based upon using some known physical features of the fish images. For example, the E.morio fish has a distinct pattern at the edge of the tail that is much lighter in color than the rest of the fish. This pattern is small in width and runs for most of the tail. Gabor filters could be used to highlight this line on the tail, and classify the images based on the existence of the line or not [6].

It is important to determine a number of anchor/land mark points in the size and shape measurements. The detection of such points helps in finding a relevant set of anchor points for patterns of interest. Therefore, the geometrical features were calculated using the angle and distance measurements. These features were obtained from the shape and size measurements of fish object, after detecting the anchor/landmark points over the fish images [3].

Edge detection is a basic step to identify an image object. Shrivakshan and Chandrasekar in [20] have made a comparison among Edge Detection Techniques with a case study of identifying a shark fish type. Bad sensitivity to noise is one of the main drawbacks in Gradient-based algorithms. This is due to the static characteristics of the kernel filter dimension and its coefficients. Hence, it cannot be adapted to a given image. A novel edge-detection algorithm is required to provide solutions with minimal error levels. Such algorithm should be adaptable to the different image noise levels. This could help in determining the valid image noise produced contents. The performance of the Canny algorithm is based on the variant Gaussian filter standard deviation parameters, and its threshold values. The Gaussian filter size is controlled by the larger size and the greater value. More noise is produced by larger size. This is necessary for noisy images, as well as detecting larger edges. The edge localization has less accuracy then the larger scale of the Gaussian. A new algorithm is needed for smaller values to adjust these parameters. Changing the parameters will help user to modify the algorithm to suit different environments. Although the Canny’s edge detection algorithm has a better performance than Sobel, Prewitt and Robert’s operator, the Canny’s edge detection algorithm is more costly. The images evaluation showed that Canny, LoG, Sobel, Prewitt, Roberts’s are exhibited better performance, under the noise conditions respectively. There are many methodologies of using edge detection techniques namely the Gradient and Laplacian transformation. Although Laplacian performs better for some features (such as the fins), it still suffers from bad performance for some of the lines [20].

Alsmadi et al., in [5], recognized a fish object in the fish images using the combination between the effective extracted features from the measurements of color texture. Therefore; gray level co-occurrence matrix (GLCM) was used to extract number of features to be used in the classification process using back-propagation classifier. They have developed a method for handling fish classification problem. The method acquires a fish image, then segments the fish image using measurements of color texture. The performance of the proposed method has been conducted based on 20 different families of fish, with different number of species for each family, and the dataset consists of 610 fish images. Where, 500 fish images were used for training process, and 110 testing for testing process. The overall accuracy of the back propagation classifier was 84%.

Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. MARERIALS AND METHODS

This work has been applied on 320 fish images obtained from Global Information System (GIS) on Fishes (fish-base). Data acquired on September, 2013.

4.1 The Feature Selection Approach

Determining the biggest set of significant features is the main goal of the feature selection approach in order to be used for successful fish images recognition.

4.1.1 Gabor filter (GF):

In the image processing Gabor filter (GF) is used for edge detection which relies on the orientation representations and frequency [20]. GF behaves like the human perception system which belongs to particularly suitable for texture differentiation and representation. GFs are connected to the Gabor wavelets. Both of them can be implemented to be used for a number of rotations and expansions [20]. In the image processing field GF is very beneficial for edge detection. This work uses the GF for fish images recognition. Four image quality features (Standard Deviation, Contrast, Homogeneity, and Mean) were calculated based on the obtained image from the GF. Figure 1 shows the results of applying GF.

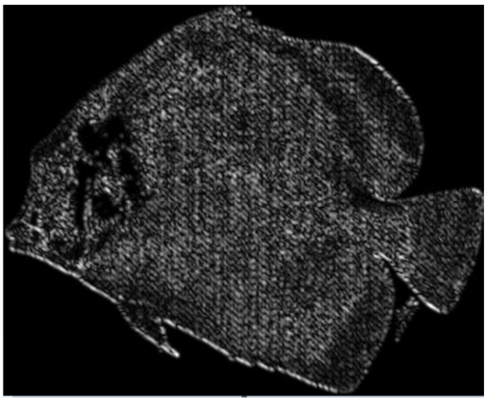

Figure 1: The results of applying GF.

4.1.2 Anchor points location detection:

A number of anchor points should be determined as labeled in Figure 2 in the fish shape measurements. In the last few years anchor point detection is the aim in many researches works in the field of pattern recognition. Points detection is applied to find a significant set of points that will help in obtaining the anchor measurements for patterns of interest (fish object). In this work the goal of anchor point detection is **to determine twenty three labeled points** that will help in determining the location of each feature for recognition of fish images. After that, the geometrical features will be calculated using the determined anchor points for the fish classification purpose. After detecting the whole anchor points over the fish object, significant features will be extracted using distance and angle measurements.

4.1.3 Shape measurements:

Shape measurements are used to calculate the edge and distance measurements of the fish object and to determine the significant similar and dissimilar parts for each fish family. Moreover; the classification procedure using the measurements of vector's angles using three points will lead to higher classification accuracy such as caudal fin angle and fish head angle [3]. Also; by using distance measurements a number of features can be determined and extracted such as radius of fish eye and pectoral fin length.

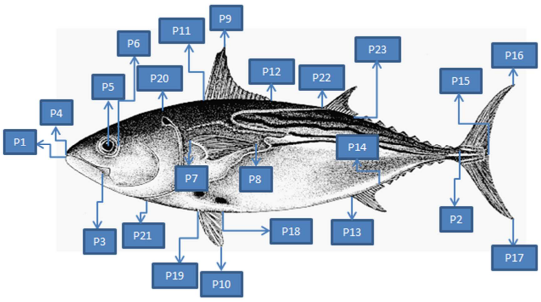

Figure 2: The locations of the anchor point measurements.

4.2 Extracted Features Calculation

Shape features were calculated using distance and angle measurements. The distance measurements is the distance between twenty one anchor points (P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P18, P19, P20, P21, P22, P23), see Figure 2. the angle between three anchor points over the fish object is the angle measurements ((P9, P4, P10), (P9, P16, P10), (P20, P4, P21), (P16, P15, P17), (P15, P10, P17), (P15, P9, P16), (P9, P15, P10) and (P16, P4, P17)) see Figure 2. Table 1 and 2 explained the selected anchor points and the feature calculation using distance and angle measurements are explained in the following subsection.

Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4.3 Distance Measuring Tools

Distance measurements are considered very useful tools in the field of pattern recognition to extract robust features in order to enhance the classification accuracy. In the field of algebraic geometry, the distance 'D' between the points C= (a_1, b_1) and E =(a_2, b_2) will be calculated by formula 1.

$$D = \sqrt{(\Delta a)^2 + (\Delta b)^2} = \sqrt{(a_2 - a_1)^2 + (b_2 - b_1)^2} \quad (1)$$

The twenty three anchor points as in Figure 2 shows the length between anchor points as in Table 1. Therefore; fifteen features were obtained using the formula of the distance measurement.

Table 1: fifteen extracted features from the determined anchor points.

D. N	Feature Name	Anchor points
D1	Fish length without the caudal fin	dist(P1, P2)
D2	Fish width without the upper and lower fins	dist(P11, P19)
D3	Mouth length of fish	dist(P1, P3)
D4	Distance between the right- end of mouth and the eye center	dist(P3, P5)
D5	Radius of the fish eye	dist(P5, P6)
D6	Pectoral fin length	dist(P7, P8)
D7	Length of first dorsal fin (spinous)	dist(P11, P12)
D8	Anal fin length	dist(P13, P14)
D9	Caudal fin length	dist(P2, P15)
D10	Pelvic fin length	dist(P19, P10)
D11	Head width	dist(P20, P21)
D12	Length of second dorsal fin (soft rays)	dist(P22, P23)
D13	Distance between the right- end of mouth and the eye center	dist(P5, P3)
D14	Distance between the right-end of first dorsal fin and the start of second dorsal fin	dist(P12, P22)
D15	Distance between end of the pelvic fin and the start of the anal fin	dist(P18, P13)

4.4 Calculating the Angles

An angle is a union of two line segments with a common endpoint. The common endpoint is defined as the vertex of the angle and the rays represents as the sides of this angle [9]. It can be written as, if ∠B represents the vertex angle and A, B represents the points of the two sides. The angle will be represented as ∠CEJ or ∠JEC. Therefore; The distance between two points (C, E) can be calculated using the distance formula (as equation 2). When the distances of the two sides are obtained, the internal angle θ will be obtained as well. The cosine rule is the only choice

The angle θ will be calculated by the following formula:

$$b^2 = a^2 + c^2 - 2ac\cos B \quad (2)$$

$$\cos B = \frac{a^2 + c^2 - b^2}{2ac} \quad (3)$$

Table 2 illustrated the obtained eight features that calculated using the angle measurements based on the anchor points as explained in Figure 2.

Table 2: the nine features that calculated using the determined anchor points

A.N	Feature Name	Anchor description
A1	The angle of lower triangle	P15,P10,P17
A2	The angle of upper triangle	P15,P9,P16

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A3	Caudal fin Angle	P16,P15,P17
A4	Fish head Angle	P20,P21,P1
A5	Front triangle angle	P9,P15,P10
A6	the whole fish angle	P16,P4,P17
A7	Eye-end mouth Angle	P1,P3,P5
A8	Second caudal angle	P9,P4,P10
A9	Rear triangle angle	P9,P16,P10

5. STATISTICAL MEASUREMENTS

In this section statistical measurements were conducted using the features that were extracted from fish images which belong to 24 fish families, in order to determine and obtain the significant features that will help to get high recognition accuracy and recognize the fish images into its dangerous or non-dangerous family. Table 3 shows the correlation results based on the features that were extracted using anchor points measurements.

Based on the statistical results which were obtained from the extracted features, the correlation value between some extracted features (head, eye and caudal angles) are different, which could be considered as good features that can be used in this work, to enhance the classification accuracy. For example; in the dangerous fish families, the correlation value between the head and eye angles are negative (which means that as the head angle increases the eye angle decreases), and the correlation value between the caudal and eye angle is also negative. Whereas in some non-dangerous fish families the correlation value between the head and eye angle is positive (which means that as the head angle increases the eye angle increases), and the correlation values between the caudal and eye angles are also positive. Thus; the obtained correlation values of the extracted features are varied from family to another, which will increase the differentiation between the fish families (poison, non-poison, wild and food fish families).

Table 3: The Correlation Results Based On The Features That Were Extracted Using Anchor Points Measurements.

Fish Family #	*Correlation(Head_ Angle , Eye _Angle)*	*Correlation (Caudal _ Angle , Eye _Angle)*
1	-0.10	-0.10
2	-0.22	-0.12
3	-0.23	-0.20
4	-0.11	-0.13
5	-0.11	-0.11
6	-0.21	-0.13
7	-0.24	-0.21
8	0.12	-0.14
9	-0.13	-0.59
10	-0.60	0.67
11	0.18	-0.087
12	-0.83	-0.39
13	-0.44	0.13
14	-0.70	-0.20
15	0.38	0.27
16	-0.56	-0.27
17	-0.11	0.34
18	-0.17	0.03
19	-0.36	-0.21

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

20	-0.35	0.22
21	-0.01	-0.29
22	-0.34	-0.17
23	-0.12	0.01
24	-0.30	0.39

5.1 Genetic Algorithm

A genetic algorithm (GA) is a population based heuristic approach that simulates the procedure of natural selection. The GA is used to generate useful new solutions to solve difficult problem based on sample solutions in a population. GA consists of three main phases which are a selection technique that attempts to select two solutions from the population and recombining them. Michalewicz in [16] has recommended a different type of selection techniques such as Tournament Selection, Truncation Selection and Roulette Wheel Selection. A crossover operator which perform for a mating process; crossover is the genetic way to find a new solutions (with better fitness value) in the search space. A Mutation operator which consider as a local search to find the neighbor solutions, and update the population in order to improve the quality of the search space by generate better solutions (new solutions with better fitness value) [12].

5.2 Iterated Local Search

Iterated Local Search has many advantages, it is simple to understand, highly effective for different optimization problems, easy to implements, and robust as well. The basic idea is searching in a small sub-space instead of searching in whole search space of solutions; this subspace is the local optimal solutions for a predefined optimization engine [11 and 15].

ILS relies on the fact that local search can be easily getting trapped in the local optimum. Rather than starting again the local search from the beginning and generate new solution randomly. ILS disturbs the existing local optimum and moving it to a new position behind the neighborhood searched using the ILS. Therefore; it is necessary to allow the ILS to avoid getting trapped in the local optima. For further explanations refer to [11 and 15]. The general structure of the ILS is shows in Figure 3 below.

General structure of Iterated Local Search

Begin

$S_0 = Generate\ initial\ Search\ Space$

$S^* = Local\ Seach\ Space\ (S_0)$

Repeat

$S' = Perturbation\ (S^*, history)$

$S^{*\prime} = Local\ Search\ Procedure\ (S')$

$S^* = Acceptance\ Criterion\ (S^*, S^{*'}, history)$

Until termination condition met

End

Figure 3: The General Structure Of The ILS [15].

5.3 Neural Network Model

The neural network with BP algorithm is used for training and classification purpose as illustrates in Figure 4, which shows the applied neural network model that involves of three layers. The neurons number for the input and hidden layer were selected based on the experiment that were conducted in this work, in order to decide the suitable neurons number to enhance the classification accuracy [21], whereas the number of neurons in the output layer will be twenty four, since the proposed GAILS-BPC need to classify twenty four fish families.

Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

In the experimental part, the back-propagation classifier was implemented with a set of input features. According to [2] back-propagation classifier is suffering from some drawbacks such as getting trapped in the local optima and low convergence rate. In order to overcome these drawbacks, this work proposed A hybrid meta-heuristic algorithm (GAILS-BPC). The meta-heuristic algorithm is utilized for solving the problems in the optimization fields, and its highly effectiveness of getting trapped in the local optima compared the traditional back-propagation algorithm. Table 3 indicates number of neurons for each neural network layer and the input number of the extracted features.

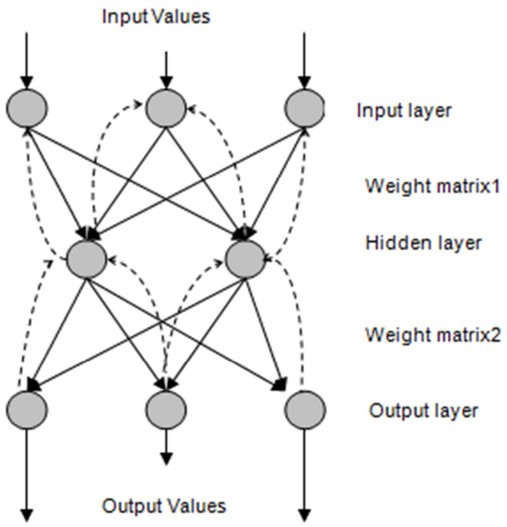

Figure 4: The Neural Network Model Consists Of Three Layers [2].

Table 3: Indicates Number Of Neurons For Each Neural Network Layer And The Input Number Of The Extracted Features.

Classifier	NO. Neurons in layers			Input number of input extracted features
	Input .Layer	H. Layer #1	Output. Layer #3	
BPC	30	50	24	30
GAILS-BPC	30	50	24	30

6 EXPERIMENTAL RESULTS

In the experimental results the recognition accuracy test results for each family (24 fish families) were obtained based on 30 combined extracted features using anchor points detection, Gabor filter and statistical measurements. Where, these extracted features were trained and tested using GAILS-BPC. Therefore; the obtained results indicated the success of the features extraction and recognition methods in obtaining high classification accuracy compared with previous methodology that was reported in the literature. Thus; the percentage of the recognition results lay between **98%** as the best accuracy results and **75% as** the worst accuracy results.

The variation of the results is due to that most of fish families have similar shape and texture among each other and might contain the original pixel values, which causes similar extracted features values that will increase the complexity of the

Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

extracted features which will be trained and classified using the proposed GAILS-BPC. In the other hand some fish families has its own species-specific-traits. That helps the proposed GAILS-BPC to classify the fish families. For example, some of the non-poison fish family has the similar angle of upper triangle with other dangerous fish families, as well as these non-poison fishes has several dissimilar features such as the distance between the right-end of first dorsal fin and the start of second dorsal fin, Pelvic fin length and Head width, are usually dissimilar from fish family to another. The recognition accuracy results for each family of fish using the features that were extracted from shape measurements, statistical and texture measurements are illustrated in table 4.

Therefore; the families of the dangerous fish were recognized successfully with high classification accuracy, because of their species-specific traits (different shape compared with other family) which different with other non-poison and poison families of fish. Moreover; the overall accuracy of recognition training results is 93% and the overall accuracy of recognition test results is 93% as shows in table 4.

Table 4: The Recognition Test Accuracy Results Based On Anchor Points, Texture And Statistical Features For Each Fish family.

	Family Name	BPC%	GAGD-BPC%
Dangerous fish families	Carcharhinus Leucas	81	84
	Carcharodon Carcharias	80	82
	Atractosteus Spatula	80	83
	Hydrocynus Goliath	81	83
Poison fish families	Red Snapper	82	85
	Trigger	88	89
	Porcupine	83	85
	Thorn	85	89
	Acestrorhynchidae	83	87
	Acropomaatidae	83	86
	Albulidae	81	85
	Anomalopidae	83	86
	Caesionidae	82	85
	Drepanidae	82	84
	Istiophoridae	81	84
	Leiognathidae	81	83
	Megalopidae	80	82
	Platycephalidae	79	83
	Priacanthidae	81	85
	Scombridae	81	86
	Siganidae	83	85
	Sillaginidae	79	85
	Stromateidae	81	86
	Triacanthidae	80	84
	Overall accuracy	82%	85%

7. DISCUSSION

The extracted features from the proposed methods (anchor points, texture and statistical measurements) and the proposed classifier ILSGA-BPC perform better compared with other traditional methods such as [14, 17, 18 and 19] in terms of speed and recognition accuracy. anchor points and texture measurements methods are less affected by the fish expression and the global variations in the appearance of fish object inside the image.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Moreover; the developed hybrid classifier ILSGA-BPC outperform the traditional BPC based on the extracted features using Gabor filter, angle and distance tools. ILS with GA significantly improve the recognition accuracy of the BPC by enhancing and optimizing the weights that will be used in the training and testing process of the BPC. Table 4 shows the obtained results using the developed ILSGA-BPC and implemented BPC.

8. CONCLUSION

This paper proposed a novel methodology for general fish classification based on significant combined features that have been extracted using Gabor filter, anchor points detection, statistical measurements from texture and shape measurements. Where 4 features were extracted using Gabor filter, 24 features were extracted using angle and distance tools and 2 features were extracted using statistical measurements. Then; the combined extracted feature are used for the recognition of fish images by the hybrid meta-heuristic algorithms (genetic algorithm with iterated local search) with back propagation classifier (GAILS-BPC), to classify the fish images into dangerous and non-dangerous, and to recognize the dangerous fish families into predatory and poison fish family, and recognize the non-dangerous fish families into garden and food fish family. The proposed features extracting methods and the meta-heuristic algorithm significantly improved the recognition accuracy of the BPC by enhancing and optimizing the weights that will be used in the training and testing process of the BPC.

ACKNOWLEDGEMENT

Deep thanks are due to the Deanship of Scientific Research at the University of Dammam by which this project no. (2013099) was funded. Grant titled "A General Fish Classification Methodology Using Meta-heuristic Algorithm with Back Propagation Classifier".

REFERENCES

[1]Al-Omari, S.A.K., P. Sumari, S.A. Al-Taweel and A.J.N. Husain (2009). Digital recognition using neural network. J. Comput. Sci., 5: 427-434. http://www.scipub.org/fulltext/jcs/jcs56427-434.pdf.

[2] Alsmadi M., Omar K.B., Noah S.A., and Almarashdeh I. (2011), "A Hybrid Memetic Algorithm with Back-propagation Classifier for Fish Classification Based on Robust Features Extraction from PLGF and Shape Measurements." *Information Technology Journal, vol. 10. pp. 944-954.*

[3] Alsmadi M., Omar K.B., Noah S.A., and Almarashdeh I. (2010), "Fish Recognition Based on Robust Features Extraction from Size and Shape Measurements Using Neural Network. Journal of Computer Science 6 (10): 1088-1094.

[4] Alsmadi M., Omar K.B., Noah S.A., and Almarashdeh I. (2009)," Fish recognition based on the combination between robust features selection, image segmentation and geometrical parameters techniques using artificial neural network and decision tree." Int. J. Comput. Sci. Inform. Secur., vol. 6, pp. 215-221.

[5] Alsmadi M., Omar K.B., Noah S.A., and Almarashdeh I. (2010)," Fish Recognation Based on Robust Feature Extraction from Color Texture Measurements Using Back-Propagation Classifier. Journal of Theoretical and Applied Information Technology. pp. 11-18.

[6] Anderson J, Lewis B. and O'Byrne C (2011). Intelligent Fish Classi_cation in Underwater Video. Research Experience for Undergraduates (REU) and the University of New Orleans funded by a grant from the National Science Foundation.

[7]Badawi U., and Alsmadi M. (2013), "A Hybrid Memetic Algorithm (Genetic Algorithm and Great Deluge Local Search) With Back-Propagation Classifier for Fish Recognition," *International Journal of Computer Science Issues (IJCSI),* vol. 10.

[8] Bai, X., X. Yang and J.L. Latecki, (2010). Detection and recognition of contour parts based on shape similarity. Patt. Recog., 41: 2189-2199. J. Computer Sci., 6 (10): 1088-1094.

[9] Bogomolny A. (2014), " What Is Angle?," from Interactive Mathematics Miscellany and Puzzles http://www.cut-the-knot.org/WhatIs/WhatIsAngle.shtml, Accessed 21 April 2014.

[10] Chen, K., V. Kvasnicka, P.C. Kanen and S. Haykin, (2001). Supervised and unsupervised pattern recognition: Feature extraction and computational intelligence. IEEE Trans. Neural Networks, 12: 644-647. DOI: 10.1109/TNN.2001.925570.

[11] Derbela H., Jarbouia B., Hanafi S., and Chabchouba H. (2012), "Genetic algorithm with iterated local search for solving a location-routing problem," Expert Systems with Applications, vol. 39, no. 3, pp. 2865–2871, 2012 *extended ed.)*. New York, NY, USA: Springer-Verlag New York, Inc.

[12] Goldberg, D. (1989). Genetic Algorithms in Search, Optimization, and Machine Learning.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[13] Kim, J.S. and K.S. Hong, (2009). Color-texture segmentation using unsupervised graph cuts. Patt. Recog., 42: 735-750. DOI: 10.1016/j.patcog.2008.09.031.

[14] Lee, D.J., R. Schoenberger, D. Shiozawa, X. Xu and P. Zhan, (2008). Contour matching for a fish recognition and migration monitoring system. Stud. Comput. Intell., 122: 183-207.

[15] Lourenc¸o, H., Martin C., and St¨utzley T. (2000), "Iterated Local Search," pp. 1-42.

[16] Michalewicz, Z. (1996). *Genetic algorithms + data structures = evolution programs (3nd,*

[17] Nery, M.S., A.M. Machado, M.F.M. Campos, F.L.C. Padua and R. Carceroni et al., (2005). Determining the appropriate feature set for fish classification tasks. Proceedings of the XVIII Brazilian Symposium on Computer Graphics and Image Processing, Oct. 912, IEEE Xplore Press, USA., pp: 173-180. DOI: 10.1109/SIBGRAPI.2005.25.
New York: Addison-Wesley.

[18] Pornpanomchai C., Lurstwut B., Leerasakultham P., and Kitiyanan W. (2013), "Shape- and Texture-Based Fish Image Recognition System," *Kasetsart J. (Nat. Sci.),* vol. 47, pp. 624 - 634.

[19] Salberg A.-B. r., Hardeberg J., Jenssen R., Larsen R., Olafsdottir H., and Ersbell B. r. (2009), "Shape and Texture Based Classification of Fish Species," in *Image Analysis*. vol. 5575: Springer Berlin Heidelberg, pp. 745-749.

[20] Shrivakshan G. T. and Chandrasekar C. (2012), "A Comparison of various Edge Detection Techniques used in Image Processing," *International Journal of Computer Science Issues,* vol. 9, no. 1 pp. 269-276.

[21] Alsmadi M., Omar K., and Noah S. (2009), “Back Propagation Algorithm : The Best Algorithm Among the Multi-layer Perceptron Algorithm”. International Journal of Computer Science and Network Security. Vol. 9 No. 4 pp. 378-383.