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Feature Extraction Based on Cellular Particle Swarm Optimization Algorithm for American Sign Language Images

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Abstract: Image Recognition is becoming a critical task and many problem-solving systems and approaches for image detection, analysis and classification are introduced by many modern researcher. The techniques should be user friendly and ease to interpret for both normal people and special people, it they should be analysed. The sign language act as a mode to transfer and exchange the message, information, knowledge and ideas from deaf to common people. The gaining information and responses to the pattern or gesture is called as sign. Sign Language is only mode to communication between the hearing-impaired people and common people. In this method each individual gesture is called as sign. In this system the American Sign Language recognition system which is used for visually impaired people to access and educate the special children's. American Sign Language (ASL) images of a special people is collected with some constraints are taken as the dataset. The objective of the research work is done with three different Phase. Phase1 is pre-processing, Phase 2 is segmentation and Phase 3 is feature extraction for static hand gestures with the maximum possible accuracy rate. A novel approach for the proposed system is analysed with its structural feature extraction and compared with its parameters. The novel feature extraction is made with 8 different structural features they are Bounding Box, Area, Perimeter, Centroid, Roundness, EquiDiameter, Number of Boundaries and Angle. F-Measure, Recall and Precision based on this Accuracy, Sensitivity and Specificity are measured for features are extracted images. The accuracy of the new Phase has been found significantly higher.

Keywords: Structural Feature Extraction, pre-processing, segmentation, image recognition, hand recognition.

INTRODUCTION:

Gesture is a physical movement to express the individual thoughts with the help of hands, head, or facial expression. Gesture recognition is about tracking and interpreting every movement done by our body. The Sign Language Recognition is with Human Computer Interaction (HCI), is act as a mode to translate the communication between deaf-mute and normal people. The Automated ASL are robustness, reliability, computational efficiency, scalability, and orientation. Orientation in sign language recognition is operated in pre-processing phase, processing of raw image to processed image by focus on proposing a new filtering techniques or algorithm to get a better result. It is designed with four essential parameters they are hand shapes, hand movements, hand orientations and hand locations to attain the most accurate. The second phase is segmentation in this Pre-processed image is taken as input and performs edge detection operation on several methodologies such as Sobel, Prewit, Robert and Canny method.

The canny method performs much better than other methods; based on the results canny is processed with PSO-Canny and CPSO-Canny for edge detection. The proposed algorithm outperforms the CPSO on all evaluated metrics. The parameters are same for both the novel PSO and optimized CPSO. The third phase is structural feature extraction; here we computed eight different features to extract the image with its novel parameters to attain the accuracy. This resulted in the development of Automatic American Sign Language Recognition Systems [ASLRS] which could automatically translate the signs into corresponding text and voice based hand gesture recognition using natural computation interpreter.

LITERATURE REVIEW

HeminaBhavsar, Dr.Jeegar Trivedi [1] in this paper presents different features of sign like hand shape, rotation, angles, movements, coordinates, pixel intensity so on. In real time the system capture sign continuously to generate meaningful sentences. In this paper they worked with words, alphabets and numbers by different signers.

V.Adithya, R.Rajesh [13] describes about ISL are analysed and classified with two different neural network such as support vector machine (accuracy of 90%) and convolutional neural network (accuracy of 96.25 %). The classification performances of the neural network are evaluated using different metrics they are precision, recall and F-score values.

I.A.Adeyanju, O.O.Bello, M.A.Adegboye [16] SVM has been proposed for the recognition of different sign language in real-time. The system combined with shape to extract features from the sign language. The performance of SVM has been compared different classifier, model achieved best recognition accuracy in Sign Language Recognition (SLR) system.

M. V. D. Prasad, P. V. V. Kishore, E. Kiran Kumar, D. Anil Kuma [14] says that the network is trained and tested with different samples there by the recognition rate increases. The Recognition Rates Compared and DWT fusion has a clear edge over Sobel edge operator then canny edge operator in ANN.

Ahmed Sultan , Walied Makram , Mohammed Kayed and Abdelmaged Amin Ali [18]The variety of sign language datasets, which includes different gestures, leads to different accuracy 97.62% due to gloves, sensors, and leap devices on CNN using preprocessing steps such as skin detector, image segmentation, hand tracking, feature extraction, and hand's gesture classification. Nikhil Gupta, we produced a model with training and validation accuracy of 89.1% and 98.6%, respectively, as well as training and training 18Yulius Obi et al. / Procedia Computer Science 216 (2023) 13–20 [14] Y.Obi et al. / Procedia Computer Science 00(2022) 000–000 validation errors of 35.5%and5.3% respectively Nikhil Gupta, we produced a model with training and validation accuracy of 89.1% and 98.6%, respectively, as well as training and training 18Yulius Obi et al. / Procedia Computer Science 216 (2023) 13–20 14

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METHODOLOGY OF SIGN LANGUAGE RECOGNITION

The optimizedFeature Extraction method is proposed to develop Automatic American Sign Language Recognition System with CPSO Segmented image as input. Feature vector is constructed with American signs (alphabets) to extract the structural features from different signs and increase the optimization based on the F-Measure, Recall and Precision. The Accuracy of the optimized extraction is higher.

1. Data collection

The digital camera captured the position of the hands. The background is white color and the distance between the hand and web camera is to be maintained in 1 to 3 feet. The image has two components that are background and hands. The snapshot images are stored in database. Each snapshot images were constructed for the true position of the hand. The signer hand, result different alphabets. ASL has 26 different alphabets are captured from a special school and the dataset from 75 children's are collected [6]. The image in the fig 1 represent the sign image of alphabets.

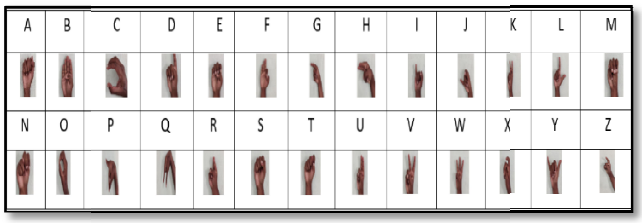

Fig 1: Sample Dataset

2. Image Pre-processing

The captured hand gesture images are in RGB colour. In the pre-processing the input image is resized and converted into a grey scale image which lies between the ranges of 0 to 255. In that image, the noise reduction is performed by Median filter, Weighted Median Filter(WMF)and proposed noise reduction method WMF–PSO based filter.

Weighted Median Filter – Particle Swarm Optimization [WMF – PSO]

The proposed filter uses Deep Clustering processing, which uses only optimized weights for the selective pixels of the corrupted image. The fig 2 explains the flowchart of proposed filter and its step wise process[11].

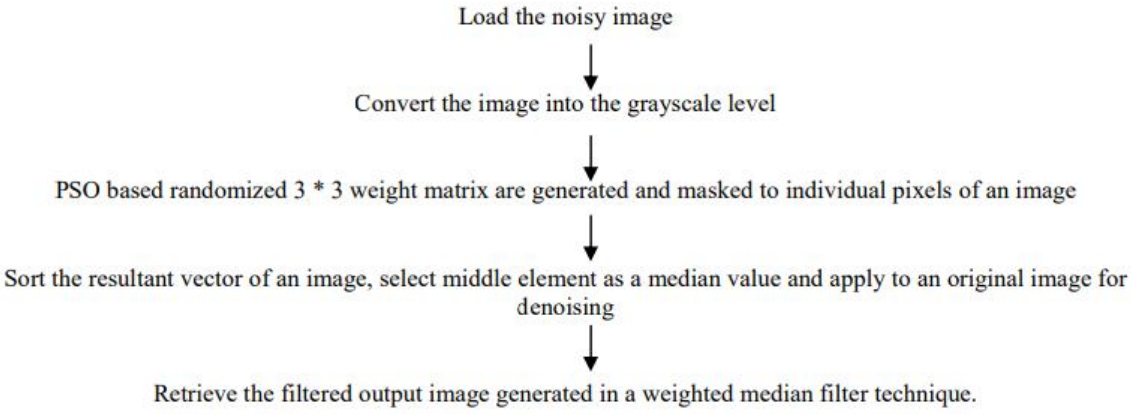

Fig 2: The proposed work of WMF-PSO.

An algorithm processes the corrupted images by detecting the impulse noise in the input image [19]. The pre-processed input image shows the different in the resulted image as given below in figure3.

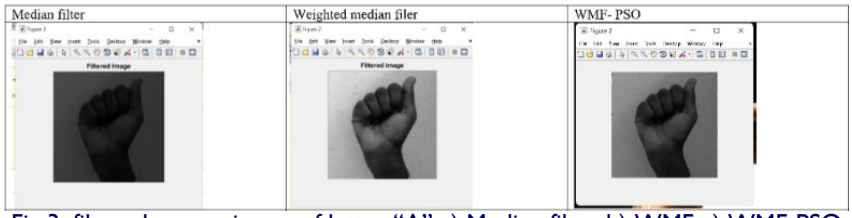

Fig 3: filtered output image of letter "A" a) Median filter b) WMF c) WMF-PSO

Some of the metrics used in Pre-Processing:

1. **Peak Signal-to-Noise Ratio (PSNR)** is distinct as the quantitative assessment between original pixel values and restore noise value of the image as denotedin eqn. **PSNR=10 $\log_{}$**

2. **Mean Square Error (MSE)** is defined as the qualitative assessment that measures the degree of distortion between the restored image ($\hat{y}$) and original image (y) as denotedin eqn. **MSE = (1/n) * Σ(y-$\hat{y}$)2**

3. **Signal-to-Noise Ratio (SNR)** is defined as mean of pixel values and the standard deviation e of the pixel values of an image as denoted in eqn. **SNR=10log10(Psignal/Pnoise)**

4. **Mean Absolute Error (MAE)** is distinct as the average difference of absolute error between original image (y) and test image ($\hat{y}$) as denoted in eqn. **MAE = (1/n) Σ(i=1 to n) |y_i – $\hat{y}$_i|**

Both MSE and MAE are good evaluation metrics. MAE estimates the mean distribution of error in all the Tamil sign language digital images, which are taken for this experimental study. MSE is most suitable metric to measure the model performance when the error distribution is expected to be Gaussian.The metrics used for pre-processing are compared, PSNR with MSE and SNR with MAE the result is shown in fig 4.

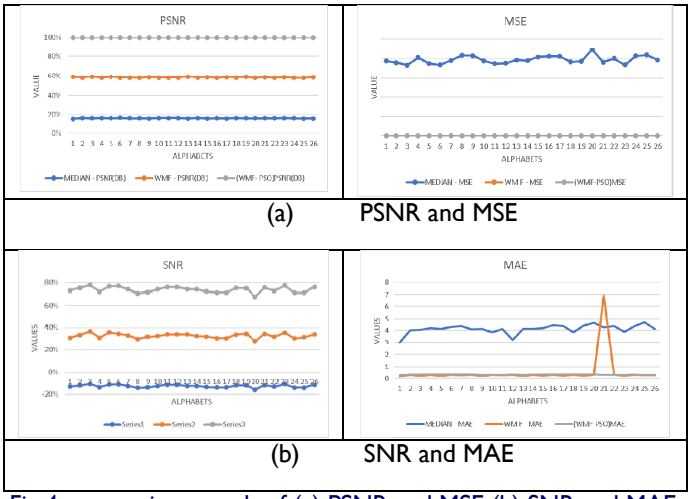

Fig 4: comparison result of (a) PSNR and MSE (b) SNR and MAE.

3. Segmentation

The Pre-processed image is taken as input in Sobel, Prewit, Robert and Canny method. The canny method performs much better than other methods, based on the results canny is processed with PSO-Canny and CPSO-Canny for edge detection.

Algorithm for the C-PSO is given as:

Step 1: Initialize the particles
Step 2: Compute velocity of every particle and its new position
Step 3: Repeat step 1&2 until attain fitness function
Step 4: Compare the fitness value of each particle with the value of individual best of Pbest
Step 5: If the current value of a particle is better than Pbest, then the value is set to Pbest and update position in the problem space
Step 6: Identify the neighborhood best (Gbest) particle in the population
Step 7: If the current value of a particle is better than Gbest, then the value is set to Gbest. The index value of a current particle is updated

The proposed algorithm outperforms the CPSO on all evaluated metrics. The parameters are same for both the novel PSO and optimized CPSO. The size and weight of the particles were set to 100 for PSO and 1000 for CPSO based on fitness evaluation function and its iterations. The result of canny edge detection method, PSO based canny and CPSO based canny are given in table1. The proposed work is implemented in MATLAB and real time American Sign Language datasets has been collected from signers with limitation of single-handed palm side right-handed signs with white background. Each sign is captured with 25 different signers. Some of the metrics that are calculate to find the segmentation of foreground and background using equation as

True positive (TP) occurs when the positive image detection really is positive
False positive (FP) exam occurs when positive image detection is really negative
True negative (TN)an image detection that is truly negative
False negative (FN) occurs when the negative image detection is actually positive

Accuracy = True Positive / (True Positive+True Negative)*100

In this CPSO canny has found better than PSO canny and canny edge detection based on Pearson Correlation Coefficient (PCC), Similarity Index (SI), Signal to Noise Ratio (SNR) and Mean Square Error (MSE), True positive (TP), False Positive (FP), True Negative (TN), False Negative (FN) and Accuracy is shown in the fig 5[15].

Metrics	Canny	PSO Canny	CPSO Canny
Accuracy	81.9	90.1	93.7
TP	82.3	87.6	94.9
FP	25	36.8	19.3
TN	75	63.4	80.5
FN	17.9	12.4	5.2

TABLE 1: Performance metrics for edge detection

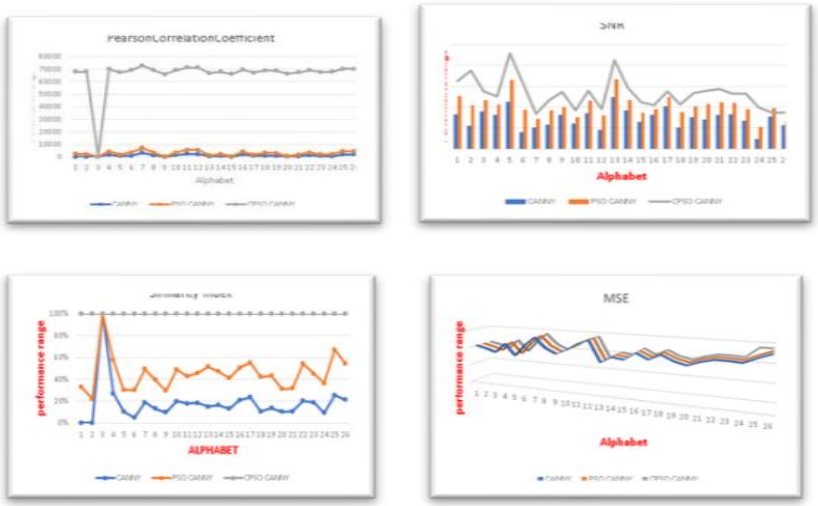

Fig 5: performance metric comparison for PCC, SNR, SI and MSE for three methods.

4. Feature Extraction

Feature extraction starts from an initial set of measured data and builds derived values after finding the edges of the hand image. The structural features of the sign include Bounding Box, Area, Centroid, Perimeter, Equiv Distance, Roundness, Number of Possible Boundaries and Angles.

The features which are extracted from the images are:

- **Bounding Box** - A bounding box is the physical shape for a given object. It defines the physical shape of an object, though it may be much different in size and shape than the objects visual appearance.
- **Centroid** - The Centroid or geometric centre of an object with all the points in the shape. The Centroid is the mean position of all the points in all of the coordinate directions.
- **Area** –The actual number of pixels in the region.
- **Perimeter** - The total number of pixels around the boundary of each region in the image.
- **Equiv diameter -** The length of the shortest path between two points. Distance may refer to a physical length of an object.
- **Roundness -**Roundness is the measure of how closely the shape of an object approaches that of a circle.
- **Number of boundaries -**Trace the possible number of boundaries of regions in image.

The feature extracted values for 26 different signs are show in the (Table 2)

ALPHABET	BBox				Obj_area	Centroid		Perimeter	EquivD	Roundness	numberOf Boundaries	angle
A	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	156	167.7
B	5.5	254.5	1	1	1	6	255	100	1.12	0.0013	204	169.9
C	8.5	253.5	2	2	2	9.5	255	102.8	1.59	0.0024	218	173.5
D	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	179	167.7
E	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	257	167.7
F	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	195	167.7
G	8.5	254.5	1	1	1	9	255	100	1.12	0.0013	158	173.5
H	5.5	253.5	2	2	2	6.5	255	102.8	1.59	0.0024	166	169.9
I	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	183	167.7
J	4.5	254.5	1	1	1	4.5	255	100	1.12	0.0013	207	167.7
K	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	133	167.7
L	4.5	253.5	2	2	2	5.5	255	100	1.59	0.0024	150	167.7
M	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	269	167.7
N	5.5	253.5	1	2	2	6	255	102	1.6	0.0024	220	169.9
O	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	177	167.7
P	7.5	253.5	1	2	2	8	255	102	1.6	0.0024	188	172.6
Q	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	202	167.7
R	4.5	253.5	2	2	2	5.5	255	102.8	1.6	0.0024	156	167.7
S	5.5	254.5	1	1	1	6	255	100	1.13	0.0013	226	169.9
T	4.5	254.5	1	1	1	5	255	100	1.13	0.0013	190	167.7
U	4.5	254.5	1	1	1	4.5	255	100	1.13	0.0013	186	167.7
V	4.5	254.5	1	1	1	5	255	100	1.13	0.0013	211	167.7
W	4.5	254.5	1	1	1	5	255	100	1.13	0.0013	181	167.7
X	4.5	254.5	1	1	1	5	255	100	1.13	0.0013	231	167.7
Y	7.5	253.5	1	1	1	8	254	100	1.13	0.0013	250	172.6
Z	4.5	254.5	1	1	1	5	255	100	1.12	0.0013	177	167.7

Table2: Structural Features for sample Dataset

Feature extraction for the alphabets are computed based on the image foreground and backgroundedge detection it evaluate by true positive, true negative, false positive and false negative. The image segmentation metrics is computed with feature extraction to classify the accuracy rate of the dataset.

Accuracy – it is the ratio of the correctly identify the image as denoted in eqn.

Accuracy = (TP+TN)/(TP+FP+FN+TN)

Precision- Out of all the images that predicted as positive, how many are really positive image as denoted in eqn.

Precision = TP/(TP+FP)

Recall -Out of all the positive images, how many are predicted as positive image as denoted in eqn.

Recall = TP/(TP+FN)

F-Measure -F-Measure considers both precision and recall. It is average of the precision and recall as denoted in eqn.

F-Measure=2*(Precision*Recall)/(Precision +Recall)

Specificity

Out of all the images that do not have the detected correctly, how many got positive results as denoted in eqn.

Specificity = TN/(TN+FP)

ALPHABET	Recall	Precision	Recall	Fmeasure	Specificity	Accuracy
A	4.3	72.69	8.1	1.4538	1.3907	98.58
B	4.5	75.14	8.5	1.5029	3.2208	98.62
C	4.5	75.68	8.5	1.5136	2.3561	98.63
D	4.6	76.56	8.7	1.5311	2.3831	98.65
E	4.5	75.04	8.5	1.5008	3.4607	98.62
F	4.6	76.56	8.7	1.5311	2.3831	98.65
G	4.5	75.04	8.5	1.5008	3.4607	98.62
H	4.6	75.89	8.7	1.5179	2.7211	98.63
I	4.6	77.11	8.7	1.5422	2.0229	98.66
J	4.5	75.85	8.5	1.517	2.3438	98.63
K	4.6	75.08	8.7	1.5016	2.5301	98.62
L	4.6	76.23	8.7	1.5246	2.0583	98.64
M	4.5	75.13	8.5	1.5025	3.1175	98.62
N	4.5	74.6	8.5	1.492	2.5581	98.61
O	4.5	75.72	8.5	1.5145	2.1393	98.63
P	4.6	75.61	8.7	1.5123	2.1665	98.63
Q	4.5	76.1	8.5	1.522	2.3539	98.64
R	4.6	75.82	8.7	1.5165	2.1665	98.63
S	4.5	74.62	8.5	1.4924	2.5113	98.61
T	4.5	75.57	8.5	1.5115	2.5394	98.63
U	4.5	75.07	8.5	1.5013	2.6497	98.62
V	4.6	75.51	8.7	1.5102	2.4147	98.63
W	4.6	75.22	8.7	1.5045	2.3652	98.62
X	4.6	76.21	8.7	1.5241	1.9607	98.64
Y	4.6	75.96	8.7	1.5192	2.402	98.64
Z	4.6	77.37	8.7	1.5475	1.7067	98.66

Table3: Performance metrics for feature extraction

CONCLUSION

Sign Language Recognition is a wide area of research. The deaf assistive system can bridge the communication gap between hearing impaired and normal people without isolating them in the society by this ASL Automation System [17]. The research developed here is a principled technique that will enable the use, not only in sign language or hand gesture recognition but also in other related areas of computer vision. In future classification is done for the improvement in accuracy and sign recognition as both voice and text which will be useful for all kind of people. In the proposed work, features are extracted using very simple mathematical formulas but to improve the performance of new geometric features can be used. The system implemented as sign to text interpreter can also be reversely implemented as text to sign interpreter.This proposed approach will be been a significant contribution for constructing Automated American Sign Language Recognition System.

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ABBREVATIONS:

ASL -American Sign Language
PSO – Partial Swarm Optimization
CPSO – Cellular Partial Swarm Optimization
ASLRS- American Sign Language Recognition Systems
WMF-PSO - Weighted Median filter – Particle Swarm Optimization
PSNR - Peak Signal-to-Noise Ratio
MSE - Mean Square Error
SNR- Signal-to-Noise Ratio
MAE -Mean Absolute Error
PCC - Pearson Correlation Coefficient
SI -Similarity Index
TP - True positive
FP - False Positive
TN - True Negative
FN- False Negative (FN)