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Identification and Recognition of Rotavirus- A Particles in Microscopic Images using Enhanced Hybrid Segmentation Methods

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Abstract: ***The medical image processing or the medical imaging helps in identifying the different types of diseases that are infected to human body. We know that virus is an infective agent that cannot be seen by the human eyes and this can be viewed with help of a microscope. Rotavirus is type of virus that affect human infants that causes diarrhea, which leads to death in severe condition. Identifying the virus particles in the microscope image is a tedious task. Giving prescription based on the medical diagnosis is dependent how accurately it is done. In this paper, the study of identification, segmentation and feature extraction of the Rotavirus-A in the electron microscopic images is considered. The proposed research method hybridizes four segmentation methods which identifies and classify the rotavirus-A particles in the microscopic image based on their features. The classification is carried out using Decision tree classifier and the accuracy rate is measured. The proposed method yields 96% average accuracy result and this can be improved by considering more dataset and training on it.***

Keywords: ***Medical Imaging, Rotavirus-A, Image Segmentation, Classification, Active Counter Model Region Based Extraction, Fuzzy Connectedness, Decision Tree Classifier.***

I. INTRODUCTION

Medical image processing mainly includes the procedure which is used to attain images of the body parts for medical uses. It helps in medical studies and processing helps to identify the diseases that is affected in the body parts. There are many imaging procedures implemented in medical imaging field which helps the doctors to diagnose the disease. Medical Imaging is improving due to the rapid improvement image processing techniques like image analysis, recognition and enhancement has got many advantages. Bio-medical imaging is a type of medical imaging which helps to understand the type of virus or the affected body part.

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Bio-medical imaging has got a drastic expansion and has got many advantages in research filed which attract the different domains experts in streams like sciences, mathematics, biology, physics, medicine [1]. The raw medical image data is processed based upon problem-specific approach and the selective visualization is done and the analysis is done in the data [1]. A virus can be an infectious agent which reproduce only within a living cell of an organism. All life forms such as animals, plant, micro-organisms like bacteria can be infected by the virus. The structure of virus mainly includes three parts mainly the genetic material which contains the DNA or RNA molecules, the protein coat which is surrounded and protects the genetic material in it and the lastly the envelops of lipids in the outer region.

Rotavirus belongs to the family Reoviridae which is contains double-stranded RNA. Rotavirus is the main reason for the infection which cause diarrhea or stomach flu among infants and young children around the world [2]. At the age of 5 nearly every child in the world has been infected by this virus that mainly affect the immunity power in the infants.

This virus is of mainly seven types such as A,B,C,D,E,F and G, Rotavirus A is main cause for the diseases in humans and other species[2].This virus can be easily manageable diseases in childhood ,but in 2013 worldwide 37 percent of death of children was reported that is around 2,15000 infants [4].

In microbiology the cell region segmentation is an important step in the analysis of the affected virus particles of the electron microscopic images. In diagnoses the result should be accurate and more should be more useful in order to obtain the data information that can assist the microbiologist. The segmentations are based on nonparametric algorithm that are categorized as edge based, region based, neural based, histogram based and clustering algorithm. The noise is an important factor in segmentation process so the region based and clustering algorithm are introduced in this paper. The algorithm deals with the four segmentation methods, then extract the features and finally the data is classified using the Decision Tree Classifier. The algorithm uses the infected child f faeces images which is acquired by Transmission Electron Microscope shown in “Fig.1”. The hybrid algorithm introduced in this deal with the segmentation and identification of rotavirus-A by applying the segmentation methods. The organization of the Section 1 describes about the introduction, Section 2 presents the proposed research method of segmentation, experimental results and classification, Section 3 presents conclusion.

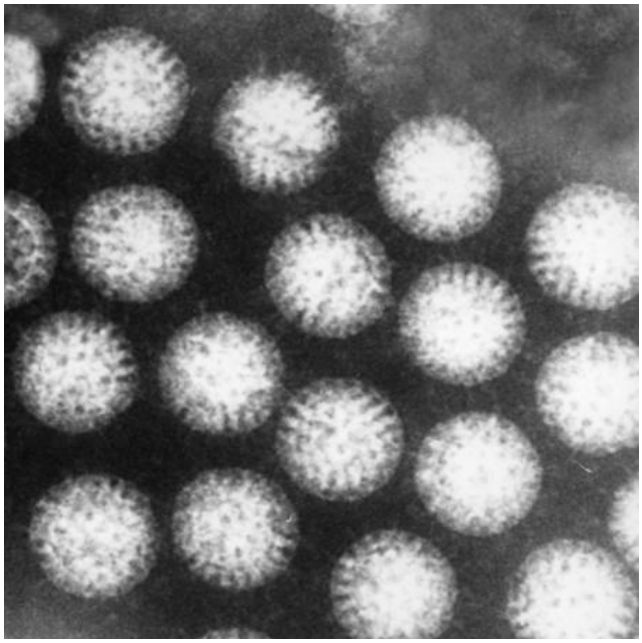

Fig. 1.Example of a Rotavirus-A image acquired form infeceted child.

II. LITERATURE REVIEW

In [5] Fuzzy c means (FCM) algorithm is an unsupervised technique that can be applied in feature analysis and image segmentation. The method helps to classify the image by grouping the similar data points into clusters. The FCM algorithm can be used to yield more region, this algorithm is less sensitive to noise and helps to remove noisy spot.

In [6] Fuzzy Connectedness helps in defining the objects in the image. This method put forward the affinity which helps to identify the strength between two image elements. Based upon the single seed region the segmentation can be done within the image.

In [7] Active Counter method helps to detect edges, segmentation and feature extraction are the main application of this method. This method helps to segment the boundaries of the objects in the image.

In [8] Marker Controlled watershed segmentation is mainly used to detect the objects in the image. Initially pre-processing is done, then segmentation and finally the extraction of features and then the maximum and minimum values are taken and then classification is done.

III. PROPOSED METHOD

The proposed algorithm includes two phases mainly training and testing phases as shown in "Fig 2". The training algorithm begins with the considering the training set which contains 50 electron microscopic images of the infected child and these images are taken as the input to the system. The system mainly includes the four segmentation techniques like Absolute Fuzzy Connectedness, Fuzzy c means (FCM), Active Counter region extraction and Marker controlled watershed segmentation. The segmentations are applied to the single image input and the features like area, eccentricity, compactness, perimeter etc. are mainly extracted in the system. The features collected from the segmentation methods are stored. Then the data collected will be stored then using the Decision Tree-classification the accuracy is calculated and stored as the knowledge base.

In this testing phase the single image input is given to the system and from the Decision Tree-Classification trained database the given input image features are checked and identifies whether it is virus affected particles or not.

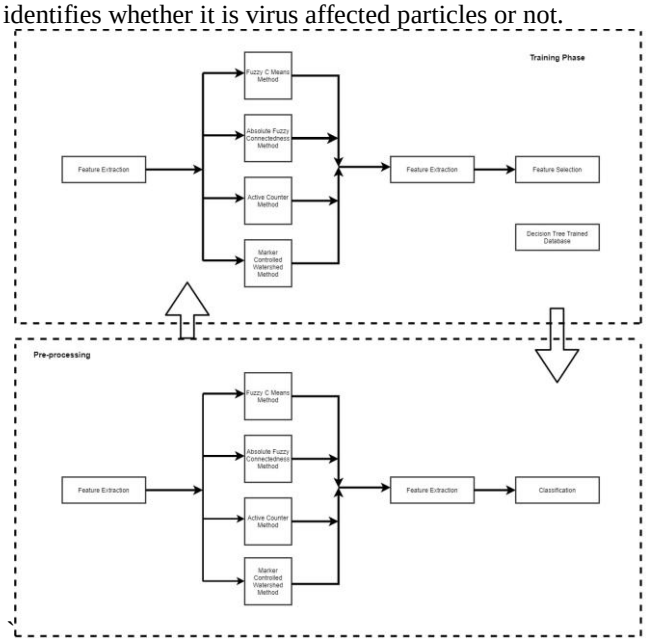

Fig. 2.Block Diagram of Propsed Method.

A. Fuzzy C Means Segmentation

Fuzzy C Means clustering (FCM) is mainly used for segmenting the noisy images. This clustering method can be applied mainly for feature extraction form an image. Fuzzy C Means clustering technique deals with segmenting the image into clusters which is having similar spectral properties. The segmentation uses the distance between the pixels and cluster center in the image. This algorithm assigns the pixel to each category which is done using the fuzzy membership. The convergences can be detected by comparing the changes in the membership function or considering the clusters [5]. In this system, the fuzzy c means clustering was implemented to find out the virus particles in the electron microscopic image and features are extracted.

B. Absolute Fuzzy Connectedness

The fuzzy connectedness segmentation method has been implemented in medical applications [6]. Fuzzy connectedness framework mainly uses local phase and the feature asymmetry to define the novel affinity function that process the segmentation algorithm [12]. Generally, images are fuzzy in nature and the main approach is to extract the objects information in the images. The main aim of this segmentation is to capture the properties based upon fuzzy properties like the hanging togetherness and graded composition [11]. The image element is having the fuzzy adjacency relation based upon the points they are in, if the points are closer than the adjacency is more between the points [11]. The affinity which is known as the local fuzzy relation are used to assign the strength of connectedness.

In an image the degree to which the elements are hang together is specified by affinity [6]. The fuzzy connected object containing a particular seed element is processed using dynamic programming [6]. The objects are identified based upon the seeded fuzzy connectedness inside the image and feature extraction is done after identify the objects.

C. Active Counter Region Based Extraction

Active counter region-based extraction is mainly implemented in-order to detect the object boundary in image processing techniques. In this method the segmentation is based on the movement of the curves through the input image that is snake or active counter, this movement can be based upon the influence of internal force that is based on object and the external force of the image [10]. The boundary of the image gives the internal and external force so the features can be extracted. The main application of these method includes the object tracking, edge detection, shape modelling etc. The movement of the curve starts from the object to detect and when this reaches the object boundary the movement stops.

D. Marker Controlled Watershed Segmentation

Marker controlled watershed method can be used for the segmentation based on the morphological operations in the image [13]. The image is considered as catchment basins and also based on the gradient magnitude the touching objects are identified. The watershed function identifies the objects in the image, this method contains external voice is added and leads to over segmentation. In order to overcome the drawback marker-controlled watershed segmentation is implemented. The proposed algorithm is mainly based upon the segmentation.

E. Decision Tree Classification

Decision tree methodology is mainly used in data mining for the building the classification system based upon the data and the also the predication algorithm is developed which is meant for the target. The regression or the classification model is in the form of tree structure. The dataset set is breakdown into smaller subsets and the simultaneously the associated decision tree is developed. The resulted tree contains two node such as decision node and leaf nodes. In this decision node will be having two or more branches and the classification is represented by leaf node.

IV. EXPERIMENTAL RESULT

In the training phase the four segmentation gives the extracted feature such as area, eccentricity, perimeter, circularity, tortuosity, length and compactness of rotavirus-A particles. For the experiment 50 electron microscopic images of the affected are considered and segmentations are implemented.

The segmentation are as follows:

1) Fuzzy C Means Segmentation:

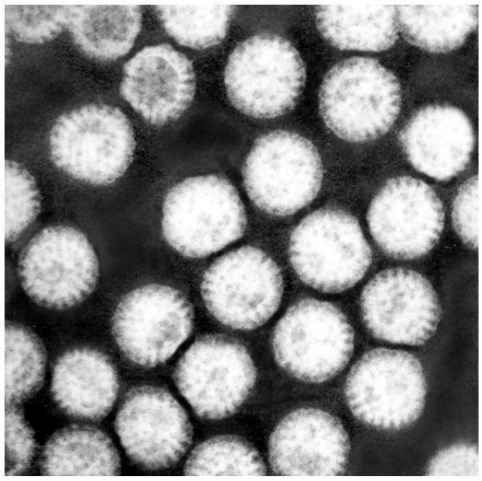

Fig. 3.Orginal Rotavirus-A TEM image.

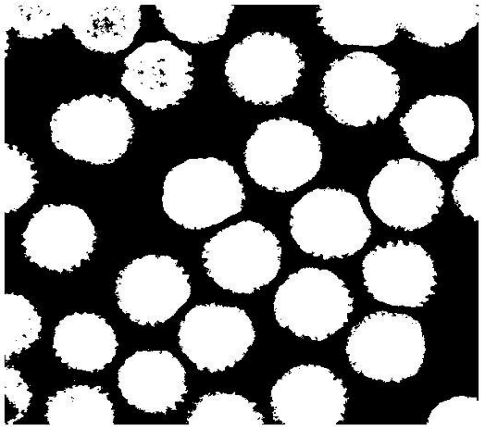

Fig. 4.Clustering operation on the image

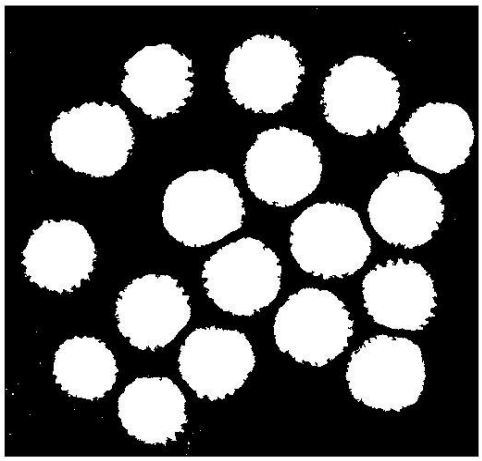

Fig. 5.Segmented virus particles in the image.

Table- I: The geometric feature values of the Fuzzy C Means.

Rotavirus-A Features	Area	Eccentricity	Perimeter	Circularity	Tortuosity	Width Ratio	Compactness
Particle 1	4952	0.375262	342.901	0.52924	0.241268	1.078843	1.8895
Particle 2	5875	0.362928	352.652	0.593643	0.255208	1.073172	1.684515
Particle 3	3829	0.401513	277.507	0.624809	0.263476	1.091878	1.600489
Particle 4	5172	0.415908	346.349	0.541802	0.246543	1.099618	1.845693
Particle 5	4424	0.329838	312.772	0.568289	0.247773	1.05928	1.759668
Particle 6	4755	0.402954	331.248	0.54457	0.247027	1.092633	1.836311
Particle 7	6015	0.340872	312.068	0.776152	0.289878	1.063706	1.288407
Particle 8	5150	0.242758	320.654	0.629425	0.257436	1.030835	1.588752
Particle 9	5582	0.314493	331.909	0.636739	0.261466	1.053452	1.570502
Particle 10	5631	0.382156	365.767	0.528916	0.241601	1.082136	1.890661
Particle 11	5785	0.363091	338.061	0.636097	0.263443	1.073245	1.572088
Particle 12	5578	0.24565	345.722	0.586455	0.248335	1.03161	1.705162

2) Absolute Fuzzy Connectedness:

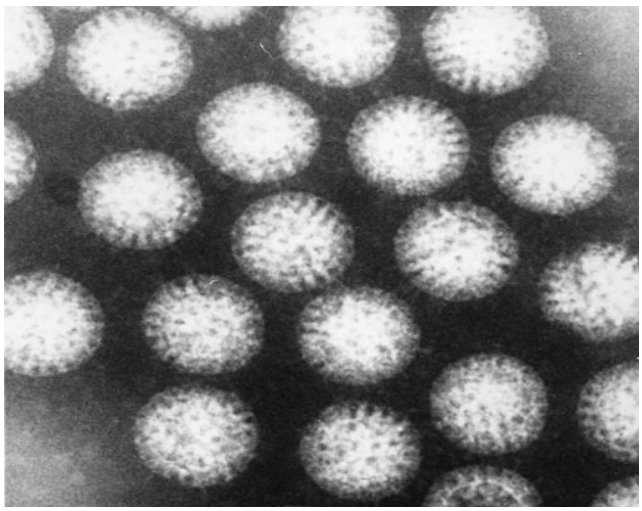

Fig. 6.Orginal Rotavirus-A TEM image.

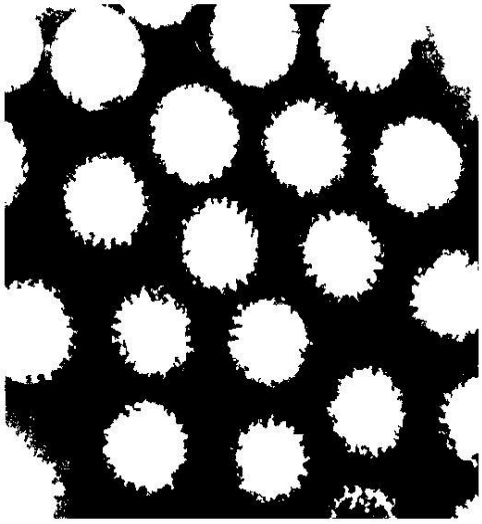

Fig. 7.Seed Region is selected.

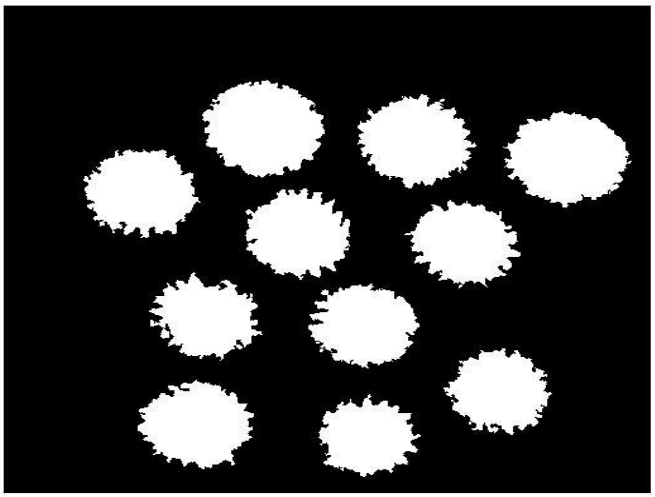

Fig. 8.Segmented virus particles in the image

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Table- II: The geometric feature values of the Absolute Fuzzy Connectedness.

Rotavirus-A Features	Area	Eccentricity	Perimeter	Circularity	Tortuosity	Width Ratio	Compactness
Particle 1	4616	0.281352	447.039	0.290258	0.177253	1.042096	3.445206
Particle 2	5104	0.415959	469.203	0.291339	0.181969	1.099646	3.432425
Particle 3	5438	0.259096	447.204	0.341694	0.190799	1.035356	2.926593
Particle 4	5531	0.167053	460.121	0.328299	0.185782	1.014252	3.046005
Particle 5	5386	0.434361	468.575	0.308261	0.187874	1.110199	3.244009
Particle 6	5609	0.42745	501.985	0.279714	0.178648	1.106147	3.575083
Particle 7	7143	0.370417	541.691	0.305905	0.184107	1.076582	3.268983
Particle 8	6866	0.258499	436.709	0.452407	0.218749	1.035184	2.210399
Particle 9	6196	0.345322	512.763	0.296134	0.180177	1.065548	3.376852
Particle 10	5487	0.362115	480.648	0.298463	0.181522	1.072808	3.350499
Particle 11	4669	0.220605	405.034	0.357644	0.19489	1.025259	2.796078
Particle 12	6133	0.331992	490.068	0.3209	0.186909	1.060128	3.116233

3) Active Counter Method:

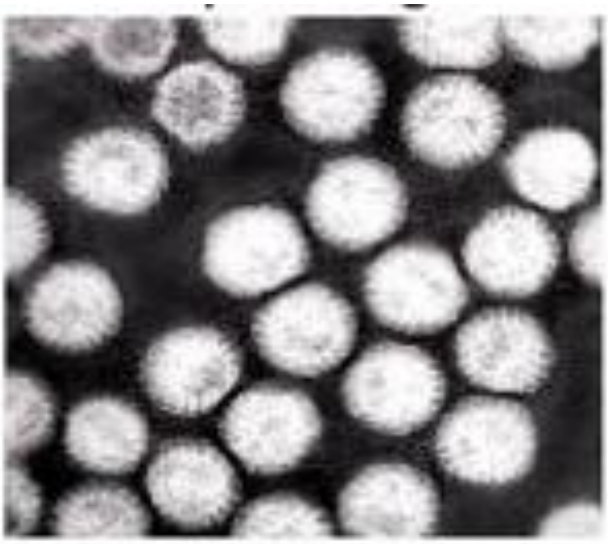

Fig. 9.Orginal Rotavirus-A TEM image.

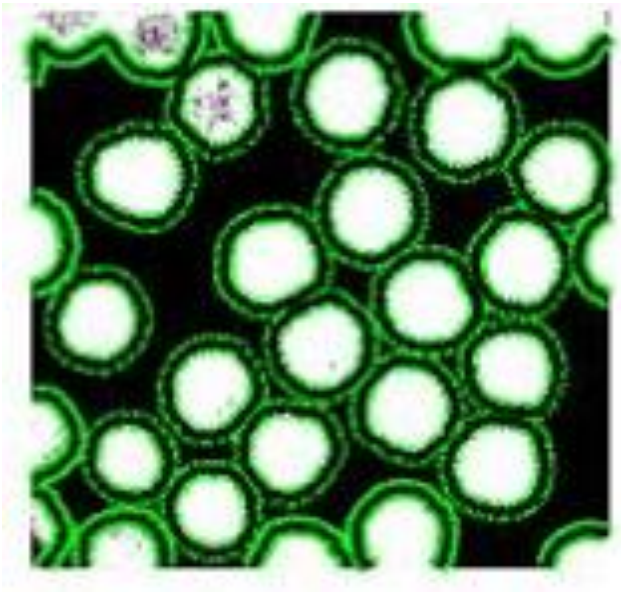

Fig. 10. Iteration of image.

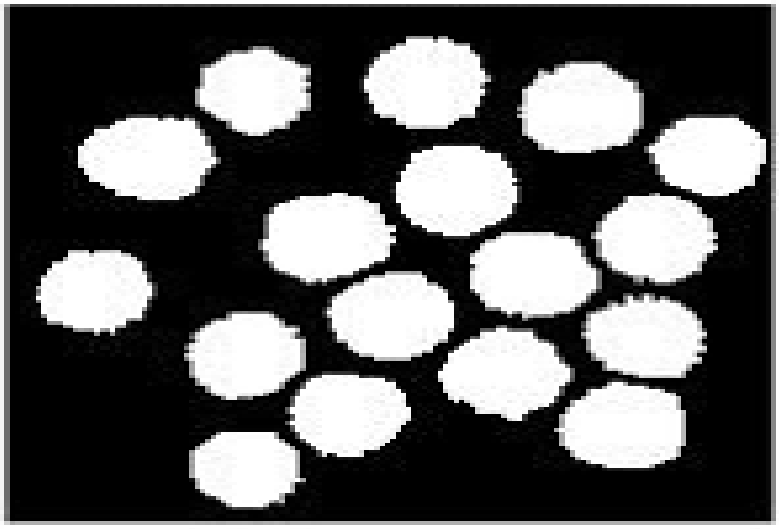

Fig. 11. Segmented virus particles in the image.

Table- III: The geometric feature values of the Active Counter Method.

Rotavirus-A Features	Area	Eccentricity	Perimeter	Circularity	Tortuosity	Width Ratio	Compactness
Particle 1	1262	0.311648	161.599	0.607284	0.25682	1.052413	1.646676
Particle 2	1584	0.159918	170.755	0.682682	0.266087	1.013037	1.464812
Particle 3	1404	0.390914	158.598	0.701426	0.279199	1.086452	1.425668
Particle 4	1490	0.273823	173.095	0.624924	0.257848	1.039739	1.600195
Particle 5	1429	0.36563	185.666	0.520928	0.240094	1.07439	1.919653
Particle 6	1486	0.440926	167.562	0.665086	0.275366	1.114152	1.503566
Particle 7	1541	0.405002	170.316	0.667577	0.273196	1.093714	1.497954
Particle 8	1666	0.263216	181.407	0.636175	0.259839	1.036552	1.571894
Particle 9	1893	0.218003	166.811	0.854892	0.298703	1.024645	1.169739
Particle 10	1698	0.340496	181.059	0.65089	0.266118	1.063551	1.536359
Particle 11	1944	0.338751	166504	0.881164	0.308499	1.062839	1.134862

4) Watershed Method:

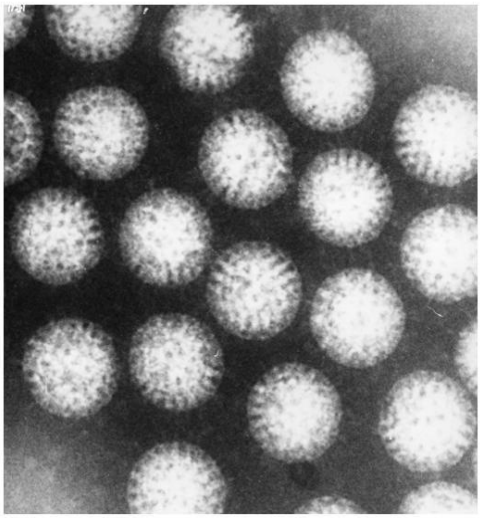

Fig. 12. Orginal Rotavirus-A TEM image.

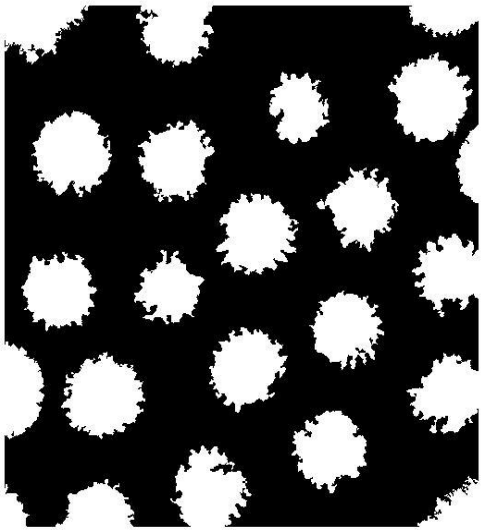

Fig. 13. Morphological Operation on the Image

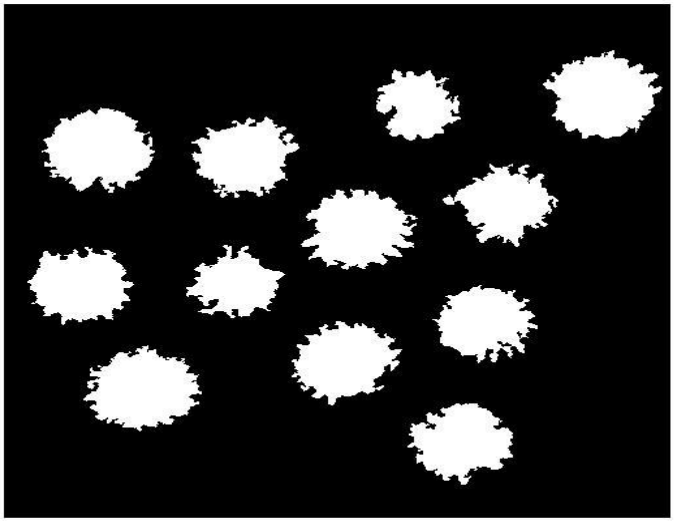

Fig. 14. Segmented virus particles in the image.

Table- IV: The geometric feature values of the Watershed Method

Rotavirus-A Features	Area	Eccentricity	Perimeter	Circularity	Tortuosity	Length/Width Ratio	Compactness
Particle 1	5462	0.300879	445.433	0.345937	0.193845	1.048589	2.890701
Particle 2	4559	0.368284	413.131	0.335663	0.193996	1.0756	2.979176
Particle 3	4452	0.305893	486.636	0.236242	0.163539	1.050347	4.232953
Particle 4	4469	0.215836	437.528	0.293365	0.177186	1.024139	3.408721
Particle 5	4962	0.435917	486.505	0.263446	0.174054	1.111127	3.795841
Particle 6	4251	0.510937	409.649	0.31833	0.196527	1.163307	3.141397
Particle 7	4067	0.251734	404.364	0.312564	0.183183	1.033275	3.199344
Particle 8	4276	0.351693	431.672	0.288363	0.179578	1.068244	3.467849
Particle 9	3224	0.335563	406.266	0.245462	0.168326	1.061551	4.073953
Particle 10	4818	0.368098	538.499	0.208789	0.153451	1.075515	4.789533
Particle 11	4333	0.340775	394.25	0.350312	0.197473	1.063666	2.854597
Particle 12	4326	0.345195	386.476	0.363958	0.20135	1.065495	2.747569

Accuracy of Segmentation Techniques:

The data that is collected from each segmentation techniques and by implementing the Decision Tree Classifier the accuracy is calculated as shown in "Table V".

Table- V: The Accuracy Rate of each Segmentaion.

Segmentation Method	Classification Rate
Fuzzy C Means	97%
Absolute Fuzzy Connectedness	95%
Maker-Controlled Watershed Method	98%
Active Counter	98%

V. CONCLUSION

Medical Imaging has got many advantages in medical science research area. The segmentation techniques are helpful to identify and analyze the different medical images. In the proposed research method, the Rotavirus-A particles TEM images are considered for training and testing. The Dataset is collected by microbiological experts from the lab which is published by Dennis Kunkel website. Once the dataset is collected, the preprocessing methods are applied on it. The four segmentation methods are used to hybridize the model and get the better segmentation outcome. Once the segmentation is done, the feature extraction method is applied and captured vital features from the image set. The classification and recognition are done using Decision tree. The proposed research method gives 96% average recognition accuracy. This could be improved further by better pre-processing techniques and other classification methods.

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