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Classification Enterococcus Faecium and Faecalis Bacteria Images using Bag of Features

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A B S T R A C T

Many numerous genera of bacteria that have a foremost influence on human health. One of them is Enterococcus, which has numerous species excluding Faecium and Faecalis. It reasons many sicknesses such as the bowel inflammation bacteremia, urinary tract infection, wound inflammation and meningitis. In instruction to describe, the fitting antibiotic used to luxury these diseases, where the antibiotics use to inhibit Faecium bacteria different from Faecalis bacteria, it is necessary to determine the exact type of bacteria, especially that the two types Faecium and Faecalis are similar in shape to the extent large.

The target of this research is to classify Enterococcus bacteria into Faecium and Faecalis by using Bag of features technique, which accomplished and tested on database of the two species bacteria. The development method that combines circular shift pixel images, discrete Rigelet transform and Bag of features method which gives a better result on the non-stationary signals, which are executed on the above technique and newly trained classifier functional on blood agar plated images.

In biological methods, the biologists cultivate bacteria in blood agar plates to determine the type of bacteria where examined in the electron microscope by using the eyes to the dependence on the form of bacteria and often they need to re-implant the sample in other mediums in order to know the type of bacteria. This requires the cost of media and chemical materials and time. The method used in this research, the input for the program is blood agar plates images only and the type of bacteria is directly and accurately, this means that the method adopted in the program reduces costs and effort in biological methods, thus, this research helps biologists to be able to diagnose bacteria with less effort, cost and time.

The results exposed that the enriched classification method stretches better classification results on samples used images, when the average accuracy in the training set and validation set by using Bag of feature method are (0.83 and 0.79) respectively, they were increased in the proposed method to (1.00 and 0.92) respectively.

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1. Introduction

The recognition of the microorganism species are crucial since the biological data of microorganisms is very necessary in medication, organic chemistry and then on the recognition of microbiological samples to discover microbial diseases and bacteria [1, 2, 3] which is preceded by the culturing process [4]. This phase needs devoted equipment and chemical means used for mark the samples. Furthermore, it involves great shelter for workers on these biological tests because of contact with these bacteria, therefore through image processing within the classification field, we can avoid all previous obstacles and classify these bacteria using several software methods [5, 6].

Classification is a very precise process for classifying varieties, which are of the same type [7, 8, 9], and is a methodical plan in crowds and classes based on its features. Image classification benefit for sinking the gap between the computer vision and human vision by preparation the computer with the data and this doing by distinguishing the image into the set category based on the content of the image [10, 11].

This paper use a freshly proposed method to classify Enterococcus Faecium and Faecalis blood agar plates images, which evidenced a very efficient classification, compared with the longer and costly biological classification method.

2. Related Works

J. Wang et al [12] looked at bag-of-features based medical image retrieval algorithms, which represented an image as a collection of local characteristics including image patch and key spots with SIFT descriptor. They initially characterized local descriptor assignment as contribution functions, then devised a new multiple assignment approach. Assuming that the local feature can be reconstruct by its vocabulary neighbors, the reconstruction weights were solved using the QP problem and employed as contribution functions, resulting in a new assignment approach known as QP assignment.

P. Hiremath [13] developed a method for bacterial classification that involved segmenting digital bacterial cell pictures and extracting geometric features.

F. Wahid et al [14] employed a deep convolutional neural network (CNN) called 'Exception architecture' based on transfer learning to automatically recognize and classify bacteria from microscopic images. Here, we used seven types of bacteria to identify those that could be deadly to humans and created a dataset of 1150 bacteria photos, with at least 160 images for each kind. They used the train dataset to train the proposed system on 920 bacterium pictures from seven different species.

M. Talo [15] used the ResNet-50 pre-trained CNN to categorize digital bacteria photos into 33 categories in order to classify them into different groups. The transfer learning technique was use to speed up the network's training process and increase the network's classification performance.

H. Wang et al. [16] used a computational live bacteria detection system that captures coherent microscopy images of bacterial growth inside a 60-mm-diameter agar plate on a regular basis and analyzes these time-lapsed holograms using deep neural networks for rapid bacterial growth detection and species classification.

This paper used a new bag of feature approach to classify Enterococcus bacteria into Faecium and Faecalis, and then used the development of this method in order to a chive a good result in these bacteria classification.

3. Bag of features method

Bag-of-features representations have freshly become well-liked for content primarily based on image classification because of their simplicity and smart performance [17]. They evolved from text on methods in texture analysis. They evolved from text on ways in texture analysis. The fundamental plan is to treat images as loose collections of freelance patches, sampling a representative set of patches from the image, evaluating a visible descriptor vector for every patch severally, and victimization the ensuing distribution of samples in descriptor space as a characterization of the image [18].

The central steps are as following [19]:

(1) Detect firstly key points by image splitting up or arbitrary sampling etc.

(2) Abstract the local features of the image and produce the descriptor.

(3) Using K-mean method to cluster these feature related descriptor and produce visual vocabulary, wherever each clustering center is a visual word.

(4) Introduce the histogram.

4. Ridgelet Transform

Ridgelet remodel is evidence to become finished the exhausting of moving ridge remodel that it inadequate for geometric options. It cause to oscillations and artificial within the energy of signal and variations on the angle is forgot. For this preventive [20, 21]. The Ridgelet transform is quite the operation of a one-dimensional wavelet transform to slices of Radon transform where the corner variable θ is static, t is inconstant, and it gives better results in classification [22, 23]. The fast Ridgelet transform can be get as the following points, To begin with determine two Dimensional Fast Fourier Transform (2D FFT),

It is offer nearby a few straight lines which it equivalent to the labelled number of projections. Late each line permissions through the center of the 2D frequency space, with a sagacity one and the same to the projection angle, and a sum of interpolation points matching to the sum of rays. To end with one-dimensional wavelet transform is gathered. The general structure of Ridgelet transform be gifted to be made known in Figure (1) [24, 25].

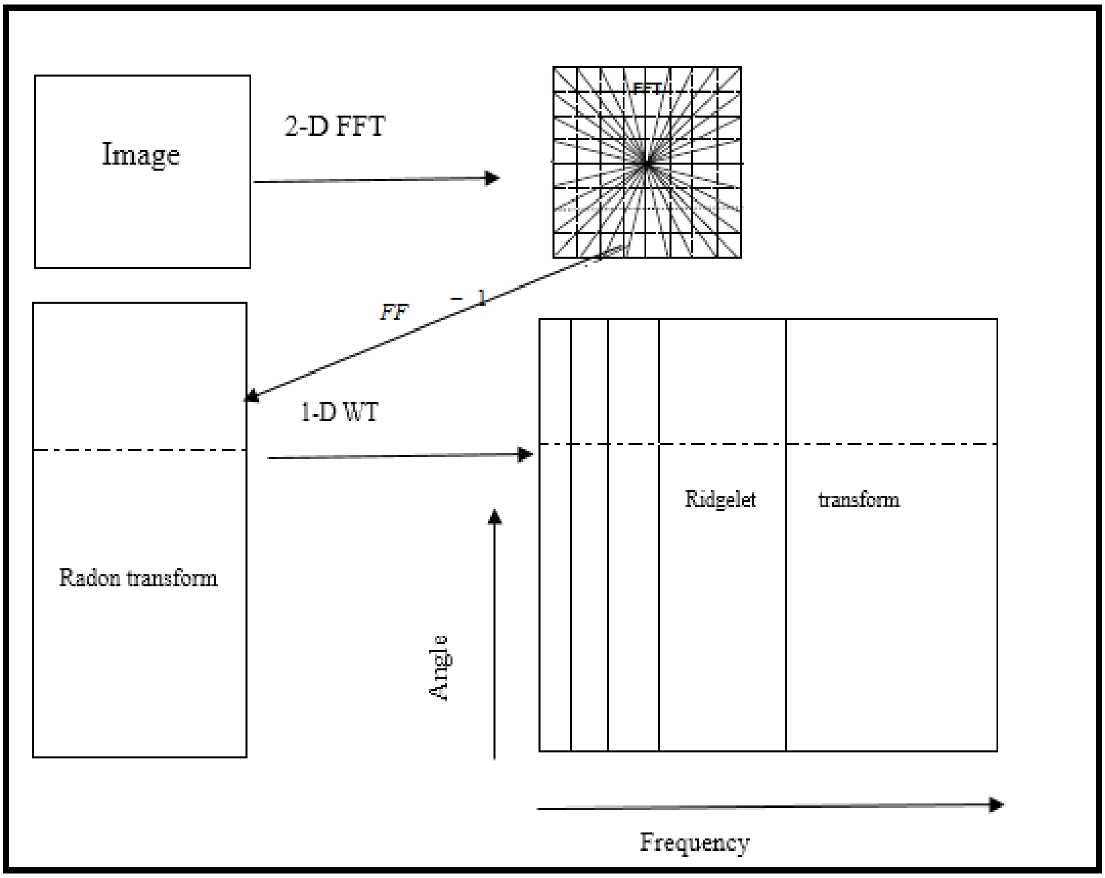


Fig. 1- Ridgelet transform scheme

5. Methods and Results

These part demonstrations the classification methods on Enterococcus Faecium and Faecalis Bacteria images using Bags of features, where DIBaS dataset [1] of bacterial colonies were used, which holds 33 bacteria species with 20 images for every kind.

5.1 Data pre-processing

Enterococcus bacteria of the most important types Faecium and Faecalis, for each Faecium and Faecalis databases images were resized to 200×200 pixels in order to reduce the amount of memory used and easy to deal with. The method used for classification between these two types is Bag of features where this method is complete2d here and then presented the improved method.

5.2 Bag of Features method

Step1: Construct the categories Faecium and Faecalis from Enterococcus database and make the numbers of images equal in the categories.
Categories = {'faecium','faecalis'}.
Number of images in faecium category= number of images in faecalis catergory=20.
Step2: Discrete the sets into training and validation data. 30% training and 70%, for the validation data and to evade biasing results randomize the split.
Step3: Generating Bag-Of-Features.
Step 4: Training Process
Perform this step which training an image category classifier for two categories.
Category 1: Faecalis
Category 2: Faecium
Coding features for 12 images With the resulting from step 3 (Bags) using vector machine (SVM) multiclass classifier
Complete training the category classifier.
Step 5: Evaluate Classifier Performance
Step 5-1: Evaluate training set (12 images)
Evaluate process between the resulting from Step (4) and the training set to compute the average accuracy as shown table (1).

Table 1 - Training set predicted evolution.

Category	faecalis	faecium	Average Accuracy
faecalis	1.00	0.00	0.83
faecium	0.33	0.67	

Table 2 - Validation set Predicted evolution.

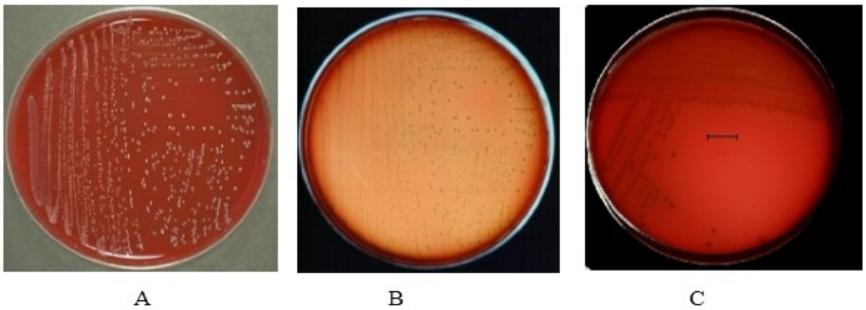
Category	faecalis	faecium	Average Accuracy
faecalis	1.00	0.00	0.79
faecium	0.43	0.57	

Step 6: Apply newly Trained Classifier on Test Images.

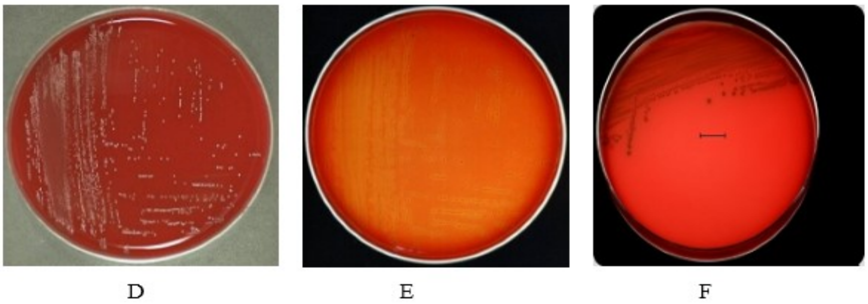
At this stage, new Enterococcus test images were taken to classify them using the above method. Blood agar plates of Enterococcus Faecium and Faecalis as shown in figure (2) were taken from:

1: The web site of university of Copenhagen/Department of Veterinary Disease Biology/Veterinary Bacteriology and Mycology Bacterial http://www.Veterinary Bacteriology and Mycology Bacterial Morphology.com

2. The web site of university of Agricultural Sciences /Faculty of Veterinary Medicine and Animal Science/Vet Back. http://www.vetbact.org



Blood agar plates of Enterococcus Faecalis



Blood agar plates of Enterococcus faecium

Fig. 2- Blood agar plates of Enterococcus Faecium and Faecalis images

Wherever they were classify and compared results between the biological method and the Bag of features method as shown in table (3).

Table 3 - Biologist test and Bag of features test.

Images	**Biologist test**	**Bag of Features test**
A	Faecalis	Faecalis
B	Faecalis	Faecalis
C	Faecalis	Faecium
D	Faecium	Faecium
E	Faecium	Faecium
F	Faecium	Faecium

As exposed in Table (3), all images conform to both the biological classification and the computer classification except one image (C).

5.3 The development process of Bag and Features classification

This part demonstration the development classification method performed on Enterococcus Faecium and Faecalis Bacteria images. DIBaS dataset were used (for each image is resized to 128×128), construct the categories Faecium and Faecalis from Enterococcus database then split them to Training set (0.6) and Validation set (0.4), then the subsequent steps were achieved on each image in the training set:

Step 1: Circularly shift each training image (row then column) as follows:

```
shiftftrow=1;
shiftcolumn=shftr;
n=200;
vk1=zerosmatrix of size(n,shiftrow);
vk2=zerosmatrix of size(shiftcolumn,n);
for i=1 to  n
   for j=1to shiftrow
  vk1(i,j)=training_image(i,j);
end
end
```

Step 2: Apply two dimensional discrete Ridgelet transform decomposition on the data resulting from step 1.

After applying a Ridgelet decomposition process on the circularly shifted data, and here are finding the features of images using the Bag of features method, then the following steps were performed:

Step 3: Circularly unshift each decomposed image (row then column) as follows:

```
for i=1to shiftcolumn
   for j=1to n
  vk2(i,j)=decomposed_trianed_image(i,j);
end
end
for i=1 to n1-shiftcolumn
   for j=1to n
  decomposed_trianed_image(i,j)= decomposed_trianed_image (i+shiftcolumn,j);
end
end
for i=1to shfitcolumn
   for j=1to n
  decomposed_trianed_image (n1-shiftcolumn+i,j)=vk2(i,j);
end
end
```

Step 4: Smear two dimensional inverse discrete Ridgelet transform on the data resultant from step 3.

As finishing point steps 4, 5 and 6 in Bag of features were done; the outline of the development classification can be seen in figure (3).

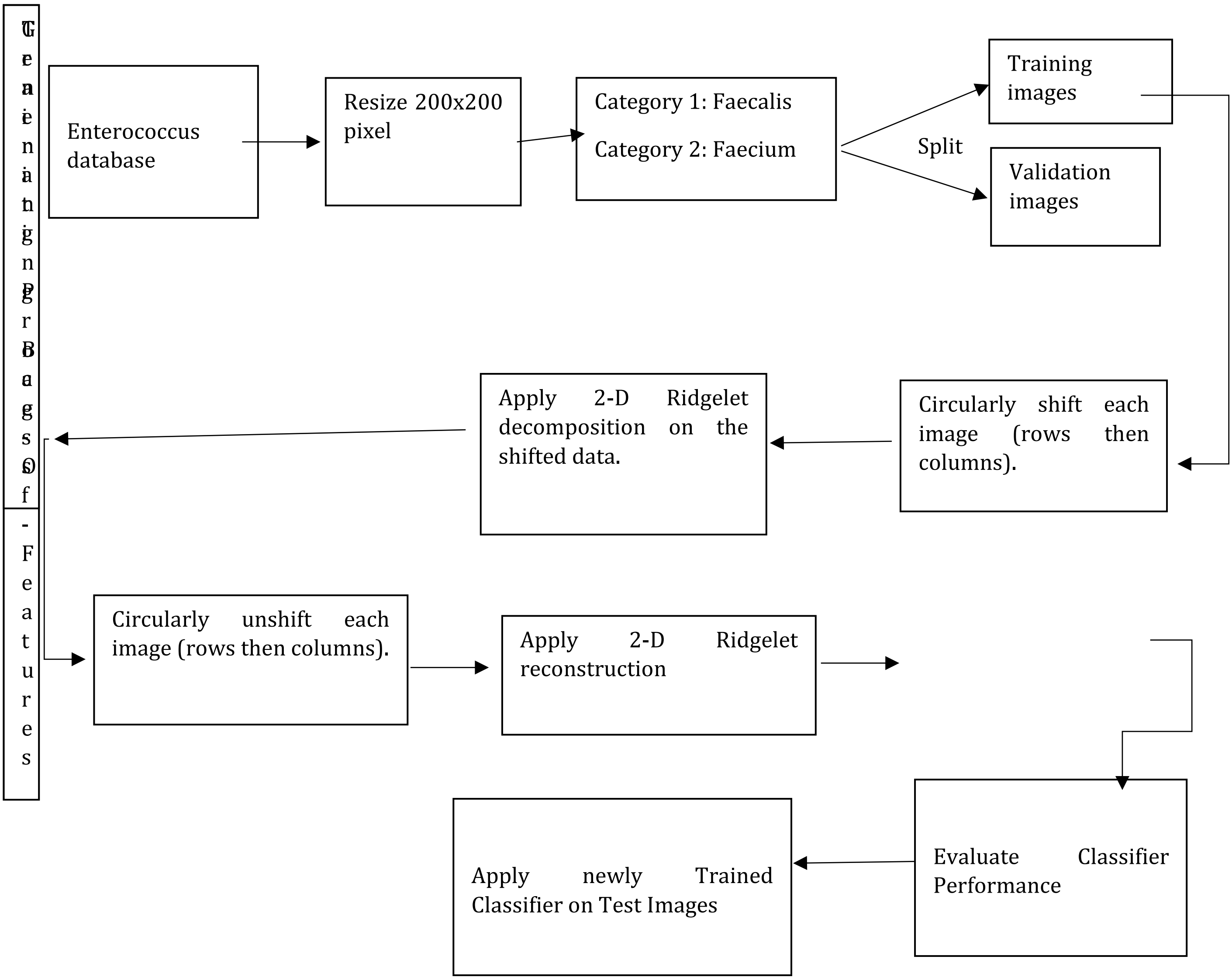


Fig. 3- The development classification method.

Here are the results of evaluate classifier performance of the development method as shown in tables (4, 5 and 6).

Table 4 - Training set Predicted evolution for the development method.

Category	faecalis	faecium	Average Accuracy
faecalis	1.00	0.00	1.00
faecium	0.43	1.00	

Table 5 - Validation set for the development method.

Category	faecalis	faecium	Average Accuracy
faecalis	1.00	0.00	0.92
faecium	0.17	0.83	

Table 6 - Biologist test and the development method test.

Images	Biologist test	Bag of Features test
A	Faecalis	Faecalis
B	Faecalis	Faecalis
C	Faecalis	Faecalis
D	Faecium	Faecium
E	Faecium	Faecium
F	Faecium	Faecium

As revealed in Table (6), all images conform to both the biological classification and the computer classification. When matching tables (4, 5 and 6) with tables (1, 2 and 3), we catch the performance method achieved the better results.

6. Conclusions:

The classification procedure is one of the imperative procedures in image processing and intrusion in several uses. There are two leading classification technique. Supervised classification and unsupervised classification. In the first technique a user can select sample pixels (training sets) in an image based on the knowledge of the use which representative of specific classes. The image processing software is assume to usage these training sets for all further pixels classification, oppositely unsupervised classification the conclusions are familiarized based on the software exploration of an image without the user given that illustration classes and the user specifies the respectable algorithm. In this paper, a hybrid classification method is charity to accomplish bacteria images classification. Customs transformation before image classifications through it non-stationary signals are characterize in both time and frequency information here Ridgelet transform which resolve the harms in the wavelet transform So, the efficiency of the classification image is improved and when used with bag of feature method, the equality of classify image process become very well.

The classification of bacteria by biological methods requires equipment, chemistry, time, and experience. Through the research, two types of bacteria Enterococcus were classified into Faecium and Faecalis using the Bag of features, which achieved good results by classifying all the images in the DIBaS database, were then seasoned on blood agar plates images and then the progressive method was applied. The results were better and the average accuracy was examine.

Also in this study, 30 blood agar plates were collected from various sources, which used to conduct the classification test and to compare with the biological methods, and the results of the tests were taken on images from (A-F) merely. All tests and progressive method were implemented on the 30 samples and 100% results were found to be parallel to biological tests.

References

[1] S.J. Lee and M. Rho " Multimodal deep learning applied to classify healthy and disease states of human micro biome‶, *Scientific Reports*,Nature,Vo.12, No. 824,(2022), PP. 1-11.

[2] B. Zielinski et al " Deep learning approach to bacterial colony classification‶, Plos One ,Vo.9, No. 12, (2017), PP. 2-14.

[3] A.H.Ali et al, "An Effective Color Image Detecting Method for Colorful and Physical Images", *Journal of Al-Qadisiyah for Computer Science and Mathematics*, Vol. 13, No.1, (2021), pp. 88–98.

[4] M.S.Mahdii et al, "Unusual Activity Detection in Surveillance Video Scene: Review", *Journal of Al-Qadisiyah for Computer Science and Mathematics*, Vol. 13, No.2, (2021), pp. 92-98.

[5] M. Sornam, , K. Muthusubash , and V. Vanitha, " A Survey on Image Classification and Activity Recognition using Deep Convolutional Neural Network Architecture ", *International Conference on Advanced Computing*, DOI: 10.1109/ICoAC,(2017), PP 121–126.

[6] M. M. krishna ,˝ Image classification using Deep learning‶, *International Journal of Engineering & Technology* , Vol. 2, No. 7, (2018),PP. 614-617.

[7] P.Gue et al " Unified Classification of Bacterial Colonies on Different Agar Media Based on Hyperspectral Imaging and Machine Learning", *Molecules , Plos One* ,Vo.25, No. 8,(2020), PP. 1-13.

[8] M.K. Hussein and J.J. Stephan "A Review of Skin Cancer Detection", *Journal of Al-Qadisiyah for Computer Science and Mathematics*, Vol. 13, No.1, (2021), pp. 67-76.

[9] S.S. Al-fraiji and D. Al-Shammary "EEG Signals Classification based on mathematical selection and cosine similarity*", Journal of Al-Qadisiyah for Computer Science and Mathematics*, Vol. 13, No.3,(2021) , pp. . 57-67.

[10] T. Vermeire et al "Explainable image classification with evidence counterfactual", *Pattern Analysis and Applications, Springer*, (2022), DOI: https://doi.org/10.1007/s10044-021-01055-y.

[11] A.K. Abdul-Hassan and I.H. Hadi "Speaker Classification using DTW and A Proposed Fuzzy Classifier", *Journal of Al-Qadisiyah for Computer Science and Mathematics*, Vol. 11,No.4,(2019) , pp. 17-26.

[12] J. Wang et al "Bag-of-Features Based Medical Image Retrieval via Multiple Assignment and Visual Words Weighting", *IEEE Transactions on Medical Imaging,* Vol.6, No. 1, (2007), PP. 1-118.

[13] P.S. Hiremath and P. Bannigidad "Automatic Classification of Bacterial Cells in Digital Microscopic Images", International *Journal of Engineering & Technology*, Vol.2, No. 4, (2009), PP. 9-15.

[14] F. Wahid et al "Deep Convolutional Neural Network for Microscopic Bacteria Image Classification", *fifth International Conference on Advances in Electrical Engineering*, (2019), DOI: 10.1109/ICAEE48663.2019.8975588.

[15] M. Talo "An Automated Deep Learning Approach for Bacterial Image Classification ", International Conference on Advanced Technologies, *Computer Engineering and Science*, (2019), Apr 26-28.

[16] H. Wang et al "Early detection and classification of live bacteria using time-lapse coherent imaging and deep learning", Light *Science & Applications*, Vol.9, No. 118, (2020), PP. 1-17.

[17] C. Hiba, Z. Hamid and A.Omar,˝ Bag of Features Model Using the New Approaches: A Comprehensive Study", *International Journal of Advanced Computer Science and Applications*, Vol.7, No. 1, (2016), PP. 226- 234.

[18] L. Xiong-wei, and et al " An Image Classification Algorithm Based on Bag of Visual Words and Multi-kernel Learning ", *Multimedia Journal,* Vol. 9, No. 2,(2014), PP 269–277.

[19] J. Singh, and C. Singh " Bag of Groups of Convolutional Features Model for Visual Object Recognition ", *IEEE Workshop on Machine Learning for Signal Processing*,(2021),doi: 25-28.

[20] J. Ma, and G. Plonka˝,The Curvelet Transform˵, *IEEE Signal Processing Magazine*, Vol.10, ISSN: 1053-5888,(2010),PP. 118-133.

[21] S. Kautkar, "Face Recognition Based on Ridgelet Transforms", *Procedia Computer Science Journal*, Vol. 2, No. 2, (2010), doi: 10.1016, PP 35–43.

[22] S. Sonoda et al "Fully-Connected Network on Noncompact Symmetric Space and Ridgelet Transform based on Helgason-Fourier Analysis", *IEEE Signal Processing Magazine*, Vol.10,(2022), ISSN: 1053-5888, arXiv:2203.01631v1.

[23] C. Jothi N. Elvina and P. Vetrivelan, "Medical Image Fusion using Ridge let Transform ", *International Journal of Computer Applications* ,ISSN: 0975 – 8887, (2013),PP 21–25.

[24] G. Ma and .J. Zhao, "Quaternion Ridgelet Transform and Curvelet Transform", *Advances in Applied Clifford Algebras*, Vol.28, No. 154, (2018).

[25] J. Zhu et al, "Fired bullet signature correlation using the finite ridgelet transform (FRIT) and the gray level co-occurrence matrix (GLCM) methods", *Forensic Science International*, Vol.330, No. 111089, (2022).