A Novel Approach For Diagnosis Of Dermatologic Diseases Based On Multi-Objective Clustering Using Particle Swarm Optimization

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Abstract: The stratification of skin diseases plays a major role in enabling effective and customized medicine. An important task in the stratification of skin diseases is to discover subtypes of diseases for effective treatment. To achieve this goal, research into cluster algorithms for the stratification of skin diseases has attracted the attention of both scholars and the medical community in recent decades. However, cluster algorithms suffer from realistic limitations such as experimental sounds, high dimension and poor interpretation. In particular, cluster algorithms usually determine the quality of clusters with only one internal evaluation operation. Unfortunately, it is obvious that one internal evaluation operation is difficult to create and strong for all datasets. Therefore, this article proposes a novel of many descriptive frameworks called a multi objective cluster algorithm with a quick search and finding the density of peaks to deal with these limitations altogether. In the proposed framework, the variable component of the candidate is developed under many objectives to select properties and estimate the density of the cluster automatically. To guide the development of multi-objective, two cluster value indices are used, including the Calinski-Harabasz index and the Davies-Bouldin index. The clustering is performed with the help of a k-means cluster by finding the best clusters using particle optimization. PSO will solve the multi-objective to determine the best cluster. Here, the proposed method will test on the dermatology dataset from UCI repository using MATLAB R2020a, under windows10 environment. Then, the proposed method performance will be evaluating using the cluster evaluation indices.

Keywords: Skin diseases, Clustering, multi-objective, K-means, Particle swarm optimization.

1. Introduction

The diagnosis of dermatologic disease is very important. Known about the disease and it is effectiveness is more important otherwise, it is affect the other parts of the body. For example, we take skin cancer; it is occur our skin epidemic layer. Skin cancer is occurred by high production of human skin cells. We immediately find out this type of disease otherwise, it affect all our skin cells. It is caused by highly radiated sun light fall on human skin. Sun light, emit ultra violet lights it is affect the human skin cells.

To find out the disease aishwariya dutta (2020) proposed a system .here they use convolution neural network for classification for find out the type of disease.to recognize the images here use CAD (computer-aided diagnosis) technology. However, in this system convolution neural network need more training, and complexity is high.[19]

Another system is designed by Ahmed H. Shalini here they use deep neural network for classification and to implementation they use PyTorch Deep learning framework is used. In this system, supervising of the algorithm is based on deep neural network but it is also need more training, it is not a robust. Not easy to understand.[5]

Tech Yan Tan is develop a system that is based on enhanced PSO techniques. Here use enhanced particle swarm optimization techniques. Here input image taken by using method of dermoscopic image, it is based on genetic programming. Local binary pattern is used for extract the high-level domain and the specific feature of the system. The classification and the feature extraction, segmentation all the work are evaluated by PH2.[4]

Shouvik Chakraborty is develop a detection of skin disease system using ANN. In this proposed method neural network is used effectively, the NN neuron is used for reduce the complexity of the pattern to understand the process certain value of feature prediction is needed, artificial neuron network arrange a set of neurons layers that layers are preceding and processing successfully. Using NN method errors has been reduced.[20]

Viraj prabhu (2020) proposed system is explain about how we learn dermatologic disease diagnosis. For the dermatologic disease image classification has some problem that is low and short learning problem. During at the time of training we have able to access labelled dataset of the image. At the training time base classes are important for label mapping. For this classification here use multiple cluster techniques. But here not use PSO algorithm and not evaluate the system. [25]

G.Kranthi Kumar develop a PSO based ANN model for disease prediction. In PSO which is particle swarm optimization is used for collect the group of data behaviour, BPSO is an improved version of the PSO it is called

Binary Particle Swarm Optimization. It have ANN classifier it is used for classify the diseases based on it is types. PPSO is Probabilistic based PSO it is use for feature set of original attribute of the Probabilistic.PSO is used to find the relationship between PPSO with ANN. for the classification here use controlled based particle swarm optimization with ANN (CPSO-ANN).this classification give multilayer neural network.[2]

To overcome this problem in our proposed system is designed by using multi-objective clustering.Multi objective clustering is a group of similar data are decomposed method is known as multi-objective clustering.in this method it find out where the similar type of data that are surrounding or close to each other.

In this system input is dermatologic dataset, that is given to cluster option, it re arrange the data. To guide the development of multi-objective, two cluster value indices are used, including the Calinski-Harabasz index and the Davies-Bouldin index. Calinski-Harabasz is external clustering scheme,[13],[14], it is score is fast to compute then Davies-Bouldin index is internal clustering scheme. Next stage is optimal cluster size using multiple objective PSO, it increase the speed of the system and particle swarm optimized is group the data is so group of data move to next stage at a same time therefore time consumption is reduced power consumption also reduced, next stage is cluster using K-Means The clustering is performed with the help of a k-means cluster by finding the best clusters using particle optimization. Clustering this used to group asset of similar data so distance between the data's are reduced, and it speed up the movement of data's.

Optimal attribute selection using PSO is used as a feature extraction if need extraction we add using this feature. For error classification in this system we use feed forward neural network (FNN),FNN also kind of neural network.it is used to solve the binary classification problems .Therefore, this system super-fast and we get result more accuracy. In evaluation unit, give the accuracy level and performance about the system.

2. Literature review

Sanapathy tharangini (2018) was developed a proposed system for skin cancer detection. Here they use particle swarm optimization technique. Skin cancer is caused by over growth of human skin cells that system used for fin out the malignant level of this cancer. Input image is taken by using several segments. Some segments for examples conventional microscopic images, demos copy images and etc.to detect the skin cancer they use following techniques that are Gray level Co-occurrence Matrix (GLCM), particle swarm optimization, and Hidden Markov Model (HMM). The GLCM process is used to feature extraction, the PSO is used to segmentation process and the HMM process used for various analysis about the disease.[3]

Another proposed system was developed by K.Melbin (2019) that is enhanced model of skin disease detection here use Dragonfly optimization based DNN. If we once detect the disease it is cured detection of the disease is one important process, many researchers are detect the disease using various methods, but the detection rate is very low and the segmentation image is in low quality. To rectify this problem and get clear detection of skin disease here use deep neural network (DNN) classification it give clear result about the disease is occurred or non-occurred . First stage is consist of enhanced level of image segmentation. Then second stage is GLCM it is used for feature extraction then third stage is optimization based Deep-RNN model it have two phases they are static and dynamic static is based on behaviour and the dynamic is based on feeding. [6]

M.Sundar Prakash (2020) was developed another proposed system that is based on firefly optimization method. Previous technologies are based on image segmentation but its first stage is hair removal. For this technique used for get clear segmentation, for this here use Pedro hispano hospital data base is used that database is divided into following types that are atypical nevi, common nevi, melanoma.in hair removal process the hair is present on skin that are removed by using morphological process. Another stage is FCS (Fuzzy C means Segmentation), this is cluster-based process. The image have two types one is affected region another one is not affected region.in feature extraction they are use GLDM process and SFTA process, then feature reduction is used for increase the speed of the analysis. In this system for classification of the segment, they use (RNN) radial basis binary network.

G.Kranthi Kumar (2016) develop a PSO based ANN model for disease prediction. In PSO which is particle swarm optimization is used for collect the group of data behaviour, BPSO is an improved version of the PSO it is called Binary Particle Swarm Optimization. [28]It have ANN classifier it is used for classify the diseases based on it is types. PPSO is Probabilistic based PSO it is use for feature set of original attribute of the Probabilistic.PSO is used to find the relationship between PPSO with ANN for the classification here use controlled based particle swarm optimization with ANN (CPSO-ANN).this classification give multilayer neural network.[2]

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Tech Yan Tan is develop a system that is based on enhanced PSO techniques. Melanoma is one of the dangerous type of skin cancer this is spread to one organ to another organ. So, we take treatment at beginning stage of this type cancer. For this reason, here use enhanced particle swarm optimization techniques. Here input image taken by using method of dermoscopic image, it is based on genetic programming. Local binary pattern is used for extract the high-level domain and the specific feature of the system. The classification and the feature extraction, segmentation all the work are evaluated by PH2.[4]

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Humayan Ahmed (2019) develop a system for automated dermatological images, that's segmentation based on ACO-GA algorithm, for classification, they use TSVM. This real time problem is optimized one to avoid this problem we use this system ACO-GA technique this is have more intelligent background and it make easy implementation and reduce the complexity of the system. In this process, have following steps that are Image Acquisition its use to analysis the colour images. Input image captured by digital camera. Then next step image pre-processing in this step remove unwanted noise from the image. TSVm is used for find out the type of skin disease.[5]

Kashan Zafar (2020) developed a proposed system using convolution neural network (CNN) classification. Input images is taken by the form of dermoscopic image .that is RGB image for get more quality of image it is converted to grayscale image ,and remove unwanted noise that are interrupted in image so here use Black top-hat filter,inpainting algorithm is used for create binary mask, and the same technique used for hair removing on the skin. To find type of skin disease here use CNN (convolution neural network) classification is used.[7]

Yading Yuan (2017) develop an Automatic skin lesion segmentation system using CNN with Jaccard Distance. This paper is to correct input image pixel here use FCN. Fully convolutional network is used for get pixel based classification. Training for FCN is important task; it has 19 layers to study about the 19 layers we want to study the large-scale study to analysis the dermoscopic image.

Saja salim mohammed (2020) is develop the skin disease classification system, it is depend on machine learning technique.to construct the diagnostic system firstly prepare the data set about the disease . This data set obtained from specialized clinic, hospitals, internet or previous surveys. Then supervising of machine algorithm is based on classifications types that are), support vector machine (SVM), convolution neural network (CNN), deep neural network (DNN), decision tree (DT), etc. They give good results with maximum accuracy.

3. Existing methodology

The existing system developed by Tech Yan Tan ,here input lesion image is get from dermoscopic and it have following stages first step is pre-processing, in this stem RGB image is convert to grey scale image for get clear image, then using filter remove unwanted noise from grey scale image otherwise it affect the image, specifically reduce ''pepper and salt' noise. For this, here use median filter it is also perform remove hair from the skin. Then next stage is feature extraction generally several feature extraction available that are used to get texture, colour, shape, for separate the lesion region. For feature selection, here use proposed particle swarm optimization.[4]Another proposed system was developed by K.Melbin (2019) that is enhanced model of skin disease detection here use Dragonfly optimization based DNN. If we once detect the disease it is cured detection of the disease is one important process, many researchers are detect the disease using various methods, but the detection rate is very low and the segmentation image is in low quality.[6] To rectify this problem and get clear

detection of skin disease here use deep neural network (DNN) classification it give clear result about the disease is occurred or non-occurred . First stage is consisting of enhanced level of image segmentation. Then second stage is GLCM it is used for feature extraction then third stage is optimization based Deep-RNN model it have two phases they are static and dynamic static is based on behaviour and the dynamic is based on feeding. It identifies the characteristics of malignant skin lesion.it incorporate mutation based local exploitation. Next step is evaluation, to evaluate about the PSO here implies several classical search method after implement compare the proposed particle swarm optimization with other classical search method. Firstly, collect a specific data set from specialized hospitals is clinic is internet. Here data set have 302 images, for test case use 128 images. [13],[12],The first evaluation done by here PH2 skin lesion data set, here lesion skins are classified three types in common nevi data set use 80 images, atypical nevi data set have 80 images and melanoma case have 40 data set images. Totally 200 images are used for data set. Second evaluation done by using UCI Spam base dataset it have 2 classes, 4601 instance and 57 attributes. Another evaluation is done by benchmark function. [31],[30],To evaluate PSO model we use various optimization techniques that are. Uni modal and multimodal. Benchmark function is more efficiency compare to other.

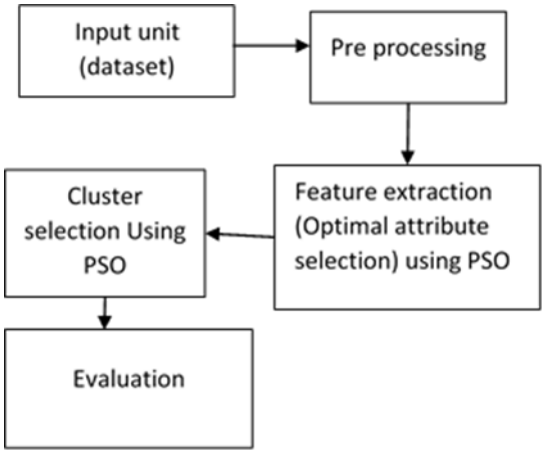
4. Proposed system

The proposed framework, the variable component of the candidate is developed under many objectives to select properties and estimate the density of the cluster automatically. This data set contains dermatology the information about skin disease and cancer. The input unit is contain dermatology data set. Input image compare with the dataset. Then the disease id detected further process is start. In pre-processing is using the technique Missing values filled by its average value. Feature selection is used to It eliminate the redundant features from real dataset. . The feature selection has two process the feature subset selection using PSO and the cluster selection. K- Mean cluster is important technique

It is a one of the technique to vector quantization; it is originated from signal processing. The main goal of this is partition number of observation into k-cluster. The observation is belonging to cluster with nearest mean value. It is one of the prototypes of the cluster. The below figure shows that different between before k-mean clustering and after k-mean clustering.

To guide the development of multi-objective, two cluster value indices are used, including the Calinski-Harabasz index and the Davies-Bouldin index.in classification here use feed forward neural network to minimize the error rate . The block diagram explains the details about that. In PSO technique the particle keep and the all the activity of the each particle stored by neighbour particle. Every particle executes fitness function that is fitness value is calculated.

Block diagram



Input

In input, we take Dermatology dataset. In this database, this data set contains 35 attributes, here 33 attributes are linear, and one is non-linear and last attribute indicates the skin diseases. This data set contains dermatology the information about skin disease and cancer. This data set discovered by Open ML – dermatology owners. H. Altay Guvenir and Nilsel Ilter. Moreover, donor of this data is H. Altay Guvenir. Attribute information is divided by two sections they are Clinical Attributes and Histopathological Attributes. Dermatology dataset is divided into

six class that are, Psoriasis, Seboreic dermatitis, lichen Planus, pityriasis rosea, Cronic dermatitis, Pityriasis rubra pilaris. The value is one when any of the disease is detect, otherwise value is one.

1. Pre-processing:

In pre-processing is using the technique Missing values filled by its average value. The data missing is occur two ways that are randomly and not randomly. In random missing, this missing not has any pattern. In not random missing, there is have pattern for missing. We use average value to replace missing value Find the average of previous row, and put it in missing value, this method is reduce artificial variables. This imputation is easy method to replace missing value. The process about the optimal attribute selection clearly explained by flow chart.

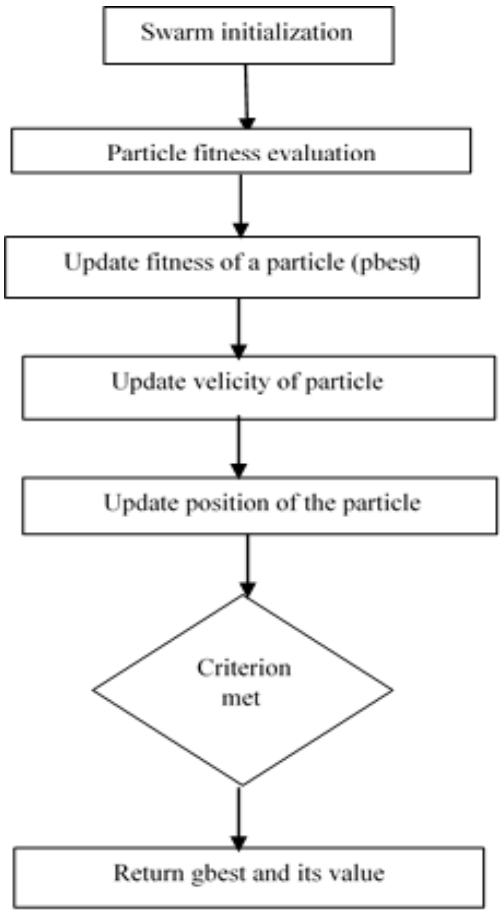
2. Feature extraction

Feature extraction technique is used to adding features. It is reduce the raw data's and produce more group of process to improve system performance. It is one of the method to group the data's for feature, it select group of data and combine it and that data for feature.

2.1. Optimal attribute selection using PSO

The particle swarm optimization is based on papulation; Eberhat, Kennaedy, develops this technique. PSO is a global searching technique, it is easy to encoding and it have global searching facilities. It being reasonable computation, it has less parameters and easy implementation.

The PSO technique is applied for got above benefits. In this technique, particles form populations which is called swarm. The swarm is formed by distributing 0 s and 1 s randomly. Then the swarm is move to search space. In this search space, we search the features by updating velocity and position.



Consider the position of particle j.

Here, derive the equation for the above process

$y_j = \{ y_{j1} , y_{j2} , \ldots\ldots y_{jd}\}$	(1)

Velocity of the particle is

$v_j = \{ v_{j1} , v_{j2} , \ldots\ldots v_{jd}\}$	(2)

d – Dimension of search space
update the velocity of the particle in below equation

$v_{jd}^{T+1} = \omega * v_{id}^{T} + k_1 * R_{1j} * (n_{jd} - y_{jd}^{T}) + k_2 * R_{2j} * (n_{hd} - y_{jd}T$	(3)

Update the velocity of the particle in below

$y_{jd}^{T+1} = y_{jd}^{T} + v_{jd}^{T+1}$	(4)

Position and velocity of the particle is calculated by below equation

$v_{jd}^{T+1} = \omega * v_{id}^{T} + k_1 * R_{1j} * (n_{jd} - y_{jd}^{T}) + k_2 * R_{2j} * (n_{hd} - y_{jd}T)$, $y_{jd}^{T+1} = y_{jd}^{T} + v_{jd}^{T+1}$	(5)

2.1.1. Feed forward Neural Network (FFNN)

Feed forward neural network algorithm is one of the successful algorithm, this algorithm also called deep neural multi-layer perceptron. Data travel through a mesh network that network is artificial, each layer have the process of filter, spot familiar, outlier, then finally produce the output. To easy understand of the FFNN, give some equation below.

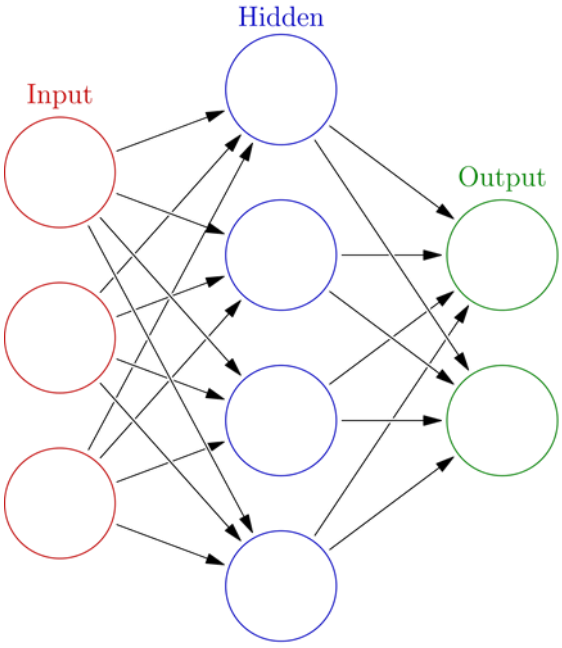


Figure 1. FFNN back propagation

Assume the variable
Y1 – night/ day
Y2 – temperature
Y3 – month

Assume the threshold is 20, and weight W, lets (Y1, Y2, Y3) = (1, 10, 12) , (W1, W2, W3) = (0, 0, 2) , biases are (B1, B2, B3) = (0,1,1)

Multiplication of the input and weights are

(Y1* W1) = (1* 0) = 0	(6)

(Y2* W2) = (10 * 0) = 0	(7)

(Y3* W3) = (12 * 2) = 24------- [8]	(8)

Cluster selection

In cluster selection, we use PSO technique this system used for energy conservation. This optimal selection of cluster using particle swarm optimization is used for reduce power consumption, by sending data packets to cluster head by direct forwarding to base station. PSO is population based optimization technique the potential is generated by random movements of particles. In PSO technique the particle keep and the all the activity of the each particle stored by neighbour particle. Every particle execute fitness function that is fitness value is calculated and stored that fitness value is called "Pbest".

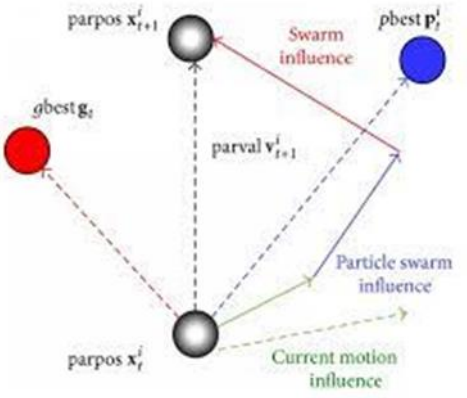


Figure 2. Particle movement of PSO

Count. the fitness value is used to get high quality products. It is making the system affordable to every users.it keep the system with high quality without increasing the system price.

Formula for fitness value calculation is given below

Fv denotes fitness value

Fv= (alpha1 + $\sum_{k=0}^{m} d(\mathrm{N},\mathrm{M})$/m+(alpha2$\sum_{k=0}^{m} E(\mathrm{M})$/E(current node) + (1-alpha1-alpha2) 1/p	(9)

N – Current Node
M – Member i
P – No of member covered by current node.

Calinski-Harabasz index

This index perform the evaluation of the model when we have not idea about the group truth table clustering validation is made by using quantities and feature are based on dataset**.** This is external evaluation method

$Gk = \frac{\text{Nr (Dk}}{\text{Nr (Ek)}} \times \frac{\text{(M – k)}}{\text{(k – 1)}}$	(10)

Here, D_k is place between group discussion matrix. And W_k is place within cluster dispersion matrix

Davies-Bouldin index.

It is one of the methods to evaluate the clustering algorithm. this evaluation method is internal evaluation method .. Clustering validation is made by using quantities and features are based on dataset.

$PQ= \frac{1}{m}\sum_{j=1}^{m} \max\left\{\frac{J(bi)+J(bk)}{J\,(bi,bk)}\right\}$	(11)

K-means cluster

It is a one of the technique to vector quantization; it is originated from signal processing. The main goal of this is partition number of observation into k-cluster. The observation is belonging to cluster with nearest mean value. It is one of the prototypes of the cluster. The below figure shows that different between before k-mean clustering and after k-mean clustering.

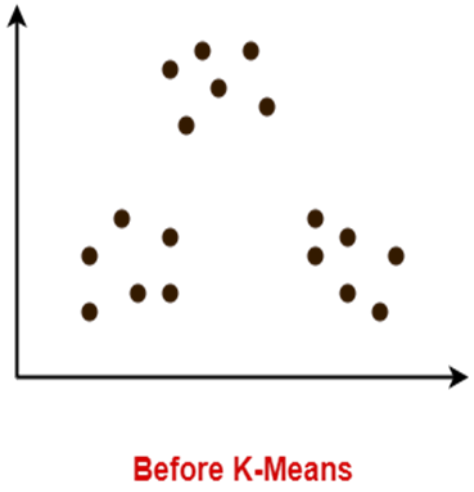


Figure 3. Before k-mean clustering

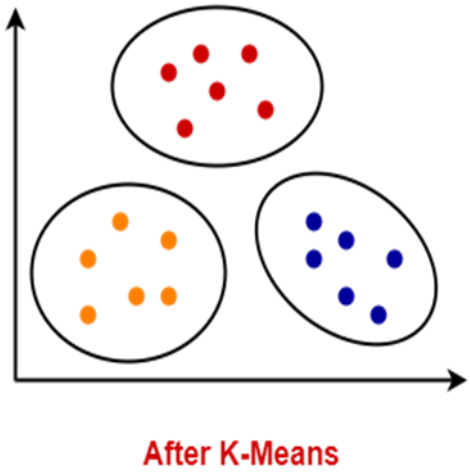


Figure 3. After k-mean clustering

1. **Evaluation**

Cluster evaluation is one of the popular approaches. It involve internal evaluation, clustering have single best clusters using particle optimization quality score in external evaluation compare the clustering with previously existing manual evaluation and group truth classification. It is most intended method. To guide the development of multi-

Objective, two cluster value indices are used, including the Calinski-Harabasz index and the Davies-Bouldin index. The clustering is performed with the help of a k-means cluster.

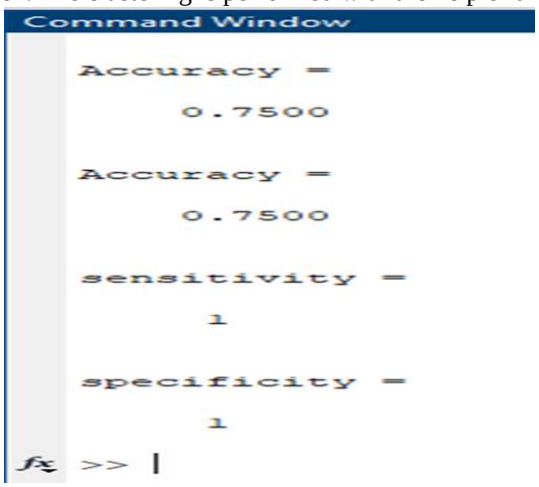


Figure 5. Accuracy of evaluation

In this clustering selection there are 34 attributes are available but here select any 2 attributes based on its priority for testing.

5. Result & discussion

The main aim of this system is give more accuracy as compared to previous technology. Here , PSO algorithm is used for to speed up the analysis and get more accuracy at result. Here clustering help to reduce power conception. And data's are forwarded directly.

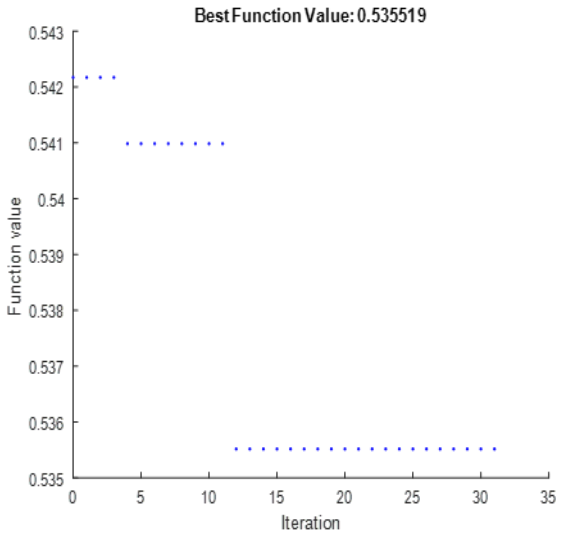


Figure 6. Best function value

The relation between function value and iteration is shown in figure. The best function value is 0.535519.

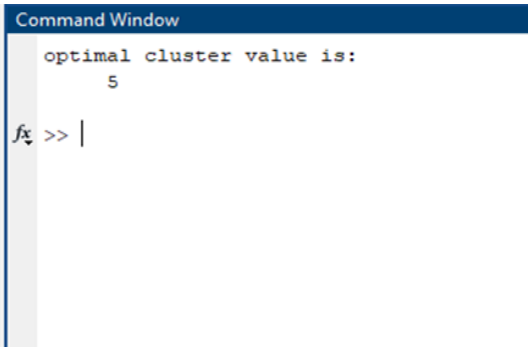


Figure 7. Optimal cluster value

In Optimal cluster by cluster index the optimal cluster value is 5. This founded by help of k-mean clustering. The numbers of observations are 366.

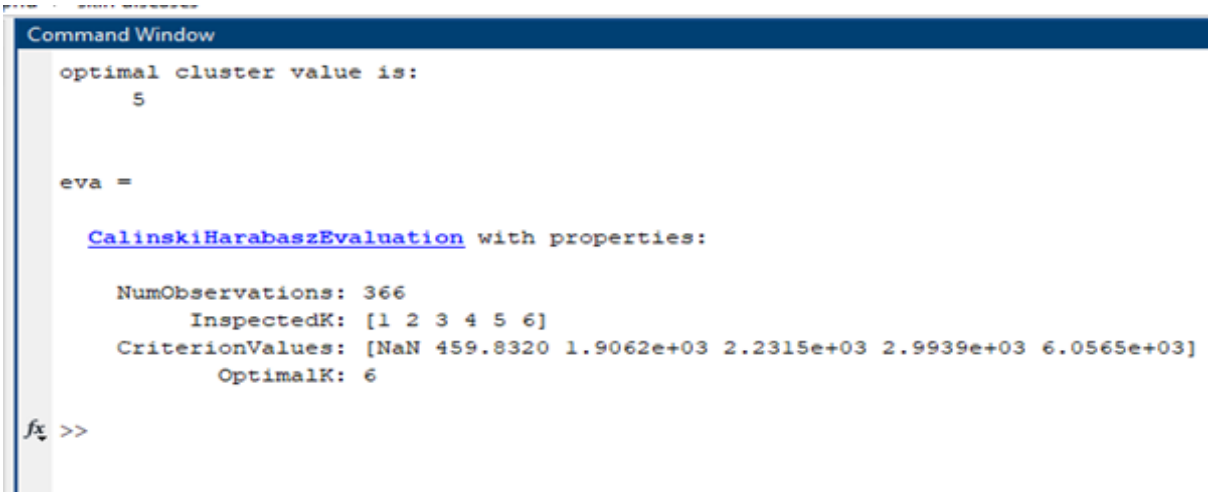


Figure 8. Calinski Harabasz Evaluation

6. Conclusion

In this section we conclude the paper, This paper evaluate the accuracy of the system. In this paper give result accuracy 0.75000This system design is most advanced compared to previously existing system.

It is easily understand to all and execution time is very low so speed and performance of the system is increase highly. This system evaluated by cluster evaluation compared to all other existing system it have high accuracy. In optimum attribute PSO control the attributes it select prior attribute and allow that attribute for further process.

7. Future work

In future work it will develop to increase the number of observation to detect more disease and much more decrease the system. Complexity and increase the accuracy. Will use advanced classification technique to identify the disease accurately.

Reference

A. Kumar G. K. (2016). An optimized particle swarm optimization based ANN Model forclinical disease prediction. *Indian J Sci Technol*, *9*.

B. Khatami, A., Mirghasemi, S., Khosravi, A., Lim, C. P., Asadi, H., & Nahavandi, S. (2017, November). A swarm optimization-based kmedoids clustering technique for extracting melanoma cancer features. In *International Conference on Neural Information Processing* (pp. 307-316). Springer, Cham.

C. Tharangini, S., & Ramakrishna, G. Skin cancer detection using particle swarm optimization. *International journal of Creative Research Thoughts (IJCRT), ISSN*, 2320-2882.).

D. Tan, T. Y., Zhang, L., Neoh, S. C., & Lim, C. P. (2018). Intelligent skin cancer detection using enhanced particle swarm optimization. *Knowledge-based systems*, *158*, 118-135.

E. IoT-Based Automated Skin Lesion Detection and Classification Using Gray Wolf Optimization wi[

F. Ahmed, M. H., Ema, R. R., & Islam, T. (2019, May). An Automated Dermatological Images Segmentation Based on a New Hybrid Intelligent ACO-GA Algorithm and Diseases Identification Using TSVM Classifier. In *2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT)* (pp. 1-6). IEEE.

G. Melbin, K., & Raj, Y. J. V. (2019, December). An Enhanced Model for Skin Disease Detection using Dragonfly Optimization based Deep Neural Network. In *2019 Third International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC)* (pp. 346-351). IEEE.

H. Balaji, M. S. P., Saravanan, S., Chandrasekar, M., Rajkumar, G., & Kamalraj, S. (2020). Analysis of basic neural network types for automated skin cancer classification using Firefly optimization method. Journal of Ambient Intelligence and Humanized Computing, 1-14.

I. Daniel, A., Venkatraman, S., Doss, S., Balusa, B. C., Maseleno, A., & Shankar, K. (2020th DeepNeural Network. *Artificial Intelligence Techniques in IoT Sensor Networks*, 197.

J. Mohammed, Saja Salim, and Jamal Mustafa Al-Tuwaijari. "Skin Disease Classification System Based on Machine Learning Technique: A Survey." *IOP Conference Series: Materials Science and Engineering*. Vol. 1076. No. 1. IOP Publishing, 2021.

K. Gavrilov, D.A., Melerzanov, A.V., Shchelkunov, N.N. et al. Use of Neural Network-Based Deep Learning Techniques for the Diagnostics of Skin Diseases. Biomed Eng 52, 348–352 (2019). https://doi.org/10.1007/s10527-019-09845-9

L. S. R. Guha and S. M. Rafizul Haque, "Convolutional Neural Network Based Skin Lesion Analysis for Classifying Melanoma," 2019 International Conference on Sustainable Technologies for Industry 4.0 (STI), Dhaka, Bangladesh, 2019, pp. 1-5,doi: 10.1109/STI47673.2019.9067979.

M. Wilches, Carlos A., Óscar J. Perdomo, and César A. Perdomo. "A method to detect potentially malignant skin lesions through image segmentation." World Congress on Medical Physics and Biomedical Engineering 2018. Springer, Singapore, 2019.

N. S. Mane and S. Shinde, "A Method for Melanoma Skin Cancer Detection Using Dermoscopy Images," 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), Pune, India, 2018, pp. 1-6, doi: 10.1109/ICCUBEA.2018.8697804.

O. Abbas, Qaisar, I. F. Garcia, and Muhammad Rashid. "Automatic skin tumour border detection for digital dermoscopy using a new digital image analysis scheme." British journal of biomedical science 67.4 (2010): 177-183.

P. Lopez, Adria Romero, et al. "Skin lesion classification from dermoscopic images using deep learning techniques." 2017 13th IASTED international conference on biomedical engineering (BioMed). IEEE, 2017.
Q. Anandaraj, A. Peter Soosai, et al. "Internet of Medical Things (IoMT) Enabled Skin Lesion Detection and Classification Using Optimal Segmentation and Restricted Boltzmann Machines. " Cognitive Internet of Medical Things for Smart Healthcare. Springer, Cham, 2020. 195-209.
R. Shahin, Ahmed H., Ahmed Kamal, and Mustafa A. Elattar. "Deep ensemble learning for skin lesion classification from dermoscopic images." 2018 9th Cairo International Biomedical Engineering Conference (CIBEC). IEEE, 2018.
S. Saherish, Farkhanda, and J. V. Megha. "A Survey on Melanoma Skin Cancer Detection using CNN." (2020).
T. Aishwariya Dutta, Md. Kamrul Hasan, Mohiuddin Ahmad doi: https://doi.org/10.1101/2020.11.24.20238246.
U. Chakraborty, Shouvik, et al. "Image based skin disease detection using hybrid neural network coupled bag-of-features." *2017 IEEE 8th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference (UEMCON)*. IEEE, 2017.
V. ALEnezi, Nawal Soliman ALKolifi. "A method of skin disease detection using image processing and machine learning." *Procedia Computer Science* 163 (2019): 85-92.
W. Nanda, Satyasai Jagannath, and Ganapati Panda. "Automatic clustering algorithm based on multi-objective Immunized PSO to classify actions of 3D human models." *Engineering Applications of Artificial Intelligence* 26.5-6 (2013): 1429-1441.
X. Sivaram, M., et al. "Advanced expert system using particle swarm optimization based adaptive network based fuzzy inference system to diagnose the physical constitution of human body." *InternationalConference on Emerging Technologies in Computer Engineering*. Springer, Singapore, 2019.
Y. Chang, Chun-Lang, and Chih-Hao Chen. "Applying decision tree and neural network to increase quality of dermatologic diagnosis." *Expert Systems with Applications* 36.2 (2009): 4035-4041.
Z. Prabhu, Viraj, et al. "Few-shot learning for dermatological disease diagnosis." *Machine Learning for Healthcare Conference*. PMLR, 2019
AA. Gross, Thelma Lee, et al. *Skin diseases of the dog and cat: clinical and histopathology diagnosis*. John Wiley & Sons, 2008.
BB. Abu-Naser, Samy S., and Alaa N. Akkila. "A proposed expert system for skin diseases diagnosis." (2008).
CC. Soenksen, Luis R., et al. "Using deep learning for dermatologist-level detection of suspicious pigmented skin lesions from wide-field images." *Science Translational Medicine* 13.581 (2021).
DD. Fioranelli, Massimo, et al. "A new medical imaging technique for diagnosing dermatologic diseases: A clue to treatment choices." *Dermatologic therapy* 33.3 (2020): e13405.
EE. Zhao, Shuang, et al. "Smart identification of psoriasis by images using convolutional neural networks: a case study in China." *Journal of the European Academy of Dermatology and Venereology* 34.3 (2020): 518-524.
FF. Verma, Anurag Kumar, Saurabh Pal, and B. B. Tiwari. "Skin disease prediction using ensemble methods and a new hybrid feature selection technique." *Iran Journal of Computer Science* 3.4 (2020): 207-216.