

Medical Image Processing Machine Learning for Feature Selection

P. Silpa Chaitanya¹, N. Harika², M. Vasumathi Devi³, G. L. Sravanthi⁴

Asst. Professor, CSE Department^{1,2,3,4},

Vignan's Nirula Institute of Technology and Science for Women^{1,2,3,4}, Guntur, India

Article Info

Volume 83

Page Number: 6892 - 6901

Publication Issue:

May-June 2020

Abstract:

The machine learning framework at that point distinguishes the best mix of these picture highlights for arranging the picture or figuring some measurement for the given picture area. There are a few techniques that can be utilized, each with various qualities and shortcomings. There are open-source variants of the vast majority of these machine learning techniques that make them simple to attempt to apply to pictures. A few measurements for estimating the presentation of a calculation exist; in any case, one must know about the conceivable related entanglements that can bring about deceiving measurements. Our point is triple: (i) supply a concise prologue to profound mastering with guidelines to middle references; (ii) show how profound gaining knowledge of has been applied to the complete MRI preparing chain, from securing to image restoration, from division to illness forecast; (iii) provide a starting stage to people eager on checking out and perhaps including to the sphere of profound learning for medical imaging through calling interest to extraordinary instructive assets, exceptional in elegance open-supply code, and interesting wellsprings of statistics and issues associated medical imaging. Right now, extraction method is proposed and done on clinical photographs which CT have a look at Cancer datasets. The trial results have given proposed method.

Article History

Article Received: 19 November 2019

Revised: 27 January 2020

Accepted: 24 February 2020

Publication: 18 May 2020

Keywords: framework, open-source, extraction method

Introduction:

Conversion of given information in to set of highlights are known as Feature Extraction. In AI, Feature Extraction begins with the underlying arrangement of constant facts and builds up the acquired traits additionally referred to as highlights, predicted for being illustrative and non-excess, streamlines the resulting mastering and watched steps. In slightly any cases it focuses to be advanced humanity investigation. It is predominantly related with Dimensionality Reduction [1].

At the point when the given contribution to the calculation is exceptionally colossal for taking care of and it is suspicious for being repetitive, at that point that can change over in to diminished arrangement of highlights. Surely little gathering of the starting highlights are known as highlight choice. The favored highlights are relied upon to get the relevant data from the given arrangement of information, with the goal that the errand can be

professional by tolerating the diminished information rather than the full given information.

Highlight Extraction relates the diminishing the measure of benefits expected to characterize a gigantic collection of data. When the stage examination request of confused data, principle issue turns out from the aggregate of factors tangled.

Investigation by huge amount of factors commonly desires major measure of recollection with calculation command, furthermore it get to calculation of order to stuff toward preparing example to compute toward novel example. Highlight removal be typical name for type of planning grouping of factors to leave these issues, while as yet characterizing the information with enough productivity.

Machine learning is an energizing field of research in software engineering and designing. It is viewed as a part of man-made consciousness since it empowers the extraction of significant examples

from models, which is a segment of human insight. The intrigue of having a PC that performs redundant and very much characterized errands is clear: PCs will play out a given undertaking reliably and eagerly; be that as it may, this is less valid for people. All the more as of late, machines have shown the capacity to learn and even ace assignments that were believed to be unreasonably perplexing for machines, indicating that machine learning calculations are possibly helpful parts of PC helped conclusion and choice emotionally supportive networks. Much all the more energizing is the finding that now and again, PCs appear to have the option to "see" designs that are past human recognition. This disclosure has prompted considerable and expanded enthusiasm for meadow of machine learning—explicitly, how it may be applied to clinical pictures.

Abrupt advancement also wide extent of profound learning, with subsequent flood of consideration and multi-billion dollar speculation, have prompted a righteous pattern of enhancements and interests during whole field of machine learning. It is currently probably the most blazing territory of concentrate worldwide and individuals with ability in machine learning be exceptionally looked for after by both industry and the scholarly community. Medicinal services suppliers create and catch colossal measures of information containing amazingly important signs and data, at a pace far outperforming what "conventional" methods of investigation can process. machine learning hence rapidly enters image, as it is perhaps most ideal approaches to coordinate, investigate and make forecasts dependent on enormous, heterogeneous informational collections (cf. wellbeing informatics). Human services utilizations of profound taking in extend from one-dimensional bio signal examination and the forecast of clinical occasions, for example seizures and heart failures, to PC helped recognition and conclusion supporting clinical dynamic and endurance investigation, to tranquilize revelation and as a guide in treatment choice and pharmacogenomics to expanded operational

productivity stratified consideration conveyance, and examination of electronic wellbeing records.

The utilization of machine learning as a rule and profound learning specifically inside medicinal services is still in its outset, yet there are a few in number activities across the scholarly community, and numerous huge organizations are seeking after social insurance ventures dependent on machine learning.

2. LITERATURE REVIEW

A.Mueen et al. [2], proposed order on new image strategy utilizing staggered photograph highlights and Machine getting to know approach and fine in class and bolster vector system(SVM). Here the creator has extricated 3 levels of highlights global, nearby and pixel.Those could be consolidated together as one principal element vector.

K.P.Philip et al. [3], exhibited a calculation which distinguishes includes in dependent on photograph on inexact geometrical fashions. This calculation has dependent on the normal and summed up Hough modifications that incorporate thoughts from fluffy set theory.By using this new calculation it tends to be profoundly evaluated the unique location of limits encompassed via the organ and to determine the district around the organ.

PC Aided Diagnosis (CAD) has been associated with the cerebrum CT photo handling. Three traditional types of highlights i.E., dark scale, shape and floor. Human cerebrum CT photo is expelled at the symmentric include [4].

D. Asir Antony Gnana, Feature determination assumes a critical job in improving the exhibition of the machine learning calculations regarding lessening an opportunity to manufacture the learning model and expanding the precision in the learning procedure. In this manner, the analysts give more consideration on the element determination to improve the presentation of the machine learning calculations. Distinguishing the appropriate component choice strategy is fundamental for a given machine learning task with high-dimensional information. Consequently, it is required to direct the

examination on the different component determination techniques for the exploration network particularly committed to build up the appropriate element choice strategy for upgrading the presentation of the machine learning undertakings on high-dimensional information. So as to satisfy this target, this paper commits the total writing survey on the different component determination strategies for high-dimensional information.

Kokula Krishna Hari Kunasekaran, these paper examinations highlights determination technique utilized in clinical picture handling. How picture is chosen by utilizing various kind of strategy correspondingly: screening, filtering and choosing. We examined on highlight determination system which is broadly utilized for information mining and information revelation and it carryout disposal of excess highlights, associatively holding the central extremist data, include choice suggests less information transmission and proficient information mining. It emphasizes the requirement for additional examination in the field of example acknowledgment that can viably decide the circumstance with caught segment of human body.

Shaik.Jakeer Hussain Content based picture recovery (CBIR) or substance based visual data recovery (CBVIR) has been one of research regions in the field of software engineering and designing from the two decades. In clinical field, X-Rays, Medical Resonance Image (MRI), ECG and CT Scan are produce advanced pictures for analysis and treatment to the patients. These computerized pictures required more extra room and high data transfer capacity. Pressure is a procedure to diminish the complete number of bits of a picture. The nature of the compacted pictures assessed a few variables like Compression Ratio (CR), Root Mean Square Error (RMSE) and Normalized Mean Square Error (NMSE) and Peak Signal-To-Noise Ratio (PSNR). Picture pressure procedures applied on pictures, to limit the capacity and transfer speed. CBIR strategy used to extricate pictures which are outwardly similar to a predefined target picture. CBIR procedure dependent on highlights like shape,

surface and shading. Each element is spoken to by at least one element descriptors. Texture is another significant property of pictures, incredible descriptor that helps in the recovery procedure. Gabor channel utilized for surface investigation. Gabor channel gives the best example recovery exactness. Edge recognition decreases the measure of information and filters out pointless data. Sobel edge indicator removes the edge highlights from the compacted clinical pictures.

3. FEATURE SELECTION

Highlight determination strategies attempt to pick a subset of highlights that are pertinent to the objective idea. It is gives a superior sight into this present reality characterization issue [2]. Romanticized: discover the negligibly estimated include subset that is essential and adequate to the objective idea. Old style: select a subset of M highlights from a lot of N highlights, $M < N$, with the end goal that the estimation of a basis work is enhanced over all subsets of size M .

Improving Prediction precision: the point of highlight choice is to pick a subset of highlights for improving expectation exactness or diminishing the size of the structure without essentially diminishing forecast exactness of the classifier constructed utilizing just the chose highlights. Approximating unique class appropriation: the objective of highlight choice is to choose a little subset with the end goal that the subsequent class circulation, given just the qualities for the chose highlights, is as close as conceivable to the first class dissemination given all component esteems.

The fundamental criteria of the component choice are arrangement exactness ought not to diminish and they chose highlights class conveyance ought to be near the class appropriation of the considerable number of highlights. Highlight determination strategies looks for best highlights utilizing some assessment work. The helpfulness of choosing subsets of factors that together have great prescient force, rather than positioning factors as per their individual prescient force. In writing, feature

determination techniques are wrappers, channels, and installed strategies. Wrappers use the learning machine of enthusiasm as a black box to score subsets of variable as indicated by their prescient force.

Channels select subsets of factors as a pre-preparing step, autonomously of the picked indicator. Implanted strategies perform variable determination during the time spent preparing and are typically explicit to given learning machines. There are four essential strides in a run of the mill highlight choice technique.

1. An age technique to create the following applicant subset;
2. An assessment capacity to assess the subset under assessment;
3. A halting model to choose when to stop; and 4. A approval method to check whether the subset is legitimate.

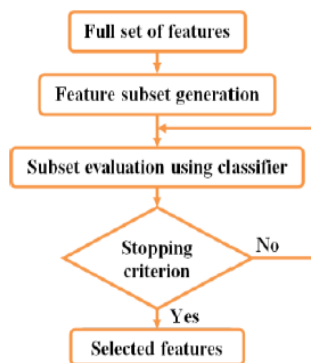


Figure 1 Feature selections with wrapper approach

Wrapper approach fuses the administered learning calculation for approving the created highlight subsets utilizing any of the looking through methodologies as appeared in Figure 1. It yields high grouping precision just for the specific learning calculation embraced. Thus, it doesn't have a high consensus and the computational multifaceted nature is higher than implanted and channel techniques.

The inserted approach utilizes a piece of directed learning calculation for include determination procedure and it delivers better exactness just for the learning calculation utilized in the choice procedure. Subsequently, it doesn't have a high simplification

and it is computationally costly than the channel and lesser than the wrapper strategy.

Information gain (IG):

Information gain (IG) gauges the measure of data in bits about the class forecast, if the main data accessible is the nearness of a component and the comparing class circulation. Solidly, it gauges the normal decrease in entropy.

Correlation based Feature Selection (CFS):

Univariate channels drawback is data gain as it doesn't consider the connections between highlights, which is overwhelmed by the multivariate channels for instance Correlation based Feature Selection (CFS). CFS assesses a subset of qualities worth thinking about each component's individual prescient capacity with level of repetition between them. Relationship coefficients gauge connection between's subset of traits and class, and with between connections between's highlights. Significance of a highlights bunch develops with connection amongst highlights and classes, diminishing with expanded between relationships. CFS decides best component subset and consolidates with search techniques like in reverse disposal, forward choice, bi-directional inquiry, best-first hunt and hereditary pursuit.

Bacterial Foraging Optimization (BFO):

BFO calculation is another transformative calculation dependent on of Escherichia coli (E. coli) microorganisms searching conduct, in the human digestive system. BFO calculation is an organically enlivened processing system which impersonates E. coli microorganisms' rummaging conduct. Characteristic determination expels creatures with poor scrounging methodologies preferring flow of qualities of creatures with effective rummaging systems, as they are bound to appreciate regenerative achievement. After ages, poor searching techniques are either expelled or molded into great ones. This scavenging movement is utilized in advancement.

4. WHAT IS MACHINE LEARNING?

Albeit all perusers of this article most likely have incredible recognition with clinical pictures, many may not recognize what machine learning implies and additionally how it very well may be utilized in clinical picture investigation and translation errands (12–14). Coming up next is one extensively acknowledged meaning of machine learning: If an machine learning calculation is applied to a lot of information (in our model, tumor pictures) and to some information about these information (in our model, amiable or threatening tumors), at that point the calculation framework can gain from the preparation information and apply what it has figured out how to make a forecast (in our model, regardless of whether an alternate picture is portraying considerate or harmful tumor tissue) (Fig 1). On the off chance that the calculation framework streamlines its parameters with the end goal that its exhibition improves—that is, more experiments are analyzed effectively—at that point it is viewed as discovering that task. Machine learning is presently being applied in numerous zones outside of medication, having a focal job in such assignments as discourse acknowledgment and interpretation between dialects, self-sufficient route of vehicles, and item suggestions [10]. A portion of these undertakings were not possible already; late advances in machine learning have made them conceivable.

There are a few terms ordinarily utilized in the machine learning, people group that may not be well-known to radiologists. The accompanying rundown of key terms may help in seeing how machine learning functions.

Characterization: The appointing of a class or mark to a gathering of pixels, for example, those named as tumor with utilization of a division calculation. For example, if division has been utilized to check some piece of a picture as "strange mind," the classifier may then attempt to decide if the stamped part speaks to generous or dangerous tissue.

Model: The arrangement of loads or choice focuses learned by a machine learning framework. When

taken in, the model can be appointed to an obscure guide to foresee which class that model has a place with.

Calculation: The arrangement of steps taken to make the model that will be utilized to most precisely foresee classes from the highlights of the preparation models.

Named information: The arrangement of models (eg, pictures), each with the right "answer." For certain assignments, this answer may be the right limit of a tumor, and in different cases, it may be whether malignancy is available or the sort of disease the injury speaks to.

Preparing: The stage during which the machine learning calculation framework is offered marked model information with the responses (ie, names)—for instance, the tumor type or right limit of an injury. The arrangement of loads or choice focuses for the model is refreshed until no considerable improvement in execution is accomplished.

Approval set: The arrangement of models utilized during preparing. This is likewise alluded to as the preparation set. **Testing:** now and again, a third arrangement of models is utilized for "genuine world" testing. Since the calculation framework repeats to improve execution with the approval set, it might learn one of a kind highlights of the preparation set. Great execution with an "inconspicuous" test set can build certainty that the calculation will yield right answers in reality. Note that various gatherings once in a while use approval for testing and the other way around. This will in general mirror the designing versus factual foundation. In this manner, it is essential to explain how these terms are utilized.

Hub: A piece of a neural system that includes at least two sources of info and an enactment work. The actuation work regularly totals the data sources and afterward utilizes some kind of capacity and limit to create a yield.

Layer: An assortment of hubs that figures yields (the following layer except if this is the yield layer) from at least one sources of info (the past layer except if this is the information layer).

5. DEEPLARNING, MEDICAL IMAGING AND MRI

Profound learning techniques are progressively used to enhance scientific exercise, and the rundown of models is long, growing day by day. We may not enterprise a complete diagram of profound gaining knowledge of in medical imaging, yet simply sketch a portion of the scene before going into a regularly orderly composition of profound mastering in MRI.

Convolutional neural systems may be applied for skill ability development in radiology rehearses via convention determi-country depending on quick-content arrangement. They can likewise be utilized to diminish the gadolinium element conversely stepped forward thoughts MRI by way of a request for greatness without huge decrease in picture best. Profound learning is applied in radio-treatment in PET-MRI constriction revision in radiomics for an audit of radiomics identified with radiooncology and scientific fabric technological know-how), and for theranostics in neurosurgical imaging, consolidating confocal laser endomi-croscopy with profound learning models for programmed reputation of intraoperative CLE photos on-the-fly.

Information procurement and image remaking

Research on CNN and RNN-based totally an image reconstruction technique is quick increasing, spearheaded by Yang et al. At NIPS 2016 and Wang et al. At ISBI 2016. Late packages addresses for example convolutional intermittent neural systems for dynamic MR image recreation , reproducing terrific fine cardiovascular MR pictures from highly under sampled complex-esteemed ok-space data through mastering spatio-worldly conditions, outflanking 3D CNN techniques and compacted detecting based totally specific MRI duplicate calculations in computational multifaceted nature, remaking exactness and speed for various under sampling fees. Schlemper et al. [135] made a profound path of linked CNNs for dynamic MR photo pastime, using records expansion, each unbending and

bendy deformations, to build the variety of the fashions seen by using the machine and reduce overfitting.²⁵ Using variational systems for single-shot quick turn reverberation MRI with variable thickness sampling, Chen et al. empowered non-stop (two hundred ms for each place) image undertaking, beating everyday equal imaging and compacted detecting remaking. In, the creators investigated the capacity for move gaining knowledge of (pretrained fashions) and surveyed the hypothesis of knowledgeable photo remaking with recognize to picture differentiate, SNR, checking out pat-tern and photo content material, utilising a variational machine and true estimation okay-space records from know-how knee MRI filings and synthetic okay-area facts comprised of photos in the Berkeley Segmentation Data Set and Benchmarks. Utilize ing least-squares generative adverse structures (GANs) that learns surface subtleties and smothers high-recurrence commotion, made a singular packed detecting shape that could create analytic first-class recreations "at the fly" (30 ms).

Picture rebuilding (denoising, historical rarity discovery)

Estimation of clamor and picture denoising in MRI has been a full-size area of research for a long term, utilize ing a plenty of techniques. For instance Bayesian Markov abnormal subject models, unpleasant set speculation, higher-request specific well worth disintegration, wavelets, free section exam or better request PDEs.

As of late, profound getting to know strategies had been acquainted with denoising. In their work on gaining knowledge of comprehended mind MRI manifolds the use of considerable neural frameworks, Bermudez et al. finished an autoencoder with bypass relationship for photo denoising, checking out their system with along with various degrees of Gaussian upheaval to greater than 500 T1-weighted cerebrum MR images from strong controls within the Baltimore Longitudinal Study of Aging. Their autoencoder

arrange beat the contemporary FSL SUSAN denoising programming as verified with the aid of top sign to-noise extents. Benou et al. tended to spatio-short lived denoising of dynamic separation stepped forward MRI of the cerebrum with bolus implantation of difference administrator (CA), offering a unique method making use of clothes of profound neural structures for clamor lower. Each DNN was prepared on an alternate scope of SNRs and types of CA focus time bends (indicated "pathology specialists", "sound specialists", "vessel specialists") to produce a recreation theory from loud contribution by utilizing a grouping DNN to choose the most probable hypothesis and give a "spotless yield" bend. Preparing information was produced artificially utilizing a three-parameter Tofts pharmacokinetic (PK) model and clamor acknowledge. To improve this model, representing spatial conditions of PK pharmacokinetics, they utilized linked loud time bends from first-request neighborhood pixels in their master DNNs and gathering speculation DNN, gathering neighboring reconstructions before a boosting methodology delivered the last perfect yield for the pixel of intrigue from picture division to analysis and expectation.

We leave the lower-level utilizations of profound learning in MRI to think about more significant level (down-stream) applications, for example, quick and exact picture division, malady pre-expression in chose organs (mind, kidney, prostate, and spine) and substance based picture recovery, commonly applied to reconstructed extent pictures. We have decided to concentrate our review on profound learning applications near the MR material science and will be brief in the present area, regardless of whether the accompanying applications are intriguing and clinically significant.

Image segmentation

Image segmentation, the sacred goal of quantitative picture investigation, is the way toward parceling a picture into different districts that share comparative traits, empowering confinement and quantification.³⁹ It has a right around 50 years in

length history, and has become the greatest objective for profound learning approaches in clinical imaging. The multispectral tissue arrangement report by Vannier et al. in 1985 [248], utilizing factual pat-tern acknowledgment procedures (and satellite picture preparing programming from NASA), spoke to one of the most seminal stirs paving the way to the present AI in clinical imaging division.

6. PROPOSED APPROACH FOR FEATURE EXTRACTION

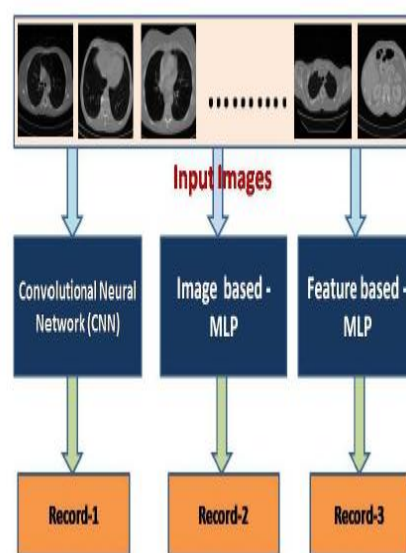


Fig. 2. Proposed methodology classification of image with and without deep learning

The investigation of this technique is introduced in underneath the Fig.2. In the proposed philosophy, a proficient procedure is appeared to control the sensible fundamentals to offer response for the exam questions. The statistics photo is segregated into 3 first-rate models (1) a Convolution Neural Network (2) A MLP based photograph (i.e., the image is taken because the obligation of MLP), and (three) A MLP based totally component (i.e., responsibility of the MLP is certainly disconnected Features in opposition to the photo). As showed up in Fig.4, the strategies gather the statistics pictures plainly and after that apply those photos to individual neural system display up for depiction. Proportionate parameter settings are utilized for making and

checking the correctness, while maximum lovely precision among various neural structure fashions is utilized to certify the final results, e.g., CNN. The individual fashions are discussed in the going with portion:

A. Programmed Feature Extraction primarily based CNN Classifier In this way of wondering, a comparative structure of Le-Cun with a tenderly balanced adjustment is used to make the association. In convolution layer, game plans of enrolled channels are utilized. Each one channel is limited spatially (cross close by stature and weight), yet expands with complete significance of data volume

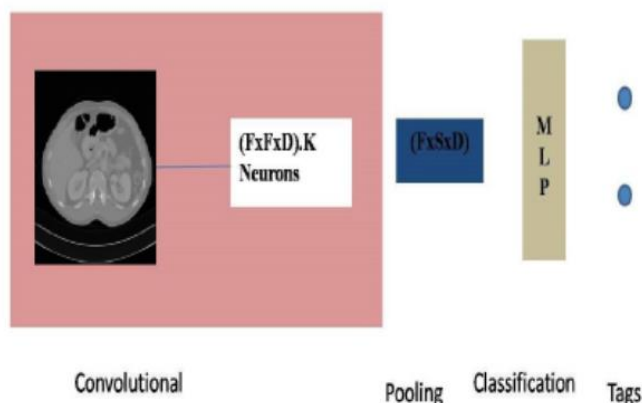


Fig. 3. Automatic Feature Extraction primarily based CNN Classifier

B. MLP based Image

Right now, the entire picture is urged to a MLP primarily based NN (Neural Network). Beginning with a image information is displayed and later the entire picture information is performed to the MLP.

A conjugate inclination plummet based back propagation is requiring for making plans. Different neurons which might be protected up and the instruction time-frame are balanced iteratively. The comic strip of this methodology is given in Fig. 4.

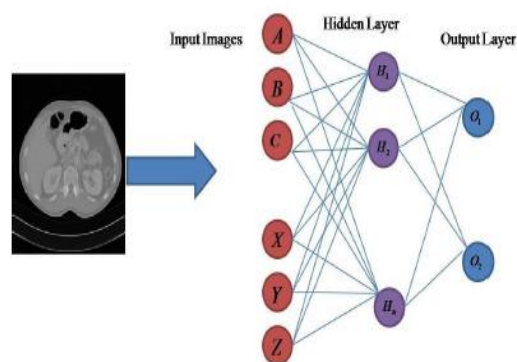


Fig. 4. An MLP based image

C. MLP based Feature

Right now, vector of feature took out from the picture is surpassed directly to Multi-Layer Perceptron base neural framework. The MLP installation part reasons a to head as for the component grid. A situation based totally human conveyed capabilities/motorized component extraction is achieved earlier than persevering with the records picture to MLP. The conjugate tendency drop based back-multiplication remembers is utilized for the readiness. By setting apart to the MLP based totally photo, MLP installation element works as for modestly kept data limit considering the manner that the capabilities that are segregated from the images are less in range. The Clear records of this system are analyzed [14] in Fig. 3.

Gonzalo Farias et al., [15] offer an unusual NN called Sparse Auto-Encoder for 2 collecting difficulty of TJ-II combination database. For all of the initial evaluation, the parameters for the SVM classifiers are steady. By using Auto-Encoder all the main capabilities are dwindled. The initial results suggest that the generous classifiers with a high effective charge are feasible, beside that the factor area is lessened to underneath 0.02.

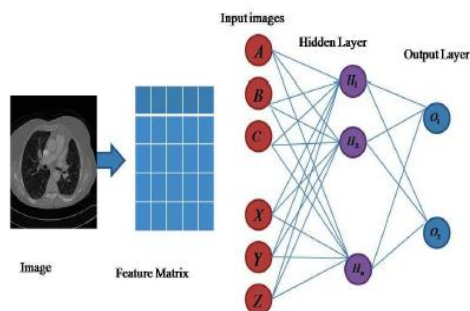


Fig. 7. MLP based Feature

7. RESULTS

Investigational outputs be exposed below: Table.1 shows the results for classification accuracy. Table.1. Classification Accuracy

Classification accuracy	Furia	Ripper	OneR
Feature selection using CFS	91.33	84.53	85.47
Feature selection using IG	92.73	86.87	87.60
Feature selection using proposed CFS -BFO	93.73	87.87	89.20

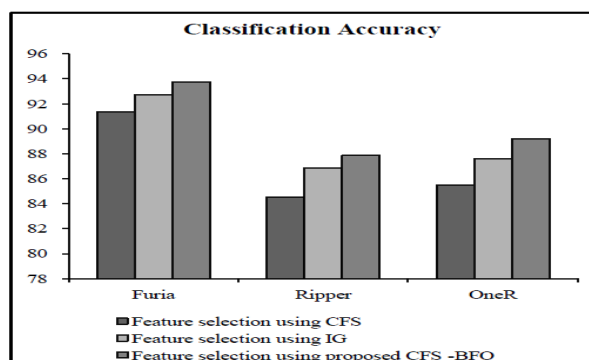


Fig.7. Classification Accuracy

Table.2. Precision

Precision	Furia	Ripper	OneR
Feature selection using CFS	0.9170	0.8455	0.8556
Feature selection using IG	0.9281	0.8728	0.8799
Feature selection using proposed CFS -BFO	0.9380	0.8824	0.8918

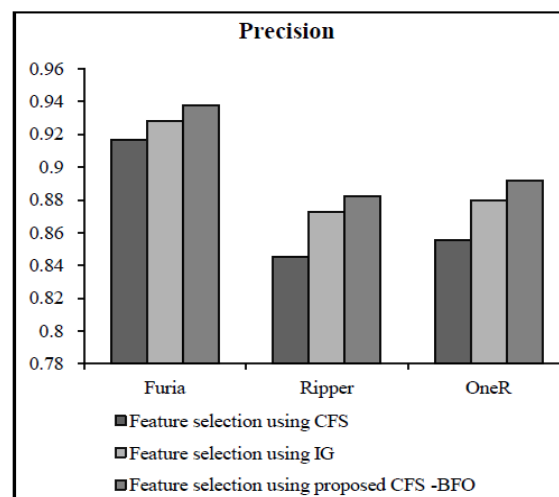


Fig.8. Precision

CONCLUSION

Clinical Image examination/handling are significant in clinical determinations, particularly in non-intrusive treatment or clinical investigation. Imaging assists specialists with picturing and break down pictures to comprehend inner structure variations from the norm and distinguish ailments. Bio-clinical gadgets' clinical picture information utilizing imaging procedures like Computed Tomography (CT), Mammogram, and Magnetic Resonance Imaging (MRI) uncover nearness or nonappearance of sore with tolerant history and are a significant demonstrative factor. Right now novel component determination system utilizing Bacterial Foraging calculation is examined. The proposed methods improve the arrangement exactness contrasted with Correlation Based Feature Selection and OneR. Further work can be completed toward improved target work thinking about different goals. Examinations can likewise be done utilizing delicate processing classifiers.

REFERENCES

1. Saeys, Y, Inza, I & Larrañaga, P 2007, „A review of feature selection techniques in bioinformatics. Bioinformatics“, vol. 23, no. 19, pp.2507-2517.
2. Bikku, Thulasi. "A Novel multi-class ensemble model for classifying imbalanced biomedical datasets." *IOP Conference Series: Materials*

- Science and Engineering*. Vol. 225. No. 1. IOP Publishing, 2017.
3. Hall, MA 1999, Correlation-based feature selection for machine learning, Ph.D. thesis, The University of Waikato, NewZealand.
 4. Liu, H & Setiono, R 1996, „A probabilistic approach to feature selection-a filter solution“, Proceedings of Eighteenth International Conference on Machine Learning, Italy, pp. 319-327.
 5. Lisnianski, A, Frenkel, I & Ding, Y, 2010, „Multi-state system reliability analysis and optimization for engineers and industrial managers“, Springer, New York.
 6. Lin, S.W, Tseng, TY, Chou, SY & Chen, SC 2008, „A simulated-annealing-based approach for simultaneous parameter optimization and feature selection of back-propagation networks“, Expert Systems with Applications, vol. 34, no.2, pp.1491-1499.
 7. Bikku, Thulasi. "A new weighted based frequent and infrequent pattern mining method on realtime E-commerce." *Ingenierie des Systemes d'Information* 23.5 (2018): 121.
 8. [8] Meiri, R & Zahavi, J 2006, „Using simulated annealing to optimize the feature selection problem in marketing applications“, European Journal of Operational Research, vol.171, no.3, pp.842-858.
 9. Zhang, H & Sun, G 2002, „Feature selection using tabu search method“, Pattern recognition, vol. 35, no.3, pp.701-711.
 10. Tahir, MA, Bouridane, A & Kurugollu, F 2007, „Simultaneous feature selection and feature weighting using Hybrid Tabu Search/K-nearest neighbor classifier“ Pattern Recognition Letters, vol. 28, no.4, pp.438-446.
 11. Bikku, Thulasi, and Radhika Paturi. "A novel somatic cancer gene based biomedical document feature ranking and clustering model." *Informatics in Medicine Unlocked* (2019): 100188.
 12. Aghdam, MH, Ghasem-Aghaee, N & Basiri, ME 2009, „Text feature selection using ant colony optimization“, Expert systems with applications, vol. 36, no.3, pp.6843-6853.
 13. Bolón-Canedo, V, Sánchez-Marono, N & Alonso-Betanzos, A, 2013, „A review of feature selection methods on synthetic data“, Knowledge and information systems, vol. 34, no.3, pp.483-519.