

Computer Aided Diagnostic Approach for Melanoma Diagnosis Using Neural Networks

Santosh Kumari Bhakal

Computer Science and Information Technology Dept.,
Govt. Engineering College,
Ajmer, Rajasthan-305025

Ravinder Singh

Computer Science and Information Technology Dept.,
Govt. Engineering College,
Ajmer, Rajasthan-305025

Abstract:- Harmful Melanoma, basically the most extremely dangerous sort of epidermis malignancy, has a phenomenal conclusion whenever taken care of inside the reparable early ranges. Early determination and careful extraction is presumably the most vigorous cure of melanoma. This work utilizes a record set of 184 clinical dermatoscopic pictures of skin injuries, in which 144 pictures are of dangerous sores and 40 photos are of the amiable sore, picture pre-handling, and division techniques are utilized to separate melanoma from considerate pigmented sores. Otsu and Entropy fundamentally based picture division rules are cultivated which improves the execution. The appropriate outcomes demonstrate that Havrda Entropy and Harris Corner Detector based melanoma analysis approach accomplish greater affectability concerning Otsu and Harris based joined methodology. The separated geometrical, fringe and shading highlight set is conveyed to characterize an outlining limit among considerate and dangerous classes of melanoma and it is seen that entropy-based neural learning approach outflanks to Otsu based neural learning approach individually.

Keywords:- Melanoma, Benign, Malignant, Neural Network, Features, Dermatoscopic Score.

I. INTRODUCTION

T Malignant growth has a term for diseases where irregular cells isolate without control and are prepared to attack exceptional tissues. Disease analyzed therapeutically as a dangerous neoplasm, bizarre cell advance has a critical time of infirmities. There are over a hundred great recognized malignant growths that influence individuals. Six patterns of malignancies had been proposed: proliferative flagging, dodging holding improvement concealment, oppose cell passing, replicative everlasting status allowing, angiogenesis instigating and actuating intrusion and metastasis can frame an immediately mass-time most diseases cell from conventional cells improvement that incorporates numerous means. Malignant growth cells can unfurl to explicitly added substances of the physical make-up through the blood and lymph techniques[1]. At the point when cells of the body at an exact site begin to extend out of overseeing, they will go wind up dangerous. Generally, 5– 10% of malignancies can likewise be followed straight away to acquired hereditary deformities. More than certain states of malignancies may be avoided with the guide of the utilization of smoking,

eating more stopped outcome, taking off veggies, and whole grains, ingesting a lousy part significantly more obvious sugars and meat, keeping up a healthy weight, work out, limiting exposure to sunshine hours, and immunization contrary to some irresistible afflictions. There are boundless strategies to have an analyze most diseases, which incorporates the nearness of centered signs and indications and signs, logical imaging or screening checks. As fast as a kind of melanoma likely practical is distinguished, it is recognized through the utilization of the minute examination of a tissue test. A malignant growth is most normally dealt with radiation treatment, chemotherapy, and surgery. The potential outcomes of enduring the affliction assortment for the most part with the helpful asset of a method for the style and zone of malignant growth and the amount of disease at the initiation of treatment. Melanoma may affect guys and females of every one of the extended term, paying little respect to the way that few styles of malignant growth are all the more genuine in children, also, the risk of building melanoma most regularly will increment with age.

At the point when greatest malignant growths begin off created, it generally delivers no signs. The few signs and signs and indications and side effects just showcase up because of the reality the mass keeps on expanding or quickens. Steady with the discoveries sway relies on the range and region of generally malignant growths. Hardly any signs are focused, with several them in addition greatest for the most part occurring in people who have exceptional circumstances prior. The disease is the present day "palatable imitator". Thusly isn't special for people determined to have most malignancies to were managed for stand-out illnesses to which it changed into once expected their signs had been expected [2].

General indications get up due to some separation away impacts of the melanoma that isn't concerning immediate or metastatic spread. These need to join inadvertent fever, weight decrease, too much exhausted, and changes in accordance with the epidermis [3]. Hodgkin disease, leukemia, and malignant growths of the liver or kidney can reason a nonstop fever of obscure beginning area.

Melanoma is a type of skin most malignant growths that begin off developed in melanocytes. Melanocytes produce the dim shade alluded to as melanin which is chargeable for the tinge of pores and skin. The dermis is the most extreme fundamental organ inside the physical make-

up. It shields the body from warmth, damage, disease, and mischief instigated with the helpful asset of bright radiation (UV). A standard dermis does certain matters[4].

It covers and empowers protect the organs inside the casing, holds out germs, permits keep up in water and different liquids, permits control body temperature, encourages by means of protecting whatever is left of the body from bright (UV) beams and encourages the casing to make dietary Vitamin D[5].

II. LITERATURE SURVEY

In this area, a walk by means of roughly the common work and procedures for identification of malignancy is given. The various procedures utilized inside the past research are delineated as underneath:

In [6], if asymmetry, outskirt inconsistency, shading variety, and measurement (ABCD) work extraction of the dermatoscopic photo for most malignancies dermis most tumors guess. Asymmetry highlight incorporates know-how of asymmetry and expanding record of the sore. Outskirt inconsistency include comprises of data of smallness file, fractal estimation, locale unexpectedness, and pigmentation progress from the sore. Shading homogeneity include is made aptitude out of hue homogeneity and the relationship among photometry and geometry of the injury. Measurement extraction is a width of the sore. The investigate utilizes 30 tests of photographs and dermatoscopic sore it is suspicious to malignant growth pores and skin generally diseases. It regularly depends upon the investigate, the precision of the strategy is around eighty-five %. There are 4 counterfeit judgments of 30 tests.

In [7], demonstrated in his perceptions that MATLAB is a solid programming program for the early forecast and examination of dangerous disease by means of utilizing numerical photo preparing procedures. Just a few lines of minimally composed code are adequate with a reason to programming the predefined calculations. Moreover, appraisal among calculations will turn out to be extremely simple and productive with a base programming endeavor and hence, determined a normal dermatoscopic rating for dangerous malignancy.

In [8], inspected frameworks by in the first place introducing the seen focuses utilized for skin injury type and ways for characterizing them and after that characterized extraction of these highlights by utilizing method for virtual picture preparing approaches, i.e., division, enlistment, outskirt discovery, shading and surface handling. What's more, providing a scope of ways to deal with make utilization of the separated highlights for

skin injury class by utilizing engineered insight methodologies and heuristics, i.e., Discriminant assessment, Neural Networks, Support Vector Machines. At that point in examination those methodologies in separating dangerous melanoma tumors versus dysplastic naevi injuries.

In [9], portrays the assessment of various division techniques connected at the minuscule gem photograph. Division by watershed remove rise as in each the non-covering and covering things in the image is intricate and the impediment emerges while the area is made by way out of the use of various components and partition subject of covering things must be thought about in view of the way that the greater part of them have a line for detachment, despite the fact that choice of this line is important for the total framework. Slope division with pre-preparing approaches in a couple of regions of devices affect in over-division and the detachment of covering devices ought not to be sure. Hence, it reasoned that area creating a division device related by utilizing way detachment of covering objects executed at the things of photo exhibits better result in contrast with the two prior methodologies.

In [10], proposed a procedure to characterize pores and skin sores as threatening or kindhearted from shading photographic slides of the sores. He utilizes shading photographs of epidermis injuries, preview preparing procedures and counterfeit neural network classifier to separate melanoma from considerate pigmented sores. For an underlying adjusted tutoring/testing set, this methodology was once arranged to acquire 79.1% of the correct grouping of threatening and kindhearted injuries on genuine dermis sore depictions.

In [11], provided coming on SVMs and a portion of the projects of SVMs in test awareness issues. SVMs have been effectively used to various projects beginning from face discovery and mindfulness, object location, mindfulness, and written by hand persona and likewise digit insight, speaker and discourse acknowledgment, and comprehension and picture recovery, forecast, etc. Considering the truth that they have yielded marvelous speculation by and large execution on numerous measurable inconveniences with no earlier capacities and when the element of a region is exceptionally radical.

John Breneman [12] proposed the ABCD rating computation calculation and actualized on an Android-arranged cell stage. He leading distinguishes and confines dermis flaws in greater pores and skin picture using the substitute of-Gaussians and SVM locator. When restricted, the fringe of each and every skin flaw changed into decided making utilization of a statute angle appraisal inside the CIE XYZ shading zone.

III. ALGORITHMS FOR MELANOMA DIAGNOSIS

The investigations area names for disease examination isn't the best controlled to picture handling. It has its more extensive parts in the area of highlight designing, include the decision, gadget picking up information of, picture union and bunches of more issues are in studies strategy these days.

Prior Contribution Includes:-	Proposed Work Includes:-
ABCD feature extraction	ABCD features with Harris Corner based border evaluation
Dermatoscopic Samples	General camera taken images.
Discriminant Analysis, Neural Networks, and Support Vector Machines.	TDS based scoring.
Watershed Segmentation	Otsu Segmentation
Difference-of-Gaussians (DoG) and Canny based border detection	Uses morphological approach.
Fractal Analysis	Mean and Variance of Radial Vector
Texture Analysis	Correlation between photometry and geometry
EPL Samples	Preprocessing with median filters

Table 1:- Contribution Table

For the discovery of dangerous malignancy, we are utilizing Image Processing Toolbox in MATLAB. The reason for modernized supported epidermis disease discovery technique is to find presumably dangerous sores in the procured pix of influenced pores and skin. The preparing comprises removing the significant and favored data of the pores and skin lesion[13]. It implies that an image handling machine will snap a photo as a section and offers again a further picture as a yield. The reason is to find threatening sore from the given example pics. The basic intention of the proposed skin melanoma indicative framework is the extraction of highlights of the image, using pre-preparing and division systems with the goal that you might need to upgrade the wonderful of the image and afterward look at the components of the image that are Asymmetry (A), Boundary (B), shading versions (C) and Diameter (D) for the discovery of threatening and non-dangerous melanoma[14].

A. Image Pre-Processing

The initial step is Hair and Noise end from the picture utilizing Median Filtering is utilized to limit the nearness of little homes like hair. In photograph handling, it's much of the time spellbinding to most likely take an interest in some state of commotion decrease on a picture. The middle channel is a nonlinear advanced method, about typically used to push off the clamor. Middle sifting might be in all respects significantly utilized in virtual photograph handling considering the reality that, beneath explicit conditions, it jam aspect at the indistinguishable time disposing of the commotion. It's particularly used to put off salt pepper clamor and spot noise[15].

B. Median Filtering

Middle separating is a nonlinear strategy used to get rid of clamor from pictures. It's definitely utilized as it's far imperatively solid at discarding commotion at the equivalent time protecting edges. It is especially viable at disposing of 'salt and pepper' kind clamor. The middle gets out works with the helpful asset of moving through the photo pixel through the pixel, changing each great worth

with the middle rate of neighboring pixels [16]. The example of companions is known as the "window", which slides, pixel by means of the pixel over the total picture 2 pixels, over the whole photo. The middle is determined by first arranging the majority of the pixel esteems from the window into the numerical request, and after that supplanting the pixel being showed up with the center (middle) pixel cost. A case of middle sifting is given with the guide of fig.1. A middle channel out is a case of a non-straight channel out and, if accurately structured, is great at safeguarding picture component. To run a normal get out:

1. Consider each pixel within the photograph
2. Sort the neighboring pixels into order based upon their intensities
3. Replace the original price of the pixel with the median value from the list

A median filter is a rank-dedication filter out

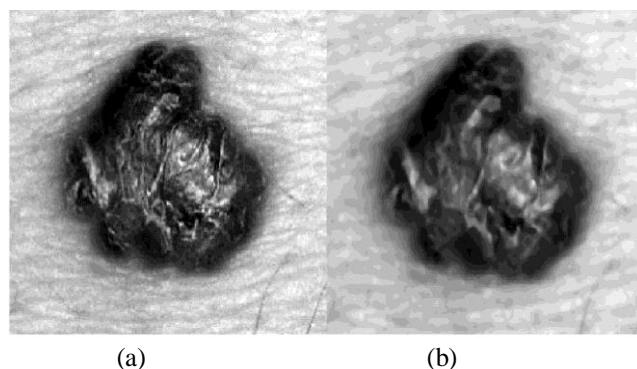


Fig 1:- (a) shows gray scale image and (b) median filtered image with threshold=5

The least complex technique for picture division is known as the thresholding strategy. This gadget depends absolutely on an edge charge to change into a dim scale photograph legitimate directly into a twofold photo. Debut limit isolates really thought to be one of the caring contraptions from certainties [16].

In this subsection, we talk about the great entropy measures [3], [8]-[10], which can be utilized on these artistic creations for relative addition information of in photo division issues. The procedure of photo division utilizing the dark dimension co-occurrence grid and Havrda entropy degree is referenced in [5]. The essential strides of the calculation are imitated appropriately directly here for comfort [18]:

- Initially, the gray value co-occurrence matrix is computed for individual color band of image.
- A Two-Dimensional probability distribution is retrieved by scaling co-occurrence matrix by total pixel count.
- Havrda entropy values are accounted for all $t \in [0, 1, 2, \dots, L - 2]$ using two-dimensional probability distribution p_{m_1, m_2} .
- The numbers of minima points are determined and smallest minima may be taken as a threshold for image segmentation problem.

The Havrda–Charvát entropy $H_{hc}(p_{m_1, m_2})$ of degree α introduced by Havrda and Charvát and later on modified by Daróczy is often used in statistical physics and is defined as follows [3]:

$$H_{hc}(p_{m_1, m_2}) = \frac{\sum \sum p_{m_1, m_2}^\alpha - 1}{2^{1-\alpha} - 1} \tag{1}$$

And corresponding entropy function is given by

$$Entropy(t) = \frac{1}{2^{1-\alpha} - 1} \left(\sum_{m_1=0}^t \sum_{m_2=t+1}^{L-1} p_{m_1, m_2}^\alpha - 1 \right) + \frac{1}{2^{1-\alpha} - 1} \left(\sum_{m_1=t+1}^{L-1} \sum_{m_2=0}^t p_{m_1, m_2}^\alpha - 1 \right) \tag{2}$$

The above-referred to entropy abilities given in (1) and (2) are determined for every limit an incentive for an offered photograph to be fragmented utilizing the likelihood conveyance which in flip is determined from its dim and shading factor degree co-event network. The quantities of minima factors are chosen from the entropy highlight rather than dim degree and shading component level plot. The dark stage and shading part level comparing to the littlest minima can be taken as a limit for photo division issues.

The highlights utilized for the indicative strategy for the recognition of melanoma are Asymmetry (A), Border (B), Color (C), Diameter (D) and Evolving (E). To choose the certificate of asymmetry we ascertain the circularity of the structure that is chosen by the region (An) and edge (P). Its essential equation is:

$$CI = \frac{P_L^2}{4\pi A_T} \tag{3}$$

Moreover, the injury is isolated into four sections by the major and minor pivot which crosses in the focal point of the sore. We figure the zone distinction over every hub with the recipe:

$$AI = \frac{\Delta A_{maj} + \Delta A_{min}}{2 * A_T} \tag{4}$$

Where the differential territory is the littlest outright zone distinction and AT is the zone of sore area. The injury is symmetric while the Asymmetry is underneath 20%. With an intention to gauge symmetry, we depend on geometrical houses known as second of latency. These inertial minutes are utilized to compute capacities: the Asymmetry Index (AI) and expanding list (LI).

For malignant growth, the element the fringe of the sore is obscured and unprecedented at the limit of the structure. To run over the indented and worn out edges the Harris alcove identification set of rules has been executed. The outskirts is separated into 8 zones and for every area, the abnormalities are stamped and checked. The Harris corner indicator segregates the charming little scope of components which can be most imperative for the examination, is invariant to revolution, little adjustments of scale and picture commotion.

Give us a chance to expect a move about a point, at that point the auto-relationship capacity could be communicated as[19],

$$c(x, y) = \sum_W [I(x_i, y_i) - I(x_i + \Delta x, y_i + \Delta y)]^2 \tag{5}$$

Where $I(\cdot, \cdot)$ denoted the image function and (x_i, y_i) were the points in the Gaussian window W centered on (x, y) . Via help of Taylor expansion shifted image could be approximated to first order term as,

$$I(x_i + \Delta x, y_i + \Delta y) \approx I(x_i, y_i) + [I_x(x_i, y_i) I_y(x_i, y_i)] \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \tag{6}$$

$I_x(\cdot, \cdot)$ and $I_y(\cdot, \cdot)$ represent the single dimension gradients in x and y directions respectively.

$$c(x, y) = \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix}^T S(x, y) \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \tag{7}$$

Spoken to the spatial profundity issue in the confined neighborhood of the point, for each point in the entered photo was a grid of size (2, 2). Accept t and y be the Eigenvalues identified with network $S(x, y)$. This decision and general reliance of Harris Detector on Eigenvalues make it perpetual to the revolution as expressed before.

Lesser estimations of every parameter finished in level focuses, because of the reality the low estimations of vehicle relationship work establish the steady force of level spot. One littler and one bigger caused edge factors. The lower cost of connection trademark establishes the level region in a way, while better estimations of it show the exchange inside the force in the confined region about a factor. High estimations of every one of those eigen parameters depicted as alcove focuses in the picture. As the more expensive rate of the two eigenvalues pondered the better charge of vehicle connection highlight in any course, this might be most straightforward portrayed with the guide of an image corner.

The ensuing parameter that is dissected is the shade variegation. In threatening melanoma, there might be situated up to six or perhaps increasingly selective hues. Six hues are mulled over to be most extreme gigantic: white, pink, gentle darker, darkish-brown, blue-dim, and dark. The shading division depends absolutely on multidimensional thresholding which plans to advantage the basic actualities roughly the present hues in the injury. The choice of essence of 6 essential colorings inside the sore is taken and 1 rating point is given for the nearness of each and every shading for the estimation of the C score. The above-expressed shades are characterized in RGB tinge place as follows in Table 1.

Color	RGB	Rgb
White	255,255,255	1.0,1.0,1.0
Black	0,0,0	0.0,0.0,0.0
Red	255,0,0	1.0,0.0,0.0
Light-brown	205,133,63	0.80,0.52,0.25
Dark-brown	101,67,33	0.40,0.26,0.13
Blue-gray	0,134,139	0.0,0.52,0.54

Table 1:- RGB Description of colors

IV. EXPERIMENTAL RESULTS

In this piece of the article, we talk the recreation result completed in MATLAB on the malignant growth pix. The trial of right execution of the dermoscopy ABCD rule approach was finished on the data sets of previews, times of which are portrayed by a method for Table 2. The machine has been tried on 184 sores (one hundred forty-four threatening and forty benevolent sores). Dataset acquired from www.Dermnetz.Com.

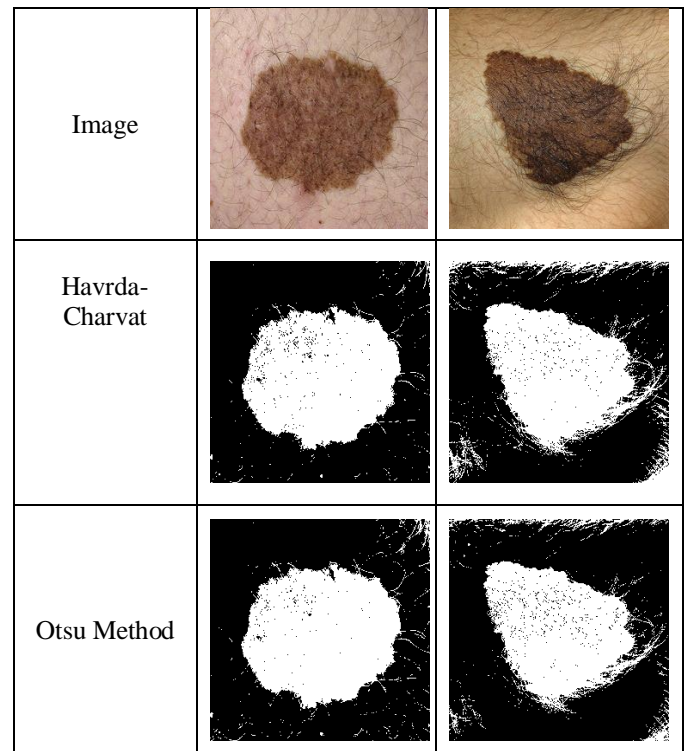


Table 2:- Original images & entropy based segmentation results for different segmentation approach

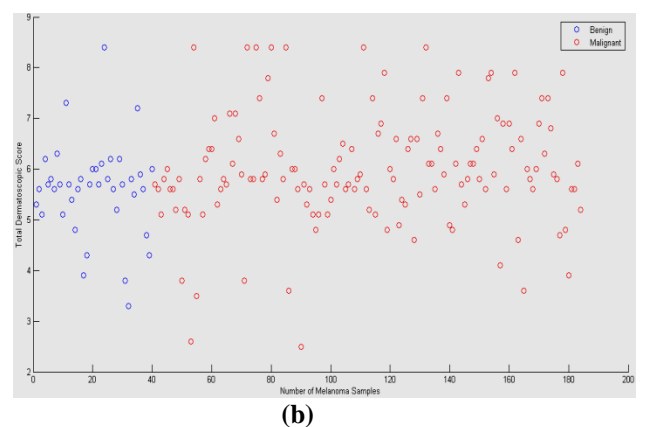
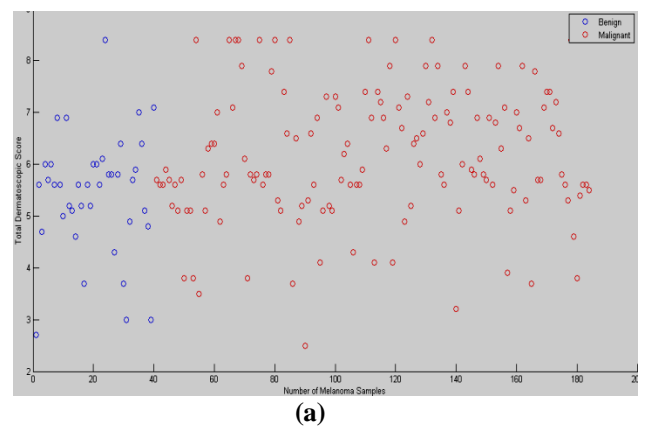


Fig. 2:- TDS plot for (a) Otsu based and (b) Havrda Entropy based feature extraction.

Approaches <i>Performance</i>	Otsu with Harris Corner (ABCD features)	Havrda with Harris Corner (ABCD features)	ZAGROUBA et.al [5] using NN based machine learning	Joanna et.al [11] using SVM
<i>Sensitivity</i>	90.41%	92.45%	61.2%	87%
<i>Specificity</i>	29.72%	27.48%	77.4%	80%

Table 3: -Comparative Performance of Otsu and Entropy based approach at TDS-6.3

For the gadget studying based totally neural community approach to determine the non-linear choice boundary separation two exclusive instructions of melanoma samples. The neural networks are heuristically trained at diverse architectures starting from ten neurons inside the hidden layer to a more wide variety of neurons to perfectly delineate the choice areas. This suggest square blunders is taken into consideration because the loss characteristic and hyperbolic tangent capabilities are the deployed activation function. The realization of a neural community is deployed with an unmarried hidden layer loaded with multiple ranges of neurons ranging from ten to 20 for heuristic trials. From the general melanoma samples, seventy-five % is taken into consideration for education and relaxation 30% are similarly distributed for trying out and validation respectively. Figure three and 4 represent the confusion matrix outcomes of the learned diagnostic model using Otsu and Entropy-based method respectively. It is apparent from the results that using entropy-based total method for melanoma prognosis, version is successful to achieve and most effective sensitivity and specificity chances respectively.

V. CONCLUSION

In this paper, we endeavored to analyze melanoma from shade pores and skin pictures the utilization of photograph preparing systems. Accomplished impacts suggest that the application might be utilized for the conclusion of dangerous melanomas. It very well may be utilized now not just by methods for youthful unpracticed dermatologist anyway first and primary with the guide of claim family doctors. This is a plausibility for individuals that live in some separation off and rustic territories out of entryways the provincial focus and is stood up to with the typical troubles of making a meeting with a dermatologist. It tends to be pivotal to analyze melanomas inward an early certificate as it will lessen the malignant growth related mortality charge.

To embellish and improve the excellent of the picture, picture pre-preparing and division systems are done. We decided Median sifting strategy gives the most extreme promising final product for the commotion and hair disposal from the picture and Canny part recognition yields the fabulous outcomes for identifying edges of the image since it has propelled flag to clamor proportion. Otsu division set of guidelines, in this way, improves the general enormity of the image.

The Havrda work is equipped for segmentizing the one of a kind sore actualities most accurately nearby keeping its geometrical capacities absolutely. The execution of Havrda is proximate to OTSU fine art as its entropy degree plot has a bowed to look like the between gathering recommend qualification level of Otsu strategy. While on account of Kapur, Renyi and Vajda degree division generally execution last results are additional disintegrated as opposed to Havrda, OTSU, and Shannon individually. The capacities Asymmetry, Border, Color adaptation and Diameter are utilized for the count of Total Dermatoscopic Score (TDS). A high TDS score is more prominent than 5.9 injury is significantly more prone to threatening generally diseases. At the learning technique, it could be inferred that entropy fundamentally based calculations beat to Otsu principally based neural form as it builds the affectability and explicitness both ideally. Also, basic the neural fundamentally based becoming more acquainted with configuration is able to give a fair depiction among threatening and considerate sores individually. The future extent of this space of studies incorporates extraction of textural highlights, work decision, and vital the product of profound neural network for melanoma determination.

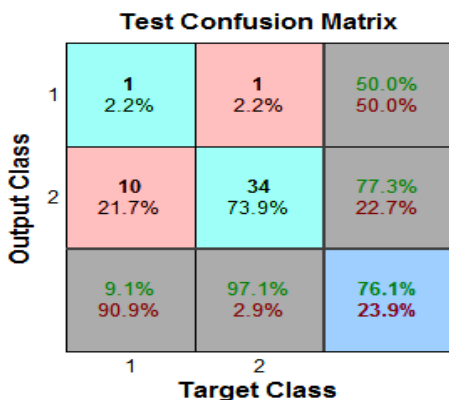


Fig 3: Confusion matrix for Otsu based diagnostic model.

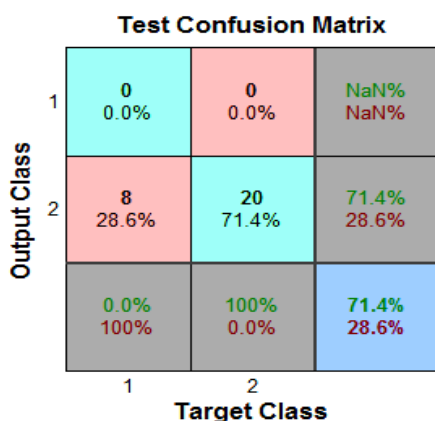


Fig 4:- Confusion matrix for Entropy based diagnostic model.

REFERENCES

- [1]. J.S. Weszka and A. Rosenfeld, "Threshold evaluation techniques," *IEEE Transactions on Systems, Man, and Cybernetics* 8, vol.8, pp. 622–629, 1978.
- [2]. John Canny, "A computational approach to edge detection. Pattern Analysis and
- [3]. Machine Intelligence", *IEEE Transactions, PAMI-* 8(6):679–698, Nov. 1986
- [4]. Franz Nachbar, "The ABCD rule of Dermatoscopy", *Journal of the American Academy of Dermatology*, Volume 30, Number 4, April 1994
- [5]. L. Xu, M. Jackowski, A. Goshtasby, D. Roseman, S. Bines, C. Yu, A. Dhawan, A. Huntley, "Segmentation of skin cancer images", *Elsevier Science B.V., Image and Vision Computing* 17 (1999) 65–74
- [6]. Harald Ganster, Axel Pinz, Reinhard Röhner, Ernst Wildling, Michael Binder, and Harald Kittler, "Automated Melanoma Recognition", *IEEE TRANSACTIONS ON MEDICAL IMAGING*, VOL. 20, NO. 3, MARCH 2001
- [7]. Alvin Ring, MD, "Melanoma Claims", *CAP Today*, August 2002.
- [8]. Hyeran Byun and Seong-Whan Lee, "Applications of Support Vector Machines for Pattern Recognition: A Survey", *Springer-Verlag Berlin Heidelberg*, LNCS 2388, pp. 213-236, 2002.
- [9]. Moncrieff M, Cotton S, Claridge E, "A new technique for imaging pigmented skin
- [10]. lesions", *British Journal of Dermatology*, 146(3), Hall P (2002), 448-457
- [11]. David Houcque, "Introduction to MATLAB for Engineering Students", *Northwestern University*, version 1.2, August 2005.
- [12]. Garnavi, Rahil, Mohammad Aldeen, and James Bailey. "Computer-aided diagnosis of melanoma using border-and wavelet-based texture analysis." *Information Technology in Biomedicine, IEEE Transactions on* 16.6 (2012): 1239-1252.
- [13]. Ng, Vincent, and Andrew Coldman. "Diagnosis of melanoma with fractal dimensions." *TENCON'93. Proceedings. Computer, Communication, Control and Power Engineering. 1993 IEEE Region 10 Conference on*. Vol. 4. IEEE, 1993.
- [14]. Pehamberger, Hubert, et al. "In vivo epiluminescence microscopy: improvement of early diagnosis of melanoma." *Journal of Investigative Dermatology* 100 (1993): 356S-362S.
- [15]. Green, Adele, et al. "Computer image analysis in the diagnosis of melanoma." *Journal of the American Academy of Dermatology* 31.6 (1994): 958-964.
- [16]. G. grammatikopoulos, A. Hatzigaidas, A. Papastergiou, P. Lazaridis, Z. Zaharis, D. Kamptaki, G. Tryfon, "Automated Malignant Melanoma Detection Using MATLAB", *International Conference on Data Networks, Communications & Computer Proceedings of the 5th WSEAS*, Bucharest, Romania, October 16-17, 2006.
- [17]. Gautam D, Ahmed M, Meena YK, Ul Haq, "A. Machine learning–based diagnosis of melanoma using macro images". *Int J Numer Meth Biomed Engng*. 2018;34:e2953. <https://doi.org/10.1002/cnm.2953>.
- [18]. D. Singh, D. Gautam and M. Ahmed, "Detection techniques for melanoma diagnosis: A performance evaluation," *2014 International Conference on Signal Propagation and Computer Technology (ICSPCT 2014)*, Ajmer, 2014, pp. 567-572.
- [19]. D. Gautam and M. Ahmed, "Melanoma detection and classification using SVM based decision support system," *2015 Annual IEEE India Conference (INDICON)*, New Delhi, 2015, pp. 1-6. doi: 10.1109/INDICON.2015.7443447.