International Journal of Advanced Technology in Engineering and Science
Vol. No. 10, Issue No. 05, May 2022
www.ijates.com
ijates
ISSN 2348 - 7550

Automatic Detection and classification of Knee Osteoarthritis using Machine learning techniques

Nilesh P Raghavan[1] ,Pradeep P[2], Ragavendiran SS[3]

[1,2,3] UG scholar
Department of Electronics and Communication Engineering
Bannari Amman Institute of Technology, Sathyamangalam
Erode-638401, Tamilnadu, India.
Email:- nileshpraghavan.ec18@bitsathy.ac.in,
pradeep.ec18@bitsathy.ac.in,
ragavendiran.ec18@bitsathy.ac.in.

Abstract

Osteoarthritis is commonly known as wear and tear arthritis. The condition of the arthritis is natural cushioning between joints, and cartilage wears away. It happens at the time the bone is rubbing more closely together against one another With less of the shock- absorbing benefits of cartilage. There doesn't seem to be any permanent cure discovered to curb this disease among a large set of the world's population.During bone rubbing the problem has to face pain, swelling,stiffness, decreased ability of movement and sometimes the formation. Since the cartilage acts as a slippery tissue, there's a smooth frictionless motion of the joints. This friction between bones causes immense discomfort and pain over time this will lead to wears and tears of the connection of the joints and the tissues .

The probability of developing osteoarthritis includes age,gender, obesity, repeated stress on the joint, genetics, bone deformities, joint injury, metabolic diseases and complications. The aim of our project is to detect and identify the presence of such an ailment through the combination of machine learning techniques, digital image processing and artificial intelligence. Through the complete dedication flow of steps and methodologies involved in image processing and machine learning algorithms, the system is trained to analyze and segregate those images of knee scans like x-ray images or MRI scans . it shows the sign of developing stage of arthritis from the rest which belong to healthy categories. This is achieved using powerful software tools like Matlab and machine learning algorithms. By developing a product similar to the scanning machine, but it does more than just scanning which is getting valuable information, vital details and complicit elicit which possibly leads to the hope of finding cure to the disease and leading to the end of the disease.

Outcome

The outcome of the project is identifying the cartilage level present in between the bone joint and tissue. Then we analyze the stage of arthritis diseases of the affected person with the help of powerful software tools like MATlab with the combination of machine learning techniques and digital image processing and artificial intelligence. Final outcome is we give a complete solution for the affected person.

Keywords : Matlab, machine learning, digital image processing and artificial intelligence.

I. Introduction :

Osteoarthritis is the most common type of arthritis. It occurs when the protective cartilage that softens the end of the two bones wears down overtime. It is also known as Degenerative Joint Disease(DND). According to the recent survey there are more than 10 million cases in each year due to this disease and it causes mainly to the elderly people. Having affected over 30% of the world's population, this is an ongoing silent epidemic that targets all those who belong to the category of middle-aged people, senior citizens, women and those of who have suffered from joint based injuries and bone deformations.

There are several symptoms of osteoarthritis leading to extra burdens of drastic deterioration in the quality of life, depression, can also completely impair people of their functional independences in their daily activities. The project aims in aiding towards the fundamental step of identifying the area of occurrence, which is prone to the symptoms of osteoarthritis. Helping researchers and medical personnel,
many scanned images can be diagnosed digitally, even going forward with brilliant recommendations of medicines to be taken, stage dependent treatments needed for an overall excellent overview of what causes the ailment, and possibly create a new road towards a permanent medical cure for the generational welfare of humanity.The finest ML platforms for running multiple applications include Kera, Pandas, Tensorflow, PyTorch, PIL, Scikit-Learn, etc, Every Deep Learning Framework has its unique set of characteristics, advantages, and disadvantages. Pixels and matrix sizes are usually the two subunits of every image. Digital Signal Processing converts the input images provided or fed by the users into high quality detailed images, which are then supplied into the processing unit. Matlab aids in enhancing
image processing productivity by regulating and controlling activities such as resizing, segmenting, merging, classification, etc, Feature extraction for all input images being supplied in a sufficient manner and not in excessive quantities is essential for improving prediction through accurate determination tasks coupled with split-wise display of graded stages of the disease, with their respective data to indicate the gradual wear and tear of the cartilage tissues. We are hoping that our idea becomes helpful to the medical researchers of our country and someday find a cure to this disease.

II. Proposed solution & working (Algorithm and Implementation).

- To Perform And Analyze Automatic Detection And Classification Of Knee Osteoarthritis Using Machine Learning Techniques.
- To Create An Efficient Software To Detect Medical Ailments And Aid Health Professionals In Treating Them And Hopefully Developing Cures For Previously Untreatable Diseases.
- To Establish The Beauty Of Having A Synergical, Symbiotic Relationship Between The Fields Of Electronics Engineering, Computer Science Engineering And Medical Science.
- The control points are created by selecting the area of interest using trial and error method.
- Then the image is smoothened using non-linear anisotropic diffusion.

- Edges are enhanced by applying Canny and Log edge detection methods.
- Later, the automatic shifting of the spline curve is done to the actual edge control points.
- Finally the thickness is measured in terms of pixels between the edges by measuring the distance between them.

III. Explanation of each segment's necessity through functions

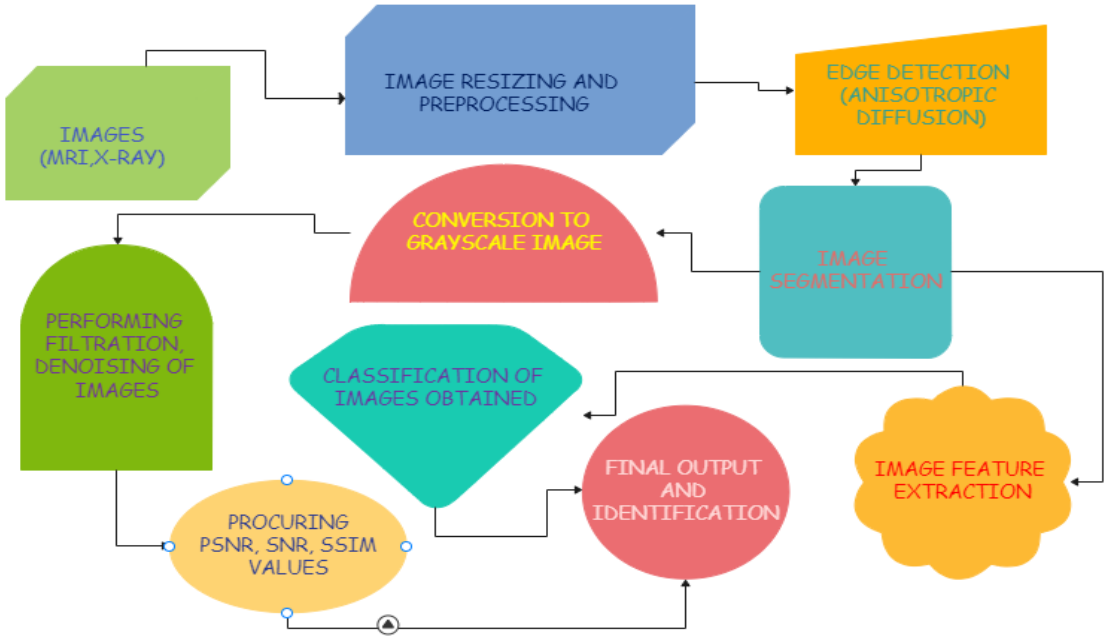
The methodology followed is split into the following steps to explain the functioning of each segment. Collection of different images from reputable sources and websites, (MRI, X-Ray) to analyze and get results for drawing desirable inferences. Perform Image Resizing and prepare the dataset for preprocessing to facilitate the smooth transition onto the next step. The Resized images are sent for edge detection using the concept of "Anisotropic Diffusion" for enabling easy encirclement of the center region among each and every knee scan. Once we get the desired output image, automatically it will be
converted to a grayscale image, which is done so to execute the segmentation step with ease. Mathematical values of PSNR, SSIM, SNR are calculated to show logical variations between each and every step accomplished along with their respective results, and use them for finalizing feature extraction to reach the end goal. After the compilation of all the experimented output images, classification is being performed to segregate the data obtained through feature extraction for trial and error feeding of spontaneous images to increase the intelligence of the machine in accurate determination of the disease, through smart algorithms and instructions being programmed onto it, detaching it from human intervention and dependence, transforming it into a powerful AI tool to be used in all situations.

Segmentation portion of the process was considered to be one of the most difficult areas of execution. Instead of manual segmentation, Programming dependent extraction methods were used for better precision and accuracy. Manually it was done using the "Image Segmentation" Tool in Matlab. Achieving this in a comprehensive manner was possible because of "Watershed Segmentation", "Anisotropic Diffusion", "Active Contour Filtering", "Region Of Interest – Center Of Mass", Etc., modules and predefined functions, the likes of which weren't applied in previous such project works. Concatenation of gray scale images, binary images produced was mandatory to split the ROI portions onto another image (Binary Image), to enable the easy generation of features, details and machine learning friendly data for classification purposes and smart upgradation in prediction probability. MRI images show complex, detailed, humongous, descriptive structural features, etc., On the contrary, X-Ray can only produce scans where it's quite plain and simple to pin-point the thickness of the middle knee portion to conclude it as a sign of Osteoarthritis at a much faster speed and lower cost, which is why we are using it for detection purposes. Thousands of images were being fed into the machine, after the preliminary steps and the embedded methodology proved worthy of being able to deliver the right response. Images are also easily categorized into X-Rays and MRIs based on Smart Differentiation algorithms. Through this way, the computer was trained in the skill of detection and identification needed to transform it into an intelligent being doing tasks without human intervention. Crafting a permanent place for ML in medical

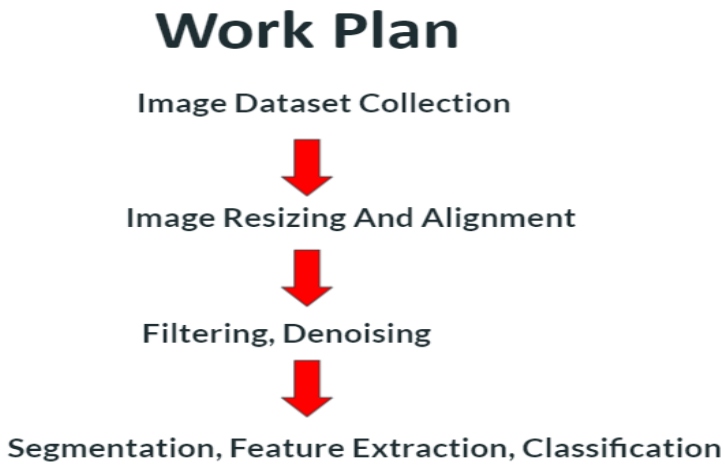
science.

IV.Methodology used and Block flow diagram explanation

fig(A)-Block Flow Diagram



Fig(b)-Workflow chart



Detailed description of the diagram:

The Design block flow diagram in Fig.(A), Work Plan flow diagram in Fig. (B), shows the different

steps involved in the overall methodology of "Digital Image Processing". Firstly, we procure images (X-Ray, MRI Knee Scans) from reputable medical journals, websites, research papers and hospital databases(online) as the very first step in ML based image processing. Secondly, we perform image preprocessing and resizing using Matlab tools and the appropriate coding to facilitate the same, this is done so as to use equally sized variations of different images of exact matrix array sizes. Thirdly, edge detection is carried out with the help of "Anisotropic Diffusion". The filtration works similar to algorithms of its kind in encirclement of boundaries within the region of interest, subsequently removing noise data and cancellation of errors present in the existing image. Fourthly, image segmentation is done using two techniques provided as built in functions, with a brief expansion from our side for further sophistication, namely, "Watershed Segmentation", "Active Contour Filtering", Etc., this cuts out the region of interest which in this case happens to be the center of the knee i.e. the cartilage joint and tissues. Fifthly, we convert the obtained images into grayscale, and then further into binary images using both the types, we merge them to ensure that only the middle or center portion has the vital considerable features to be
extracted for classification and deterministic values being calculated and train the computer to think smartly in splitting images of two kinds. Sixthly, after executing filtration and denoising of the respective images, the PSNR, SNR, SSIM values to check whether the obtained images and data suggests zero errors and miscalculations with each step before this. Lastly, Feature extraction and classification is accomplished, thereby completing the cycle of image processing.

V. Analyzing various arthritis detection methods, Studying their mechanism and features.

Many such similar projects involving the detection, inspection, identification and verification of symptoms pertaining to arthritis, etc., make use of segmentation techniques such as Threshold, Region, Edge-Based and Neural Networks Segmentation, etc. The uniqueness of our project is portrayed by incorporating the technique of "**Watershed Segmentation**", along with "**Active Contour Filtering**", which helps to extract the portion of the knee where there's a gradual development of arthritis. Feature Extraction, is performed in quite a lot of image processing, machine learning projects, helped by the functioning of "**Local Center Of Mass Method (LCM)**", On the contrary we are performing this task using the "**Image Segmentation Tool**", in combination of merging the original image and segmented image, using Looping and convolution.

VI. Results and Inferences drawn

A Machine Learning based Osteoarthritis detection system aims to utilize the features of Digital Image Processing to make radiographic scanning simple. Having thousands of images fed to the computer, the system reads each image, classifies and extracts valuable data from them separately, and then the obtained data is processed using machine learning algorithms. The programmable source code is the mind and the overall powerful decision maker of this system embedded in the software, which can be used for any types of scans of knee cartilages to detect and identify the presence of osteoarthritis, and possibly helping find a breakthrough cure, which will be the first step in developing much more strong medicines and powerful treatments, ending the

overall long battle between mankind and diseases. Many Deep learning frameworks, machine learning computer platforms will be innovated, designed and invented where such features will come in with much better and advanced detection techniques, identification protocols and suggestive solutions using the advent of "Artificial Intelligence".

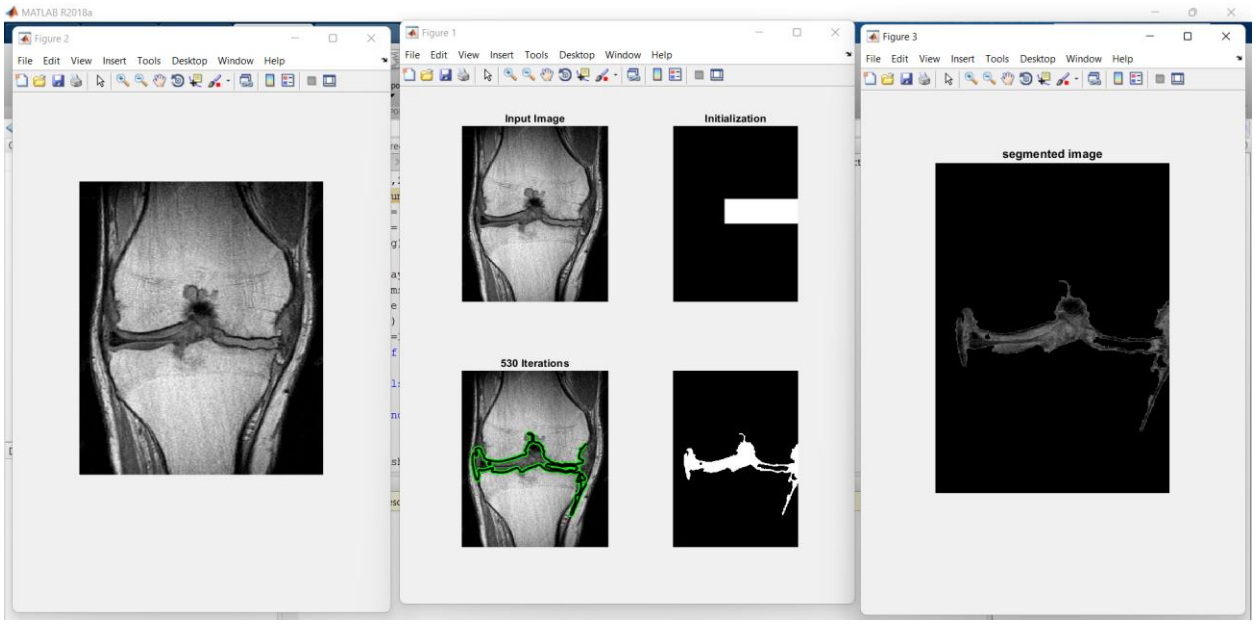
VII. SCOPE OF THE PROJECT :

Osteoarthritis being a common ailment, adding to the fact that there hasn't been a permanent cure discovered and developed, will find a breakthrough using machine learning. Algorithms and mathematical functions coupled with derivative equations will act as a catalyst to detect and analyze the causes of the disease, and help innovate a cure, by a synergy with computer programming. The project can be expanded in a wide range of medical fields for research and diagnostics, such as identifying and analyzing brain tumors, kidney stones, rheumatoid arthritis, bone fractures, concussions, defects in the heart and other organs, etc.

VIII. Tabular analysis

Types	Original Image	Image 5	Image 7	Image 9	Image 10	Image 11	Image 12	Image 13	Image 14	Image 15
autoc	1.20E+04	1.08E+04	8.08E+03	1.05E+04	1.07E+04	9.51E+03	1.29E+04	1.10E+04	1.15E+04	7.71E+03
contr	2.91E+03	1.37E+03	1.44E+03	5.06E+03	1.46E+03	1.14E+03	9.86E+01	1.61E+03	2.91E+03	2.51E+03
corrm	2.05E-01	-1.05E-01	-8.63E-01	-1.60E-01	1.40E-01	4.32E-02	7.18E-01	-1.24E-01	-2.49E-01	-2.27E-02
corrp	2.05E-01	-1.05E-01	-8.63E-01	-1.60E-01	1.40E-01	4.32E-02	7.18E-01	-1.24E-01	-2.49E-01	-2.27E-02
cprom	2.54E+07	2.24E+06	5.98E+04	3.17E+07	6.08E+06	2.94E+06	3.30E+05	3.61E+06	9.95E+06	1.33E+07
cshad	6.55E+04	-7.51E+02	-6.34E+02	-4.89E+04	-1.66E+04	8.57E+03	3.49E+03	-4.82E+03	-1.93E+03	3.94E+04
dissi	4.50E+01	2.87E+01	3.08E+01	6.25E+01	3.32E+01	2.66E+01	8.04E+00	3.20E+01	4.46E+01	4.28E+01
energ	3.78E-04	1.20E-03	1.39E-03	2.64E-04	8.54E-04	6.77E-04	2.48E-03	9.78E-04	2.82E-04	2.08E-04
entro	7.95+00 + 2.31e-02i	6.87e+00 + 4.64e-02i	6.61e+00 + 2.86e-02	8.28e+00 + 2.22e-02	7.15e+00 + 3.77e-02i	7.34e+00 + 3.01e-02i	6.08e+00 + 3.20e-02i	7.08e+00 + 4.73e-02i	8.20e+00 + 2.12e-02i	8.48e+00 + 1.67e-02i
homom	5.41E-02	1.01E-01	8.04E-02	4.68E-02	5.51E-02	1.16E-01	2.03E-01	9.10E-02	6.32E-02	5.21E-02
homop	1.85E-02	4.60E-02	3.39E-02	1.80E-02	1.61E-02	6.28E-02	1.17E-01	4.14E-02	2.54E-02	1.70E-02
maxpr	7.37E-04	2.78E-03	2.39E-03	5.54E-04	1.74E-03	1.26E-03	4.84E-03	2.35E-03	4.82E-04	2.89E-04
sosvh	1.13E+04	1.28E+04	1.05E+04	1.18E+04	1.09E+04	1.02E+04	1.31E+04	1.28E+04	1.11E+04	8.18E+03
savgh	2.18E+02	2.09E+02	1.83E+02	2.07E+02	2.06E+02	1.95E+02	2.27E+02	2.11E+02	2.16E+02	1.76E+02
svarh	4.86e+04 - 4.67e-02i	4.26e+04 - 1.51e-01i	3.23e+04 - 4.32e-01	4.48e+04 - 4.11e-02i	4.21e+04 - 1.19e-01i	3.73e+04 - 4.69e-02i	4.99e+04 - 1.16e+00i	4.35e+04 - 2.75e-01i	4.66e+04 - 3.19e-02i	3.15e+04 - 6.36e-02i
senth	5.23e+00 + 1.09e-04i	4.68e+00 + 3.70e-04i	3.84e+00 + 1.20e-03	5.36e+00 + 1.02e-04	4.90e+00 + 2.96e-04i	4.75e+00 + 1.23e-04i	4.05e+00 + 2.61e-03i	4.78e+00 + 6.68e-04i	5.12e+00 + 7.57e-05i	5.22e+00 + 1.86e-04i
dvarh	2.91E+03	1.37E+03	1.44E+03	5.06E+03	1.46E+03	1.14E+03	9.86E+01	1.61E+03	2.91E+03	2.51E+03
denth	4.63e+00 + 1.21e-05i	4.21e+00 + 1.62e-04i	4.22e+00 + 1.16e-04	4.68e+00 + 4.28e-05	4.24e+00 + 7.42e-05i	4.14e+00 + 1.68e-04i	3.01e+00 + 1.58e-03i	4.29e+00 + 2.48e-04i	4.62e+00 + 5.77e-05i	4.56e+00 + 6.56e-05i
inf1h	-1.48e-01 + 4.60e-03	-2.86e-01 + 1.00e-02i	-2.91e-01 + 6.46e-03	-1.88e-01 + 4.146e-0	-2.65e-01 + 7.91e-03i	-2.02e-01 + 6.30e-03i	-2.88e-01 + 8.08e-03i	-2.76e-01 + 9.54e-03	-1.66e-01 + 4.20e-03i	-1.01e-01 + 3.13e-03i
inf2h	8.78e-01 - 5.93e-03i	9.63e-01 - 3.42e-03i	9.56e-01 - 2.39e-03i	9.20e-01 - 3.38e-03i	9.53e-01 - 3.33e-03i	9.21e-01 - 4.78e-03i	9.43e-01 - 3.56e-03i	9.62e-01 - 3.38e-03i	8.96e-01 - 4.46e-03i	7.96e-01 - 7.04e-03i
indnc	8.28E-01	8.83E-01	8.74E-01	7.76E-01	8.63E-01	8.90E-01	9.62E-01	8.71E-01	8.30E-01	8.33E-01
idmnc	9.37E-01	9.68E-01	9.67E-01	8.94E-01	9.66E-01	9.73E-01	9.98E-01	9.63E-01	9.37E-01	9.44E-01

International Journal of Advanced Technology in Engineering and Science
Vol. No. 10, Issue No. 05, May 2022
www.ijates.com
ijates
ISSN 2348 - 7550



Fig(3)- Result of the Osteoarthritis

In this fig(3) As we see that the uploaded x-ray image gets scanned using the edge detection algorithm and it gets scanned and we get a black and white image since it get no data we merge the original image with the resulted image and we crop it and thorough feature extraction we get the resulted data.

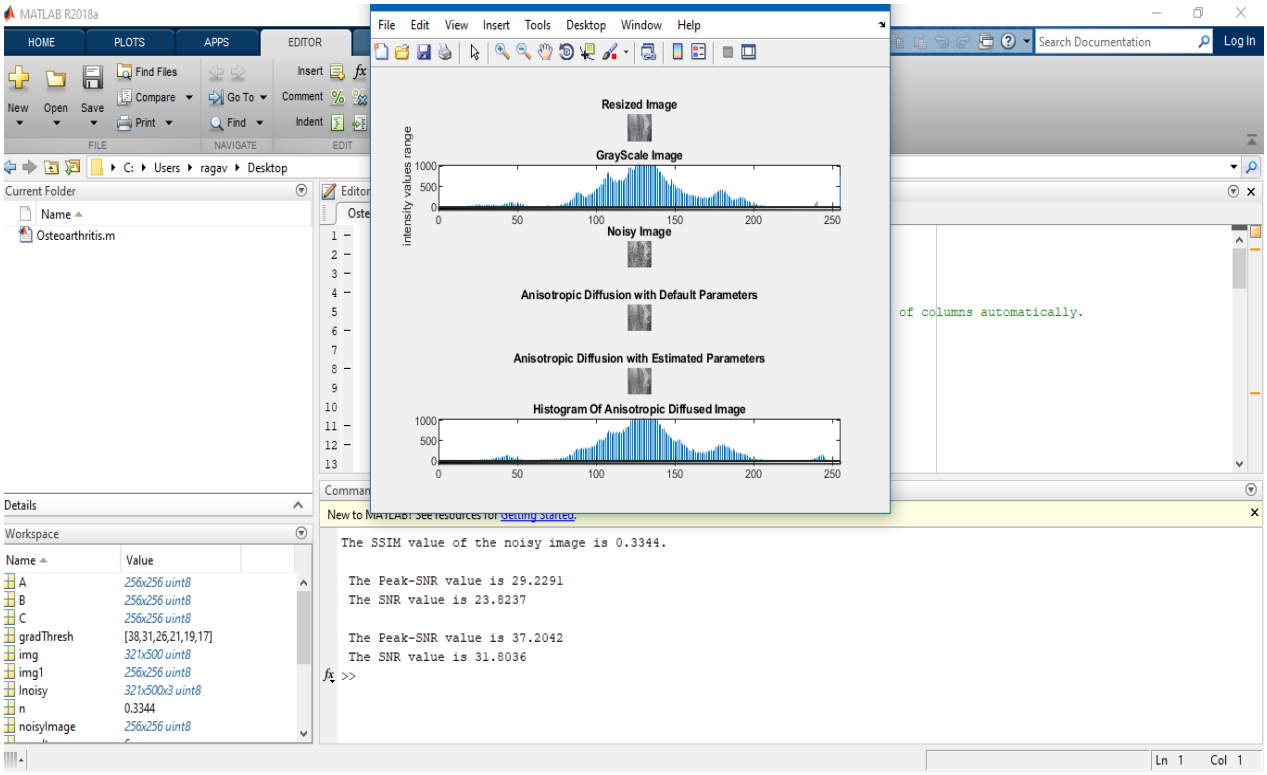


Image Preprocessing Output_1

International Journal of Advanced Technology in Engineering and Science
Vol. No. 10, Issue No. 05, May 2022
www.ijates.com
ijates
ISSN 2348 - 7550

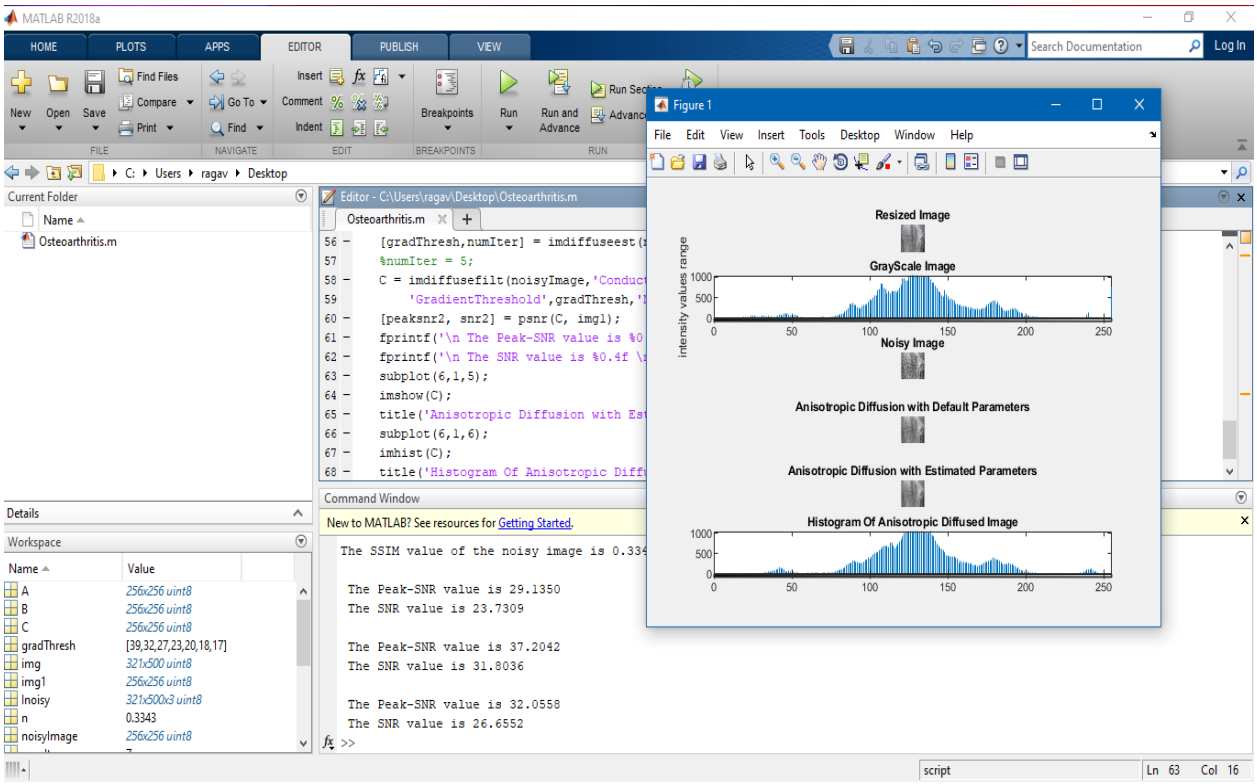


Image Preprocessing Output_2

IX. Conclusion:

Detailed description of the project.

I. Simple and user-friendly software device for detection and identification of arthritis.

II. Can Work for Both X-Rays and MRI Scans, showing grade stages of the ailment

III. Accurate prediction, calculation and classification of features and values

IV.Low maintenance cost of the scanner and easy-to-afford, cost efficient software

V.Acknowledging users about the possibilities, stages of osteoarthritis with information**.**

The Results of the project show the functionalities of the software capabilities benefits, and activation of image processing tools using appropriate machine learning, digital image processing tools, built within the software. The programming modules used for detecting, locating and analyzing osteoarthritis needs to be upgraded for wider uses in radiographic technologies and to incorporate 5G and 6G Technologies (In the near future), and operate in WAN or MAN networks, for Internet-Of-Things based medical operations and transfer of

information between hospitals, research laboratories, medical associations, organizations, manufacturing plants, vaccine production plants, medicine facilities, etc. In order to further reduce costs and other components, Cloud computing platforms such as Amazon AWS, MicrosoftAzure are being researched and considered for the project.

Standard Internet of Technologies such as ZigBee, IBM Watson Platforms are being compared and analyzed for further improvements and advancements. Multitude applications in brain tumor detection, cancer and other disease identifications and precise prediction, categorization of the final scans sorting them into healthy and unhealthy types (Still under progress), are being checked with respect to the position in the digital medical field, and which particular location ensures maximum efficiency and proper extraction of crucial, vital data, for enabling faster and cheaper production of cures, manifesting ideas which were previously thought to only exist in theoretically, into beautiful and spectacular realities.

X. Acknowledgement:

We wish to express our sincere thanks to Project Coordinator, for their constructive ideas, inspirations, encouragement and much needed technical support extended to complete our project work.

We wish to express our sincere thanks to Faculty Members, Assistant Professors, Electronics And Communication Engineering for his/ her constructive ideas, inspirations, encouragement, excellent guidance and much needed technical support extended to complete our project work.

We would like to thank our friends, faculty and non-teaching staff who have directly and indirectly contributed to the success of this project.

XI. References:

[1] M. Sliepen, M. Brandes, and D. Rosenbaum, “Current physical activity monitors in hip and knee osteoarthritis—A review,” Arthritis Care Res., vol. 69, no. 10, pp. 1460–1466, 2016.

[2] B. Greene et al., “Fall risk assessment through automatic combination of clinical fall risk factors and body-worn sensor data,” IEEE J. Biomed. Health Informat., vol. 21, no. 3, pp. 725–731, May 2017.

[3] G. Cooper et al., “Inertial sensor-based knee flexion/extension angle estimation,” J. Biomech., vol. 42, no. 16, pp. 2678–2685, 2009.

[4] J. Favre et al., “Functional calibration procedure for 3D knee joint angle description using inertial sensors,” J. Biomech., vol. 42, no. 14, pp. 2330–2335, 2009.

[35] T. Seel et al., "IMU-based joint angle measurement for gait analysis,"Sensors, vol. 14, no. 4, pp. 6891–6909, 2014.

[36] H. Dejnabadi et al., "A new approach to accurate measurement of uniaxial joint angles based on a combination of accelerometers and gyroscopes,"IEEE Trans. Biomed. Eng., vol. 52, no. 8, pp. 1478–1484, Aug. 2005.

[37] H. Dejnabadi et al., "Estimation and visualization of sagittal kinematics of lower limbs orientation using body-fixed sensors," IEEE Trans. Biomed. Eng., vol. 53, no. 7, pp. 1385–1393, Jul. 2006.

[38] M. El-Gohary and J. McNames, "Human joint angle estimation with inertial sensors and validation with a robot arm," IEEE Trans. Biomed. Eng.,vol. 62, no. 7, pp. 1759–1767, Jul. 2015.

[39] M. Kadaba et al., "Measurement of lower extremity kinematics during level walking," J. Orthopedic Res., vol. 8, no. 3, pp. 383–392, 1990.

[40] C. Reinschmidt et al., "Effect of skin movement on the analysis of skeletal knee joint motion during running," J. Biomech., vol. 30, no. 7, pp. 729–732, 1997.

[41] M. Esch et al., "Knee varus–valgus motion during gait a measure of joint stability in patients with osteoarthritis?" Osteoarthritis Cartilage, vol. 16, no. 4, pp. 522–525, 2008.

[42] A. Chang et al., "Thrust during ambulation and the progression of knee osteoarthritis," Arthritis Rheumatism, vol. 50, no. 12, pp. 3897–3903, 2004.

[43] E. Grood and W. Suntay, "A joint coordinate system for the clinical description of three-dimensional motions: Application to the knee," J.Biomech. Eng., vol. 105, no. 2, pp.136–144, 1983.

[44] J. Favre et al., "A new ambulatory system for comparative evaluation of the three- dimensional knee kinematics, applied to anterior cruciate ligament injuries," Knee Surg. Sports Traumatology Arthroscopy, vol. 14, no. 7, pp. 592–604, 2006.

[45] A. Sabatini, "Quaternion-based extended Kalman filter for determining orientation by inertial and magnetic sensing," IEEE Trans. Biomed. Eng., vol. 53, no. 7, pp. 1346–1356, Jul. 2006.

[46] S. Piazza and P. Cavanagh, "Measurement of the screw-home motion of the knee is sensitive to errors in axis alignment," J. Biomech., vol. 33, no. 8, pp. 1029–1034, 2000.

[47] P. W. Stratford et al., "Modeling knee range of motion post arthroplasty: Clinical applications," Physiotherapy Can., vol. 62, no. 4, pp. 378–387, 2010.

[48] E. Papi et al., "A knee monitoring device and the preferences of patients living with osteoarthritis: A qualitative study," BMJ Open, vol. 5, no. 9, 2015.