Detection of Kidney Cysts of Kidney Ultrasound Image using Hybrid Method: KNN, GLCM, and ANN Backpropagation

by Mardison Mardison

Detection of Kidney Cysts of Kidney Ultrasound Image using Hybrid Method: KNN, GLCM, and ANN Backpropagation

1st Mardison
Computer System
Computer Science Faculty
Universitas Putra Indonesia YPTK
Padang, Indonesia
mardison@upiyptk.ac.id

2nd Yuhandri
Information Technology
Computer Science Faculty
Universitas Putra Indonesia YPTK
Padang, Indonesia
yuyu@upiyptk.ac.id

***Abstract*—This research is aim to detect kidney cysts from human kidney Ultrasound (USG) 2D Images. This research uses data from Hospital patients as many as 25 Ultrasound images of the human kidney in the format image .jpg. This research uses the K-Nearest Neighbor (KNN) method for image classification of ultrasound images then using Gray Level Co-Occurrence Matrix (GLCM) method for image extraction to detect cyst and non-cyst regions from the result of classification after that using Artificial Neural Network (ANN) method type Backpropagation for image detection to find cysts from human kidney Ultrasound (USG) 2D Image from the result of image extraction. The result of this research is producing the algorithm to implement the method and the tool software application to detect kidney cysts from ultrasound 2D images. The accuracy of this tool is 84% which can detect with accurate 21 kidney cysts from 25 kidney ultrasound 2D images that validate of a Urology Specialist Doctor.**

Keywords—ultrasound (USG) 2D Image, kidney cysts, KNN method, GLCM method, ANN type Backpropagation method.

I. Introduction

Digital image processing (DIP) is one of the branches of science in the field of computer science that studies techniques or methods for processing images in digital format [1]–[4]. The image referred to here is a still image (photo) and a moving image (derived from the camera). While digital here means that image processing is done digitally using a computer. Mathematically, the image is a continuous function with light intensity in a two-dimensional plane. To be processed by a digital computer, an image must be presented numerically with discrete values. The representation of a continuous function into discrete values is called image digitization.

Along with the development of technology and information today, the digital image is a very important thing. Digital images have been widely used in various fields, one of which is the health sector [5]–[9]. In the field of Health, digital images are used to take pictures of the condition of human organs when they are in the human body that is not directly visible to the eyes of a doctor. There are many digital imaging technologies of the human body in the world of Health such as ultrasound digital images, Rongen digital images, X-Ray digital images, CT Scan digital images, and MRI digital images. Each type of digital image has its advantages and disadvantages.

The urinary system consists of three parts: the kidneys, the bladder, the ureters, and the urethra (urinary tract). Each part of the urinary system has its function and role. One of the organs of the human body that is very important in the urinary system is the kidney. Kidneys function as organs that function to filter and dispose of waste in the human body, such as toxins, excess salt, and urea (nitrogen-containing waste resulting from protein metabolism) [10]–[13]. Urea formed in the body is transported through the blood to the kidneys for disposal. Without kidneys, waste and toxins would accumulate in the blood.

Ultrasonography or better known as ultrasound is a technology for capturing images of the human body and is widely used in the medical world [14]–[16]. One of the organs of the human body can be captured using kidney ultrasound technology. This is done to find out what disease occurs in the kidney. Ultrasound images are divided into several types, namely 2D, 3D, and 4D ultrasound images. 2D ultrasound is a type of examination that uses 2-dimensional technology in which the imaging results are flat black and white images.

Previous research was conducted by Paladugu Raju et al in 2020 [17] who detected and segmented kidney cysts and tumors using the Optimal GLCM method combined with FCM. This study uses data in the form of ultrasound images of the kidneys which are transformed as 3 × 3 blocks and the attribute is omitted. The analysis in this study is that the proposed process is augmented when contrasted with the obtained process through different metrics such as sensitivity, specificity, accuracy, Positive Predictive Value (PPV), and Negative Predictive Value (NPV). The results of this study are the sensitivity, specificity, and accuracy of the proposed FB-FCM-WOA (91.1%, 98.6%, and 98.4%) than the obtained process. PPV and NPV (71.8% and 99.6%) were also better than the obtained process.

Another study conducted by Qiang Zheng et al in 2021 [18] conducted a dynamic graph-cutting method with integrated feature maps for kidney segmentation in 2D ultrasound images. This study used data in the form of 2D ultrasound images of the kidneys from 85 subjects. Imaging data from 20 randomly selected subjects were used as training data to set the parameters of the image segmentation method, and the remaining data were used as test data for validation. The analysis in this study is to compare our method with image segmentation methods, such as LRAC, GAC, and AMFSM. The results of this study are the proposed method obtains promising segmentation results for bilateral kidneys (Mean dice index = 0.9446, average distance = 2.2551, average specificity = 0.9971, average accuracy -mean = 0.9919), better than the other methods compared ($P < 0.05$, paired Wilcoxon rank count test).

The USG image produced by ultrasound technology is still in the form of a black and white image that is not clear

2023 International Conference on Computer Science, Information Technology and Engineering (ICCoSITE) | 979-8-3503-2095-4/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICCoSITE57641.2023.10127703

or blurry so that ordinary people or people who do not know in the field of medicine cannot read what is displayed by the ultrasound image [19], [20]. A doctor who specializes in Urology has expertise in reading and translating the results of ultrasound images in the human kidney. The quality of the results of reading or translating ultrasound images from a urology specialist depends on the quality of the ultrasound images captured from the human body. The better and cleaner the ultrasound image, the more precise and accurate the results of reading and translation by the doctor will be so that the diagnosis of a person's disease becomes very precise. Under these conditions, it is better if the image produced by the ultrasound can be improved to be clearer and more detailed so that the reading results become more precise and accurate.

At the moment, based on a discussion with a Urology specialist in Padang City, it is stated that a Urology specialist is still unable to detect cyst objects that have cysts in the human kidney only based on 2D ultrasound images because the images produced by 2D ultrasound are still blurry. and less clear. A more accurate detection to detect Kidney Cysts is by taking a CT (Computed Tomography) Scan image of the human kidney. However, the cost required to perform a CT-Scan is very large, plus not all hospitals (RS) in Indonesia have CT-Scan machines because the price of the CT Scan machine is very expensive.

More specifically, based on a search for reputable international journals and impact factors, currently, there are no researchers who have tried to detect Multiple Kidney Cysts known as Multiple Kidney Cycsts (Multiple Kidney Cysts). If the results of 2D Kidney Ultrasound (Ultrasonography) images can be as good and as good as CT (Computed Tomography) Scans of human kidneys in detecting Multiple Kidney Cysts, it will be very helpful for the medical world, especially in the field of Urology in detecting the disease and also very helpful for hospitals that serve the treatment of diseases. Urology especially kidney and is very helpful for patients suffering from kidney disease. In this study, the Hough transform and GLCM methods were developed to detect multiple kidney cysts automatically based on 2D ultrasound (ultrasonography) images of human kidneys. The data used to validate the results of this study is the data from the CT-Scan image of the human kidney.

II. METHODOLOGY

A. *Research Framework*

This research collects the data input in the form of an Ultrasound (USG) Image of a Kidney that has Multiple Cysts. Then processing that data image using K-Nearest Neighbors (KNN) Method after that using GLCM Method and lastly using the Artificial Neural Network (ANN). The research framework can be seen in figure 1 below.

B. *Research Framework details*

The first step of this research is to collect the data input. The input data is a very important thing for research because this is the resource problem that will be solved. The data input of this research is the Ultrasound (USG) image of the Human Kidney. The USG kidney image is on the left and right sides of a human kidney. The number of pictures that are collected is 40 kidney USG images. The 40 kidney USG images intend to get better results in detecting cysts of the kidney. The format file of USG Image of Kidney is. JPG. The USG kidney image that collected using an ultrasound image capture machine. All of the images are from a general hospital in Padang City, West Sumatera Province, Indonesia.

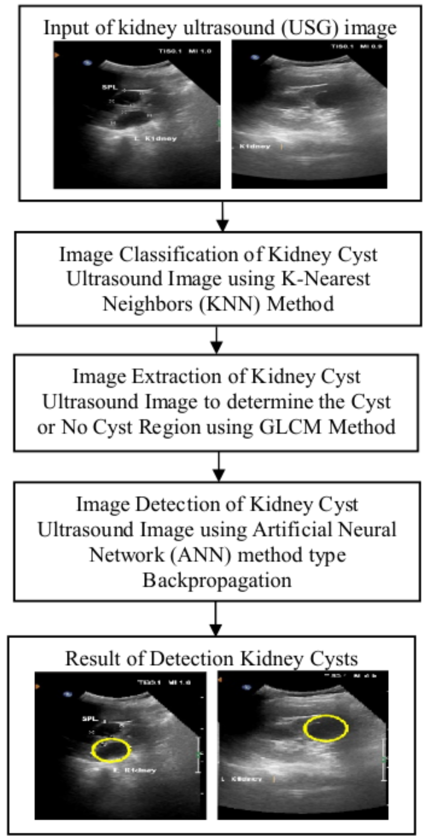


Fig. 1. Research Framework

The second step of this research is image classification. Image classification intends to partition an image into non-overlapping regions with homogeneous characteristics, such as intensity, color, and texture. In this image classification in this research using K-Nearest Neighbors (KNN) Method. KNN method uses the Euclidean value distance in the calculation of the image data. The Euclidean distance between each segment in the segmentation image and each training region that you specify is calculated using the K Nearest Neighbor (KNN) approach. In n-dimensional space, where n is the number of attributes for that training zone, the distance is measured. The KNN method algorithm is followed [21]–[25]:

1. Step 1: Select the number K of the neighbors
2. Step 2: Calculate the euclidean distance of K number of neighbors using the formula below:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

Where: d is euclidean distance, x_1 and x_2 is two points in a two-dimensional x axis, y_1 and y_2 is two points in a two-dimensional y axis.

3. Step 3: Take the K nearest neighbors as per the calculated Euclidean distance.
4. Step 4: Among these k neighbors, count the number of the data points in each category.
5. Step 5: Assign the new data points to that category for which the number of neighbors is maximum.
6. Step 6: Our model is ready.

The third step of this research is image extraction. The data resulting from the image segmentation process of the second step before. To do image extraction in this research using the GLCM method to detect cyst and non-cyst regions. The image implementation process is carried out, namely clarifying the object to be studied in the image by performing calculations to reverse the value in the binary image. After the image implementation process is carried out, then perform an Open Area BW aimed at estimating the area of the binary image object. The GLCM method algorithm is followed [26]–[28]:

1. Step 1: Quantize the image data. Each sample on the echogram is treated as a single image pixel and the value of the sample is the intensity of that pixel. These intensities are then further quantized into a specified number of discrete gray levels as specified under Quantization.
2. Step 2: Create the GLCM. It will be a square matrix $N \times N$ in size where N is the Number of levels specified under Quantization. The matrix is created as follows:
   - Let s be the sample under consideration for the calculation.
   - Let W be the set of samples surrounding sample s that fall within a window centered upon sample s of the size specified under Window Size.
   - Considering only the samples in the set W, define each element i,j of the GLCM as the number of times two samples of intensities i and j occur in a specified Spatial relationship (where i and j are intensities between 0 and Number of levels-1).
   - The sum of all the elements i, j of the GLCM will be the total number of times the specified spatial relationship occurs in W.
   - Make the GLCM symmetric:
     - Make a transposed copy of the GLCM
     - Add this copy to the GLCM itself
     - This produces a symmetric matrix in which the relationship i to j is indistinguishable from the relationship j to i (for any two intensities i and j). As a consequence, the sum of all the elements i, j of the GLCM will now be twice the total number of times the specified spatial relationship occurs in W (once where the sample with intensity i is the reference sample and once where the sample with intensity j is the reference sample), and for any given i, the sum of all the elements i, j with the given i will be the total number of times a sample of intensity i appears in the specified spatial relationship with another sample.
   - Normalize the GLCM:
     - Divide each element by the sum of all elements. The elements of the GLCM may now be considered probabilities of finding the relationship i, j (or j, i) in W.
3. Calculate the selected Feature. This calculation uses only the values in the GLCM. The formula is as followed:

$$Shade = sgn(A)|A|^{\frac{1}{3}} \quad (2)$$

   Where: $Shade$ is shade value, $sgn(A)$ is a sign of a real number
4. The sample s in the resulting virtual variable are replaced by the value of this calculated feature.

The fourth step of this research is image detection. Image detection is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. The categorization law can be devised using one or more spectral or textural characteristics. The result data of image extraction is used from the GLCM method. To do image detection in this research using Artificial Neural Network (ANN) method type Backpropagation. It can improve ultrasound images, to detect Kidney Cysts. This helps Urology Specialists and related Hospitals in using the Ultrasound Machine Optimally. The ANN method type Backpropagation algorithm is followed [29]–[32]:

1. Step 1: Prepare the data set, which is the source of information for the classification problem. he following concepts—Data source, Variables, and Instances—need to be configured in order to achieve that.
2. Step 2: Choose the correct neural network architecture. for classification problems, it is usually composed of: A scaling layer, Two perceptron layers, and A probabilistic layer.
3. Step 3: Set the training strategy, which is composed of: Loss index, Optimization algorithm.
4. Step 4: Set the model selection, which is composed of: The inputs selection algorithm, Neurons selection algorithm.

The result of this research is can be seen which part is a kidney cyst on the ultrasound image of the kidney automatically without the need for a diagnosis from a doctor and the accuracy of the detection results is the same as that done by a doctor and or by a CT scan of the kidneys.

III. Result and Discussion

A. Data Collection

Step 1. Data is gathered from an ultrasound image. A total of 25 USG pictures of a human kidney make up this image. Cysts should be visible in the USG images of the human kidney. As a result of this procedure, the software now has the data needed to perform ultrasound (USG) image classification. The K-Nearest Neighbors (KNN) Method using to solve this problem. Four USG scans of the kidneys used in this study are shown in Figure 2 below:

a. Kidney USG Image 1 b. Kidney USG Image 2

c. Kidney USG Image 3

d. Kidney USG Image 4

Fig. 2. Data Collection Kidney USG Image a, b, c, d

The following Algorithm 1 shows the algorithm that employs to gather data from 4 kidney USG images using MATLAB software:

Algorithm 1: Read Data Collection

```
start
clc; clear; close all; warning off all;
% set the folder name
nama_folder = 'Citra Kista Ginjal';
% read filenames with the extension .jpeg
nama_file = dir(fullfile(nama_folder,'*.jpg'));
% read number of files
jumlah_file = numel(nama_file);
% processing all files
for k = 1:jumlah_file
% read image files
Img = imread(fullfile(nama_folder,nama_file(k).name));
end
```

B. Process

Step 2. After collecting four Kidney USG Images then doing image classification of the USG kidney image using the K-Nearest Neighbors (KNN) Method. The algorithm used to classify the four kidney USG images using the MATLAB application can be seen in Algorithm 2 below:

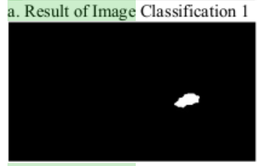
Algorithm 2: image classification using K-Nearest Neighbors (KNN) Method

```
start
% convert rgb image color space to grayscale
Img_gray = double(rgb2gray(Img));
% call the training result network
load jaringan
% read output clusters
[row,col] = size(Img_gray);
x = reshape(Img_gray,row*col,1);
y = predict(Mdl,x);
% compile the clustering result image
Img2 = zeros(row,col);
for n = 1:numel(Img2)
if isequal(y{n},'region 1')
Img2(n) = 1;
elseif isequal(y{n},'region 2')
Img2(n) = 2;
elseif isequal(y{n},'region 3')
Img2(n) = 3;
end
```

The resulting image of image classification using algorithm 2 above can be seen in figure 3 below:

a. Result of Image Classification 1

b. Result of Image Classification 2



c. Result of Image Classification 3

d. Result of Image Classification 4

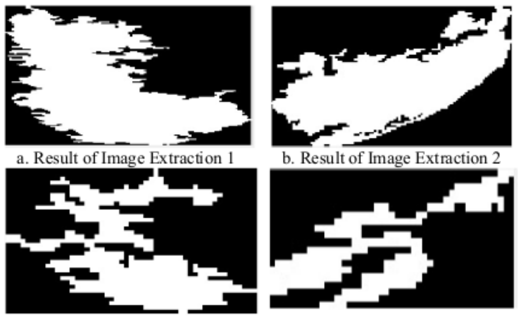
Fig. 3. Result in Image Classification of Kidney USG Image a, b, c, d

Step 3. After image extraction then use Gray Level Co-Occurrence Matrix (GLCM) method to Detect Cyst and Non-Cyst Regions. The algorithm used to extract from the result of image classification using MATLAB application can be seen in Algorithm 3 below:

Algorithm 3: image extraction from image extraction result using Gray Level Co-Occurrence Matrix (GLCM)

```
start
% look for the region of the kidney cyst
bw = Img2==1;
% perform morphological operations
bw = imclearborder(bw);
bw = imfill(bw,'holes');
bw = bwareaopen(bw,100);
% extensive feature extraction
cc = bwconncomp(bw,8);
s = regionprops(cc); Area = cat(1,s.Area);
% GLCM feature extraction
[B,L] = bwlabel(bw);
ciri_uji = []; for m = 1:L
bw2 = B==m;
[row,col] = find(bw2==1);
Img_gray2 = Img_gray;
Img_gray2(~bw2) = 0;
Img_crop = imcrop(Img_gray2,[min(col), min(row),
max(col)-min(col),... max(row)-min(row)]);
pixel_dist = 1;
GLCM = graycomatrix(Img_crop,'Offset',[0 pixel_dist;...
-pixel_dist pixel_dist; -pixel_dist 0;...
-pixel_dist -pixel_dist]);
stats = graycoprops(GLCM,{'contrast','correlation',...
'energy','homogeneity'});
Contrast = mean(stats.Contrast); Correlation =
mean(stats.Correlation);
Energy = mean(stats.Energy); Homogeneity =
mean(stats.Homogeneity);
ciri = [Area(m),Contrast,Correlation,Energy,Homogeneity];
% construct test features
ciri_uji = [ciri_uji;ciri];
end
```

The resulting image of image extraction using algorithm 3 above can be seen in figure 4 below:



a. Result of Image Extraction 1 b. Result of Image Extraction 2

c. Result of Image Extraction 3 d. Result of Image Extraction 4

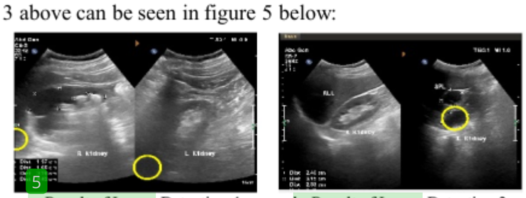
Fig. 4. Result in Image Extraction of Kidney USG Image a, b, c, d

Step 4. After image extraction then image detection using Artificial Neural Network (ANN) method type Backpropagation based on the input value of the GLCM method result. The algorithm used to detect kidney cysts from the result of image extraction using MATLAB application can be seen in Algorithm 4 below:

Algorithm 4: image classification from image extraction result using the Artificial Neural Network (ANN) method

```
start
% transpose the test feature
ciri_uji = ciri_uji';
% read network output value
nilai_keluaran = round(sim(jaringan,ciri_uji));
% look for the index region of kidney cysts
[~,n] = find(nilai_keluaran==1);
% displays the segmented image
bw3 = false(size(bw));
for i = 1:numel(n)
bw3(cc.PixelIdxList{n(i)}) = true;
R = Img(:,:,1);
G = Img(:,:,2);
B = Img(:,:,3);
R(bw3) = 255;
G(bw3) = 255;
B(bw3) = 0;
RGB = cat(3,R,G,B);
% display image
Figure; subplot(1,2,1)
imshow(Img,[]);
title('Citra Asli');
subplot(1,2,2) ;
imshow(RGB,[])
title('Hasil Segmentasi');
end
```

The resulting image of image detection using algorithm 3 above can be seen in figure 5 below:



a. Result of Image Detection 1 b. Result of Image Detection 2

c. Result of Image Detection 3 d. Result of Image Detection 4

Fig. 5. Result in Image Detection of Kidney USG Image a, b, c, d

IV. CONCLUSION

The K-Nearest Neighbors (KNN) method used to classify 2D Kidney ultrasound images that are input into the program data works very properly and accurately classifies which parts of the image are kidney cysts and which parts are not kidney cysts. The image data that have been classified are then extracted using the Gray Level Co-Occurrence Matrix (GLCM) method to obtain image characteristics which are the area of the kidney cyst and not the area of the kidney cyst. This method can also work properly and accurately. After obtaining data extraction of kidney cyst areas with non-kidney cyst areas, the data was used to detect kidney cysts using the Backpropagation type Artificial Neural Network (ANN) method. This method can also work properly and accurately. Overall the performance of the program Which is made from the 25 2D ultrasound images of the kidneys tested resulted in 21 images that could detect well and accuracy of the presence of kidney cysts of 84%. These results have been validated by a specialist urologist. For future or prospective of this work could be extended for the imaging techniques such as Optical coherence tomography (OCT), which is an optical counter part of the ultrasound imaging, as a potential future scope/

REFERENCES

[1] G. U. Kaya and T. Ö. Onur, "Genetic algorithm based image reconstruction applying the digital holography process with the Discrete Orthonormal Stockwell Transform technique for diagnosis of COVID-19," *Comput. Biol. Med.*, vol. 148, no. August, p. 105934, 2022, doi: 10.1016/j.compbiomed.2022.105934.

[2] N. Geier, G. Póka, Á. Jacsó, and C. Pereszlai, "A method to predict drilling-induced burr occurrence in chopped carbon fibre reinforced polymer (CFRP) composites based on digital image processing," *Compos. Part B Eng.*, vol. 242, no. December 2021, p. 110054, 2022, doi: 10.1016/j.compositesb.2022.110054.

[3] G. Póka and B. Z. Balázs, "A robust digital image processing method for measuring the planar burr length at milling," *J. Manuf. Process.*, vol. 80, no. October 2021, pp. 706–717, 2022, doi: 10.1016/j.jmapro.2022.06.037.

[4] O. Angel, G. Rothwell, R. English, J. Ren, and A. Cummings, "Effect of post processing of digital image correlation on obtaining accurate true stress-strain data for AISI 304L," *Nucl. Eng. Technol.*, no. xxxx, 2022, doi: 10.1016/j.net.2022.03.038.

[5] S. Iyanna, P. Kaur, P. Ractham, S. Talwar, and A. K. M. N. Islam, "Digital transformation of healthcare sector . What is impeding adoption and continued usage of technology-driven innovations by end-users ?," *J. Bus. Res.*, vol. 153, no. August, pp. 150–161, 2022, doi: 10.1016/j.jbusres.2022.08.007.

[6] M. Alhasan and M. Hasaneen, "Digital imaging, technologies and artificial intelligence applications during COVID-19 pandemic," *Comput. Med. Imaging Graph.*, vol. 91, no. December 2020, p. 101933, 2021, doi: 10.1016/j.compmedimag.2021.101933.

[7] E. Mbunge, B. Muchemwa, S. Jiyane, and J. Batani, "Sensors and healthcare 5.0: transformative shift in virtual care through emerging digital health technologies," *Glob. Heal. J.*, vol. 5, no. 4, pp. 169–[illegible], 2021, doi: 10.1016/j.glohj.2021.11.008.

[8] E. Mbunge, J. Batani, G. Gaobotse, and B. Muchemwa, "Virtual

healthcare services and digital health technologies deployed during coronavirus disease 2019 (COVID-19) pandemic in South Africa: a systematic review," *Glob. Heal. J.*, vol. 6, no. 2, pp. 102–113, 2022, doi: 10.1016/j.glohj.2022.03.001.

[9] S. Wongvibulsin, T. M. Frech, M.-M. Chren, and E. R. Tkaczyk, "Expanding Personalized, Data-Driven Dermatology: Leveraging Digital Health Technology and Machine Learning to Improve Patient Outcomes," *JID Innov.*, vol. 2, no. 3, p. 100105, 2022, doi: 10.1016/j.xjidi.2022.100105.

[10] J. Fabian *et al.*, "Articles Measurement of kidney function in Malawi , South Africa , and Uganda : a multicentre cohort study," *www.thelancet.com/lancetgh*, vol. 10, 2021, doi: 10.1016/S2214-109X(22)00239-X.

[11] A. Aklilu and C. Delgado, "The removal of race from kidney function estimation: Key points for primary providers," *J. Natl. Med. Assoc.*, vol. 114, no. 3, pp. S25–S33, 2022, doi: 10.1016/j.jnma.2022.05.008.

[12] S. Geurts *et al.*, "Disentangling the association between kidney function and atrial fibrillation: a bidirectional Mendelian randomization study," *Int. J. Cardiol.*, vol. 355, no. January, pp. 15–22, 2022, doi: 10.1016/j.ijcard.2022.03.004.

[13] J. Jefferis, A. Pelecanos, V. Catts, and A. Mallett, "The Heritability of Kidney Function Using an Older Australian Twin Population," *Kidney Int. Reports*, vol. 7, no. 8, pp. 1819–1830, 2022, doi: 10.1016/j.ekir.2022.05.012.

[14] H. Nösslinger, E. Mair, H. Toplak, and M. Hörmann-Wallner, "Measuring subcutaneous fat thickness using skinfold calipers vs. high-resolution B-scan ultrasonography in healthy volunteers: A pilot study," *Clin. Nutr. Open Sci.*, vol. 41, pp. 19–32, 2022, doi: 10.1016/j.nutos.2021.11.[illegible].

[15] D. M. Pavão *et al.*, "Pulsed Radiofrequency Rhizotomy of the Genicular Nerves of the Knee Guided by Radioscopy and Ultrasonography: Step-By-Step Technique," *Arthrosc. Tech.*, vol. 11, no. 3, pp. e3[illegible]–e396, 2022, doi: 10.1016/j.eats.2021.11.006.

[16] I. R. S. Lucena *et al.*, "A comparison between ultrasonography and single-phase computed tomography for preoperative assessment of solid abdominal tumors in children," *J. Pediatr. (Rio. J).*, vol. 000, no. xxx, pp. 1–6, 2022, doi: 10.1016/j.jped.2022.05.003.

[17] P. Raju, V. M. Rao, and B. P. Rao, "Optimal GLCM combined FCM segmentation algorithm for detection of kidney cysts and tumor," *Multimed. Tools Appl.*, vol. 78, no. 13, pp. 18419–18441, 2020, doi: 10.1007/s11042-018-7145-4.

[18] Q. Zheng, S. Warner, G. Tasian, and Y. Fan, "A Dynamic Graph Cuts Method with Integrated Multiple Feature Maps for Segmenting Kidneys in 2D Ultrasound Images," *Acad. Radiol.*, vol. 25, no. 9, pp. 1136–1145, 2021, doi: 10.1016/j.acra.2018.01.004.

[19] M. S. Alzubaidi *et al.*, "Towards deep observation: A systematic survey on artificial intelligence techniques to monitor fetus via Ultrasound Images," *arXiv*, vol. 25, no. 8, p. 104713, 2022, doi: 10.1016/j.isci.2022.104713.

[20] [illegible] Mbbs, B. S. Mbbs, P. Hughes, M. B. Chb, and M. S. B. A. H, "Value of serial ultrasound imaging in conservative management of epididymo-cutaneous fistula in a person with cervical spinal cord injury ☆ , ☆☆," *Radiol. Case Reports*, vol. 17, no. 10, pp. 3938–3945, 2022, doi: 10.1016/j.radcr.2022.07.075.

[21] L. Yijing *et al.*, "Impact of temperature condition in crop disease analysing using machine learning algorithm," *Build. Environ.*, vol. 184, no. August, p. 107229, 2020, doi: 10.1016/j.kint.2021.06.011.

[22] S. Suyanto, P. E. Yunanto, T. Wahyuningrum, and S. Khom[illegible], "A multi-voter multi-commission nearest neighbor classifier," *J. King Saud Univ. - Comput. Inf. Sci.*, no. xxxx, 2022, doi: 10.1016/j.jksuci.2022.01.018.

[23] M. Cubillos, S. Wøhlk, and J. N. Wulff, " A bi-objective k - nearest-neighbors-based imputation method for multilevel data ," *Expert Syst. Appl.*, vol. 204, no. February, p. 117298, 2022, doi: 10.1016/j.eswa.2022.117298.

[24] X. Sun *et al.*, "Environmental Technology & Innovation Modeling and optimization of vegetable oil biodiesel production with heterogeneous nano catalytic process : Multi-layer perceptron , decision regression tree , and K-Nearest Neighbor methods," *Environ. Technol. Innov.*, vol. 27, p. 102794, 2022, doi: 10.1016/j.eti.2022.102794.

[25] D. A. Adeniyi, Z. Wei, and Y. Yongquan, "Automated web usage data mining and recommendation system using K-Nearest Neighbor (KNN) classification method," *Appl. Comput. Informatics*, vol. 12, no. 1, pp. 90–108, 2016, doi: 10.1016/j.aci.2014.10.001.

[26] Ş. Öztürk and B. Akdemir, "Application of Feature Extraction and Classification Methods for Histopathological Image using GLCM, LBP, LBGLCM, GLRLM and SFTA," *Procedia Comput. Sci.*, vol. 132, no. Iccids, pp. 40–46, 2018, doi: 10.1016/j.procs.2018.05.057.

[27] M. J. Drielsma, J. Love, S. Taylor, R. Thapa, and K. J. Williams, "General Landscape Connectivity Model (GLCM): a new way to map whole of landscape biodiversity functional connectivity for operational planning and reporting," *Ecol. Modell.*, vol. 465, p. 109858, 2022, doi: 10.1016/j.ecolmodel.2021.109858.

[28] S. Bakheet and A. Al-Hamadi, "Automatic detection of COVID-19 using pruned GLCM-Based texture features and LDCRF classification," *Comput. Biol. Med.*, vol. 137, no. June, p. 104781, 2021, doi: 10.1016/j.compbiomed.2021.104781.

[29] A. Ansari, M. Heras, J. Nones, M. Mohammadpoor, and F. Torabi, "Predicting the performance of steam assisted gravity drainage (SAGD) method utilizing artificial neural network (ANN)," *Petroleum*, vol. 6, no. 4, pp. 368–374, 2020, doi: 10.1016/j.petlm.2019.04.001.

[30] R. Shamass *et al.*, "Thin-Walled Structures Web-post buckling prediction resistance of steel beams with elliptically-based web openings using Artificial Neural Networks (ANN)," *Thin-Walled Struct.*, vol. 180, no. August, p. 109959, 2022, doi: 10.1016/j.tws.2022.109959.

[31] A. Afandi, N. Lusi, I. Catrawedarma, and B. Rudiyanto, "Prediction of Temperature in 2 Meters Temperature Probe Survey in Blawan Geothermal Field Using Artificial Neural Network (ANN) Method," *SSRN Electron. J.*, vol. 38, no. July, p. 102309, 2021, doi: 10.2139/ssrn.3954816.

[32] R. Langbauer, G. Nunner, T. Zmek, J. Klarner, R. Prieler, and C. Hochenauer, "Development of an artificial neural network (ANN) model to predict the temperature of hot-rolled steel pipes," *Adv. Ind. Manuf. Eng.*, vol. 5, no. June, p. 100090, 2022, doi: 10.1016/j.aime.2022.100090.

Detection of Kidney Cysts of Kidney Ultrasound Image using Hybrid Method: KNN, GLCM, and ANN Backpropagation

ORIGINALITY REPORT

24%	19%	21%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	faq-courses.com Internet Source	2%
2	www.mi-research.net Internet Source	1%
3	www.opennn.net Internet Source	1%
4	Jasperine James, Arunkumar Heddallikar, Pranali Choudhari, Smita Chopde. "Chapter 16 Analysis of Features in SAR Imagery Using GLCM Segmentation Algorithm", Springer Science and Business Media LLC, 2021 Publication	1%
5	Takafumi Nishikawa. "Image Processing Techniques for Detection of Pavement Cracks vusing Parallel Image-filters", IABSE Symposium Report, 01/01/2008 Publication	1%
6	Paladugu Raju, Veera Malleswara Rao, Bhima Prabhakara Rao. "Optimal GLCM combined	1%

FCM segmentation algorithm for detection of kidney cysts and tumor", Multimedia Tools and Applications, 2019
Publication

7 www.coursehero.com 1%
Internet Source

8 Wiharto -, Wisnu Widiarto, Esti Suryani, Nurmajid Hidayatullah. "A Comparative Study of Segmentation Method for Computer-aided Diagnosis (CAD) Leukemia AML Subtype M0, M1, and M2", International Journal of Advanced Computer Science and Applications, 2021 1%
Publication

9 Aseem Aneja. "Blockchain Technologies in 5g and Beyond Connections: A Review of the Taxonomy, Practice Area, Prospects, and Challenges", 2023 International Conference on Artificial Intelligence and Smart Communication (AISC), 2023 1%
Publication

10 ijircst.org 1%
Internet Source

11 Pradeep Kautish, Mujahid Siddiqui, Aaliyah Siddiqui, Veenu Sharma, Safiya Mukhtar Alshibani. "Technology-enabled cure and care: An application of innovation resistance theory to telemedicine apps in an emerging market 1%

context", Technological Forecasting and Social Change, 2023
Publication

12	Hadeel Sabti Gharraf, Galip Cansever, Ali Saadoon Ahmed. "Image Filtering of Impulsive Noise Using Biologically Inspired Algorithms", 2022 International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), 2022 Publication	1 %
13	dspace.uii.ac.id Internet Source	1 %
14	www.joics.org Internet Source	1 %
15	www.joiv.org Internet Source	1 %
16	Shivi Kesarwani, Rajesh Kumar Verma, S.C. Jayswal. "Evaluation of the Cutting force, Burr formation, and Surface quality during the Machining of Carbon Nanoparticle modified Polymer Composites for Structural Applications", Materials Today Communications, 2023 Publication	1 %
17	Han Yang, Zhaohai Wang, Jianfei Cao, Quanyuan Wu, Baolei Zhang. "Estimating soil salinity using Gaofen-2 imagery: A novel	1 %

application of combined spectral and textural features", Environmental Research, 2022
Publication

18	Abdul Hai, G. Bharath, Muhamad Fazly Abdul Patah, Wan Mohd Ashri Wan Daud, Rambabu K., PauLoke Show, Fawzi Banat. "Machine learning models for the prediction of total yield and specific surface area of biochar derived from agricultural biomass by pyrolysis", Environmental Technology & Innovation, 2023 Publication	1 %
19	Aji Prasetya Wibawa, Ahmad Chandra Kurniawan, Harits Ar Rosyid, Ali M. Mohammad Salah. "International Journal Quartile Classification Using the K-Nearest Neighbor Method", 2019 International Conference on Electrical, Electronics and Information Engineering (ICEEIE), 2019 Publication	1 %
20	unisbank.ac.id Internet Source	1 %
21	www.yumpu.com Internet Source	1 %
22	John Batani, Manoj Sewak Maharaj. "Towards Data-Driven Pediatrics in Zimbabwe", 2022 International Conference on Artificial	1 %

Intelligence, Big Data, Computing and Data Communication Systems (icABCD), 2022
Publication

23 Nina Rodrigues Stein, Lisa VanHouwelingen. "Making good use of ultrasound for abdominal tumors in children", Jornal de Pediatria, 2022 1%
Publication

24 www.philstat.org.ph 1%
Internet Source

25 Vaidyanathan Subramanian, Bakul Soni, Peter Hughes, Mark Swindells. "Value of serial ultrasound imaging in conservative management of epididymo-cutaneous fistula in a person with cervical spinal cord injury", Radiology Case Reports, 2022 1%
Publication

26 Raphael Langbauer, Georg Nunner, Thomas Zmek, Jürgen Klarner, René Prieler, Christoph Hochenauer. "Modelling of thermal shrinkage of seamless steel pipes using artificial neural networks (ANN) focussing on the influence of the ANN architecture", Results in Engineering, 2023 1%
Publication

27 Tracy M. Frech, Madeleine Frech, Inga Saknite, Katie A. O'Connell, Shramana Ghosh, Justin Baba, Eric R. Tkaczyk. "Novel therapies and 1%

innovation for systemic sclerosis skin ulceration", Best Practice & Research Clinical Rheumatology, 2023
Publication

28	Chia-Ming Lin, Yungho Leu. "Applying Taguchi’s Method, Artificial Neural Network and Genetic Algorithm to Reduce the CoSi Resistance Deviation of DRAM Products", IEEE Transactions on Semiconductor Manufacturing, 2020 Publication	1 %
29	Douglas Mello Pavão, José Leonardo Rocha Faria, Marcelo Mandarino, Phelippe Augusto Valente Maia et al. "Pulsed Radiofrequency Rhizotomy of the Genicular Nerves of the Knee Guided by Radioscopy and Ultrasonography: Step-By-Step Technique", Arthroscopy Techniques, 2022 Publication	1 %
30	Ketty Siti Salamah, Lutfi Arif Setiyawan, Imelda Uli Vistalina Simanjuntak. "Design of Smart Home Security System With Face Recognition And Voice Command Based On Internet of Things", ELKHA, 2023 Publication	1 %
31	Chuanrui Qin, Mengtao Dang, Yifei Meng, Dongfeng Zhao. "Fusion calorimetric experiments and QSPR modeling to inversely	1 %

explore the accuracy of thermodynamic methods: A case study of the apparent activation energies of 18 aromatic nitro compounds", Process Safety and Environmental Protection, 2023

Publication

32	dblp.uni-trier.de Internet Source	1 %

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	Off		