ATCSJ
Applied Technology and Computing Science Journal

Open Access

p-ISSN 2621-4458 | e-ISSN 2621-4474

Available online to journal2.unusa.ac.id

UNUSA

S4-Accredited – SK No.79/M/KPT/2023

Journal Page is available at https://journal2.unusa.ac.id/index.php/ATCSJ

Classifying Dental Caries Types Using Panoramic Dental Images Using Watershed Method and Multiclass Support Vector Machine

Rangga Pahlevi Putra[1]*, Aviv Yuniar Rahman[2]

[1,2]*Informatics Engineering, Universitas Widyagama Malang, Indonesia*
Jl. Borobudur No. 35, Malang
[1*]rangga@widyagama.ac.id [2]aviv@widyagama.ac.id

Article history:

Received 25 July 2024
Revised 5 August 2024
Accepted 8 August 2024
Available online 5 September 2024

Keywords:

Dental Caries,
Panoramic Dental Images,
Watershed,
Multiclass SVM.

Abstract

Teeth are one of the calcified and hard structures found in the human mouth. One of the tooth defects that often appears and is experienced by several people in the world is damage caused by dental caries. Diseases that can arise from dental caries include swelling of the gums and fever in the body. To classify and determine the level of damage in dental disease, dentists usually utilise examinations through dental panoramic images. Dental panoramic images are digital images of x-rays that can help provide a lot of information about teeth such as cavities or tooth structure. However, the problem that occurs sometimes to identify or classify the type of caries is still found to be a mismatch of analysis so that technological aids are needed to provide analysis or decision support. Therefore, by applying digital image processing technology by applying methods in image processing, namely Watershed segmentation and the Multiclass Support Vector Machine method, it is possible to classify the type of caries using dental panoramic images. From the results of the research conducted, it can be explained that the results of segmentation of dental panoramic images using the Watershed method can show the detected caries area spots. Meanwhile, the use of the Multiclass SVM method for the classification method shows accuracy results reaching 88%.

I. INTRODUCTION

The rapid development of technology has driven the advancement of research, including on digital image processing technology [1]. Imaging technology is constantly developing and of course also covers the field of health as a tool for diagnosing diseases or disorders of one of the dental organs [1]. Teeth are one of the hard and calcified structures found in the human mouth [1]. Teeth have many tasks like biting, chewing, and tearing food. One of the teeth damages that often appears and is experienced by some people in the world is the damage caused by tooth decay [2]. One of the diseases that can arise from tooth decay is swelling of the gums and causing a fever in the body. Besides, tooth decay can lead to more fatal dangers

1* Corresponding author

ISSN 2621-4474 (online) 2621-4458 (print) © 2023 The Authors. Published by UNUSA

DOI: https://doi.org/10.33086/atcsj.v6i2.5910

like cancer or tumors [3]. One of the causes of this disease is the occurrence of demineralization of the tissue email from the surface of the tooth due to acid, one of which is caused by foods that have sugar content that continues to become dental caries [4]. The process of caries through dentin emails can result in local white turning brown to black.[4] Then, to detect dental caries disease to make it easier to identify, a grouping or classification is carried out [4].

To classify or determine the extent of damage to dental diseases, dentists usually use examinations through panoramic dental images or dental panoramic images [2]. A dental panoramic image is a digital X-ray image that can help provide a lot of information about a tooth such as a hollow tooth or tooth structure [5].

However, the problems that sometimes arise to perform the identification or classification of the type of caries are still found inappropriate analysis, so it is necessary to provide technical aids to support the analysis or decision [6]. So, the aim of this research is to provide a supporting medium to support the process of classification of caries types based on dental panoramic images by utilizing digital image processing technologies such as segmentation methods as well as utilizing the development of machine learning classification methods that are now developing rapidly. This study will use the image segmentation method as a method to segment the area of tooth damage using the method of watershed transformation. As in the study carried out by Yuting Lu et al, that is, the application of the water segmentation method for the segmentation of medical images MT and MRI in breast tumors [7].From the results of the research conducted it was concluded that this method is excellent for doing segmentation on the image MRI of tumors in the breast because it can display the morphological character of the image as well as can show more fine segmentation results.

As for the selection of machine learning methods, in the previous research conducted by Rijah Khan et al, it was to classify lung diseases based on X-ray imaging using Support Vector Machine methods in the use of kernels on SVM [8]. The study examined the types of diseases in the lungs: asthma, pleural effusion, fibrosis, and pneumonia. The SVM kernel is usually used to classify several classes or types so it can be called the Multiclass SVM. From the results of the research, it is concluded that the uses of the kernel used are Linear, Polynomial, and Radial types. From the results of the research, the classification results reached an average accuracy of almost 100%. Then, based on the explanation of the previous exposure then in the research will use the watershed method as the method of caries segmentation and the method Multiclass Support Vector Machine as a method of classification to determine the type of dental caries. The research is expected to provide assistance to the parties involved in providing a diagnosis in determining the type of caries through panoramic dental imaging.

II. METHODS

The classification of the type of dental caries through the panoramic image of the tooth in this study utilizes image processing technology. Image processing in this research is the main process to determine the kind of tooth caries starting with the process of image input, preprocessing, as well as segmentation. After the segmentation phase, characteristic values for each type of research data will be obtained so that the classification process can be applied using the Multiclass Support Vector Machine. The following is a flowchart of this research.

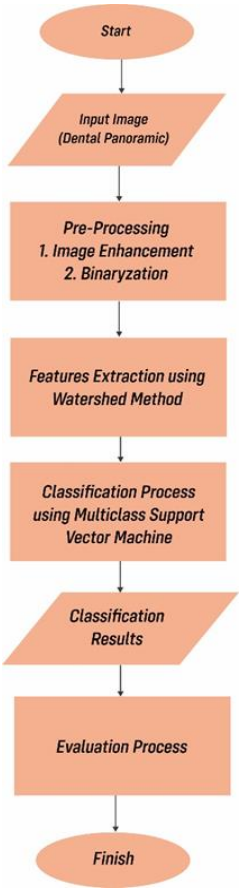


Figure 1. Flowchart Process

Figure 1 explains that the course of the study begins with the inclusion of panoramic images of the teeth according to the type studied and tested. In this study, the applied panoramic dental image data was downloaded from the site https://www.kaggle.com/datasets/walidphd/dental-caries-classificationv3 in the Joint Photographic Experts Group format. (.JPEG). The research data is divided into three classes or types, namely the deep caries class, the superficial caries, and the normal or healthy tooth class [2]. The data analyzed in this study is 240 images. The following is an example of the test image applied in this research.

(a) (b) (c)

Figure 2. Dental Panoramic Image (a) Profunda Caries, (b) Superficial Caries, (c) Healthy Teeth

Figure 2(a) is the result of a panoramic image of a tooth for a profunda caries condition, with the main feature that caries has reached the pulp so that inflammation occurs in the pulp tissue with an indication that the patient often feels pain suddenly without any stimulation [9]. For **Figure 2** (b) is a superficial caries condition with characteristic caries already reached inside the email with indications the patient has not felt a pain complaint. While **Figure 2** (c) is a panoramic image of a tooth in a healthy or normal condition [9].

The next process is the segmentation method using the watershed transform method. Watershed transform is a derivative of a morphological pattern that has the concept of region or region segmentation [7]. The initial process applied to the segmentation process is the panoramic image result of the acquisition in the application will be applied preprocessing i.e. image enhancement by improving contrast through contrast stretching and as well as transforming into Black and White (BW) mode through binaryzation. Image enhancement is applied as a step to improve image quality so that image characteristics can be more prominent [10].

The basic principle of watershed segmentation is to define an image with the three-coordinate model x, y, and z with pixels with different color intensities [11]. The coordinates x and y are the basic region of the pixel position, and the z coordinate is a pixel with a level of obscurity that has a magnitude of bright intensity so that it is thought to have an increasingly high magnitudo intensity.

Based on the results of the watershed segmentation, several characteristic values are obtained which are applied to distinguish the characteristics of one object from the other. In this study will be obtained several characteristics namely area, perimeter, centroid, and equiv diameter [12]. A perimeter is the edge of an area or region on the outermost part of an object in an image that is in a position next to the background of an image [13]. A centroid is the coordinate position of the center point of the object, wh[13]ile an equiv diameter is a diameter of the circle shape of a nucleus or lesion [12].

The next stage, after the segmentation is completed and the characteristic values of each type of test data are obtained, is the next stage of classification using the method Multiclass Support Vector Machine or MSVM. MSVM is the development of the support vector machine algorithm. This development provides a solution of the SVM characteristics in providing solutions to real-world problems that have some types of classifications of more than one [14]. In this study will be applied the properties of MSVM which is the concept of One Against All in order to obtain classification in some type or class [14]. For the type of class classified in this study are the deep caries class, the superficial cariasis class, and the normal tooth class. Here is a classification equation using MSVM on equation (1) [14].

$$\left(w^{i}\right)^{T} \emptyset\left(x_{j}\right) + b^{i} < -1 + \xi_{j}^{i} \rightarrow y_{j} \neq i \qquad (1)$$

From equation 1 it can be explained that the variable w is the weight of the support vector, while the variables i and j are the classes studied. Variables b and ξ_{j}^{i} each are bias and soft margins on the MSVM equation. The classification process in this research is divided into two: the training process and the testing process. In the research conducted, classifications utilized kernel functions because there were some data that could not be divided in a linear form [15]. The kernel provided a mapping of each test data on each input area into a new vector in a better or higher dimension [15]. The kernel type in this study is the polynomial type of kernel and the gaussian type [16]. Here are the equations of the polynomial kernel as well as the Gaussian kernel used in this study.

$$A(b,c) = (b \times c)^d \quad (2)$$

$$A(b,c) = \exp \times (-||b - c||^2 / 2\sigma^2) \quad (3)$$

On equations (2) and (3) for variables (b) and (c) are data pairs of the trained data partition. For the parameters σ and d are constants in the equation. As for $||b - c||^2$ is the mathematical square of the vector distances b and c.

For the training process at the classification stage, start by reading the panoramic input image to be preprocessed then perform the feature extraction using the watershed and classified using the MSVM method [15]. Then the testing process also has almost the same process as training. However, in the test phase there is a difference that the results of the vector features are not stored in the database but matched with the class that has been recorded by the training database so that matching is done with the test image data that has the same class.

The next stage is the evaluation of the classification process. This phase is aimed at obtaining the most accurate outcome of the prediction with the actual outcome [15]. Here are the results of the accuracy equation used in this study.

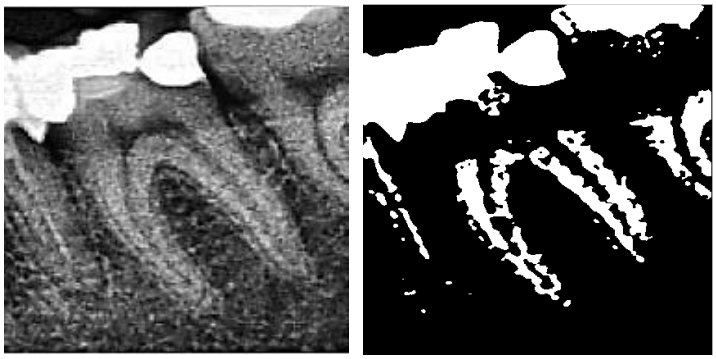
$$Accuration = \frac{TP}{TA} \times 100\% \quad (4)$$

In the equation (4) can be explained for TP is the total number of relevant images that are accurately classified according to the test stage.

III. RESULTS AND DISCUSSIONS

The initial step in this research is to enter the dental panoramic test image into the image processing application then preprocess it by resizing the test image to 200 x 200 pixels [14]. The preprocessing is also given a contrast stretching method so that the image quality becomes better. From the results of contrast stretching the image will be converted into binary or Black and White (BW) mode through the binarization process. Here are the results of the preprocessing done.

(a) (b)



(c) (d)

Figure 3. *Preprocessing Results* (a) Test Image, (b) *Resize Image*, (c) *Contrast Stretching*, (d) *Binarization*

Figure 3(a) is a panoramic test image of a tooth with a sample of profunda caries type while **Figure 3**(b) is the result of resizing the image to 200 x 200 px. This is done to shorten the time in the image processing process. **Figure 3** (c) is the result of the contrast stretching process to obtain a clearer contrast. With a clearer contrast, an increase in color sharpness will be obtained in the image, so that a clear characteristic value can be obtained [17]. While **Figure 3**(d) is the result of the binarization process which will be used as input in the watershed segmentation process.

After the preprocessing stage, the next step is segmentation using the watershed method. The process is carried out to obtain characteristic values that will be used as a reference for the classification process using the Multiclass Support Vector Machine method. The following are the segmentation results using the watershed method.

Figure 4. Segmentation Results (a) Colour Labelling, (b) Bounding Box, (c) Caries Dental Spot Region

Figure 4 (a to c) shows the panoramic image of the tooth segmented using watershed. In **Figure 4**(a) the color labeling process is the first step in watershed segmentation which aims to facilitate the gradation analysis process between normal regions and different regions in the dental organ area. Furthermore, **Figure 4** (b) is a bounding box to detect special areas that are considered as different regions from normal areas. For Figureure **Figure 4** is the final result of watershed segmentation with the spot characteristics of the detected caries region marked with a red circle.

Based on the results of the watershed segmentation that has been carried out, characteristic information will be obtained from each type of research test sample that has been tested in the training process and

stored in the database [14]. For the characteristic values obtained according to what is described in the methodology chapter, namely the area, perimeter, centroid, and equiv diameter characteristics. The following presents the range of characteristic values from the group of test data studied in Table 1, so that it can be a reference indicator for the classification of the type of caries studied.

Table 1. Feature Range Values of each Type of Dental Panoramic Image Studied

No	Tooth Conditions	Area	Perimeter	*Centroid*	*EquivD*
1.	Profunda Caries	9,42 -11,22	12,47 -13,85	0,89 - 0,93	116,21 -125,76
2.	Superficial Caries	6716 - 9690	10,85 – 11,41	0,77 – 0,80	103,42 – 106,65
3.	Normal Condition	5512	13,4	0,54	94,3

Based on Table 1 for panoramic images of teeth with profunda caries type has a characteristic range of area (9.42-11.22), perimeter (12.47-13.85), centroid (0.89 - 0.93), and equivD (116.21 - 125.76). For the type of superficial caries type, the characteristic range values are area (6716 - 9690), perimeter (10.85 - 11.41), centroid (0.77 - 0.80), and equivD (103.42 - 106.65). As for the normal tooth class, the characteristic values are area (5512), perimeter (13.4), centroid (0.54), and equivD (94.3). Based on these results, the value of the characteristic range of certain types of conditions has a difference depending on the extent of caries and the distribution of caries in the dental organ area.

The next stage is classification using Multiclass Support Vector Machine or MSVM, applied to the training process and testing process. In the training process, each type of condition has a total data of 40 dental panoramic image data. While the testing process also applied test data of 40 image data for each type. The method applied to the process of dividing training data and test data utilizes the Cross Validation method [14]. Tests were applied to each type of kernel planned to obtain information on which kernel obtained the maximum accuracy value. In this research, the parameters of the Multiclass Support Vector Machine method applied are iterations = 100, lambda = 1, $\varepsilon = 0.001$, $\gamma = 1$, and $C = 1$ [14]. The following presents the identification results that have been carried out with each type of kernel.

Table 2. Test Classification Results

No	Tooth Condition	*Polynomial*	*Gaussian*
1.	Profunda Caries	89,2	87,2
2.	Superficial Caries	87,3	85,3
3.	Normal Condition	88	89,2

Based on the results from Table 2, it can be explained that the best average accuracy is 89.2% in the polynomial kernel type for profunda caries conditions. As for the gaussian kernel, the best accuracy is 89.2 for normal dental panoramic conditions. The following graph presents the classification accuracy value based on the kernel type.

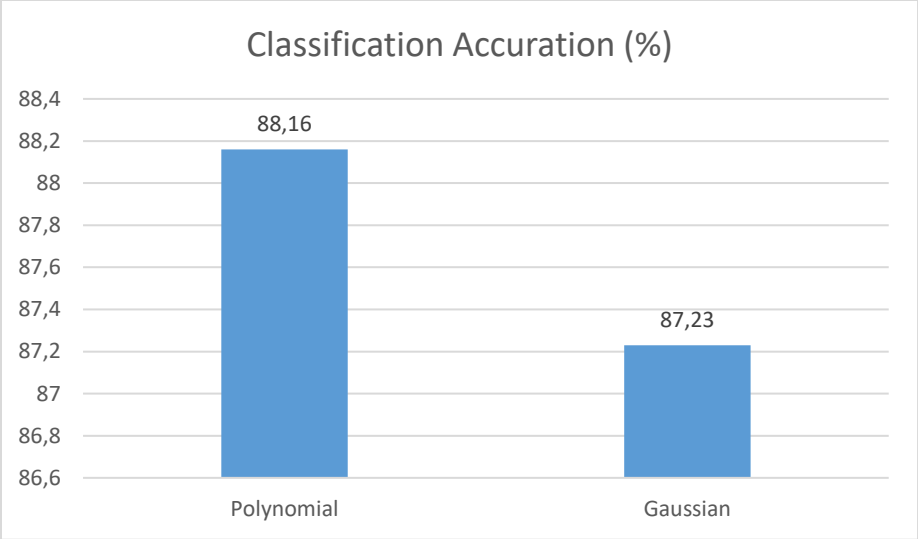


Figure 5. Classification Accuration

In **Figure 5**, it can be explained that the polynomial kernel test has an average accuracy of 88.16%. Meanwhile, the gaussian kernel has an average test accuracy of 87.23%. From the explanation, it is concluded that the polynomial kernel in this study has the maximum classification accuracy compared to the use of the gaussian kernel.

IV. CONCLUSIONS AND RECOMMENDATIONS

From the research conducted, the application of the watershed segmentation method and classification using the Multiclass Support Vector Machine method in the classification of dental panoramic images to determine the condition of the type of dental caries can be used as one of the considerations in the process of diagnosing the condition of patients affected by dental health problems. This is because the segmentation process using the watershed method can partition the components of the normal condition area image with the caries area in the dental panoramic image.

While the use of the Multiclass Support Vector Machine method obtained a fairly optimal accuracy value reaching an accuracy value of 88% of the test process. For further development suggestions, other segmentation methods can be considered that can be applied to reduce over-segmentation areas to improve the accuracy of the classification process. And it is hoped that this research can be useful for other researchers and related parties, especially in the medical field.

V. REFERENCES

[1] H. Hasnita, S. Anraeni, and F. Umar, "Klasifikasi Penyakit Periodontal Pada Citra Panoramic Gigi Dengan Ekstraksi Fitur Gray Level Co-Occurrence Matrix (GLCM)," *Buletin Sistem Informasi dan Teknologi Islam*, vol. 2, no. 4, pp. 284–288, Nov. 2021, doi: 10.33096/busiti.v2i4.1013.

[2] A. S. A.-M. AL-Ghamdi, M. Ragab, S. A. AlGhamdi, A. H. Asseri, R. F. Mansour, and D. Koundal, "Detection of Dental Diseases through X-Ray Images Using Neural Search Architecture Network," *Comput Intell Neurosci*, vol. 2022, pp. 1–7, Apr. 2022, doi: 10.1155/2022/3500552.

[3] L. G. Zanini, I. R. Rubira-Bullen, and F. de L. Nunes, "Segmentation and Classification of Dental Caries in Cone Beam Tomography Images Using Machine Learning and Image Processing," in *Proceedings of the 17th International Joint Conference on Biomedical Engineering Systems and Technologies*, SCITEPRESS - Science and Technology Publications, 2024, pp. 428–435. doi: 10.5220/0012365300003657.

[4] D. N. D. Iriantoro, C. Dewi, and D. Fitriani, "Klasifikasi pada Penyakit Dental Caries Menggunakan Gabungan K-Nearest Neighbor dan Algoritme Genetika," *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, vol. 2, no. 8, pp. 2926–2932, 2018.

[5] Rutuja Madhukar Kale and Asst Prof. Arjumand Masood Khan, "DENTAL CARIES DETECTION AND CLASSIFICATION USING CONVOLUTIONAL NEURAL NETWORK," *International Journal Of Creative Research Thoughts (IJCRT)*, vol. 12, no. 4, pp. 216–226, Apr. 2024.

[6] M. P. Muresan, A. R. Barbura, and S. Nedevschi, "Teeth Detection and Dental Problem Classification in Panoramic X-Ray Images using Deep Learning and Image Processing Techniques," in *2020 IEEE 16th International Conference on Intelligent Computer Communication and Processing (ICCP)*, IEEE, Sep. 2020, pp. 457–463. doi: 10.1109/ICCP51029.2020.9266244.

[7] Y. Lu, Z. Jiang, T. Zhou, and S. Fu, "An Improved Watershed Segmentation Algorithm of Medical Tumor Image," *IOP Conf Ser Mater Sci Eng*, vol. 677, no. 4, p. 042028, Dec. 2019, doi: 10.1088/1757-899X/677/4/042028.

[8] R. Khan and T. Mehmood, "Classification of Thoracic Diseases Based on Chest X-ray Images Using Kernel Support Vector Machine," *Math Probl Eng*, vol. 2022, pp. 1–9, Nov. 2022, doi: 10.1155/2022/9457730.

[9] L. W. Widianti, S. Madenda, J. Harlan, S. Sudiro, and F. Pramanik, "Generation of Teeth Caries Features for Human Dental Caries Classification," *Jurnal Telekomunikasi dan Komputer*, vol. 11, no. 3, p. 254, Dec. 2021, doi: 10.22441/incomtech.v11i3.13804.

[10] H. Nugroho, M. Hakimah, and A. W. Azinar, "IMAGE ENHANCEMENT CITRA ZOOM DENGAN MENGGUNAKAN METODE BILINEAR INTERPOLATION DARI KAMERA WEBCAM," *Network Engineering Research Operation*, vol. 4, no. 2, May 2019, doi: 10.21107/nero.v4i2.125.

[11] S. Saifullah, "Segmentasi Citra Menggunakan Metode Watershed Transform Berdasarkan Image Enhancement Dalam Mendeteksi Embrio Telur," *Systemic: Information System and Informatics Journal*, vol. 5, no. 2, pp. 53–60, Mar. 2020, doi: 10.29080/systemic.v5i2.798.

[12] R. Riries *et al.*, "Cervical single cell of squamous intraepithelial lesion classification using shape features and extreme learning machine," *J Phys Conf Ser*, vol. 1816, no. 1, p. 012081, Feb. 2021, doi: 10.1088/1742-6596/1816/1/012081.

[13] I. P. Wardhani, A. M. Putri, S. Widayati, and others, "Algoritma Identifikasi Ciri Citra Pegunungan dengan Metode Copping," *Jurnal Ilmiah Komputasi*, vol. 20, no. 2, pp. 283–290, 2021.

[14] R. P. Putra, "Identifikasi jenis tanaman anggrek melalui tekstur bunga dengan tapis Gabor dan M-SVM," *JOINTECS (Journal of Information Technology and Computer Science)*, vol. 6, no. 1, pp. 29–34, 2021.

[15] C. Purnama Yanti and I. G. Andika, "HSV image classification of ancient script on copper Kintamani inscriptions using GLRCM and SVM," *Jurnal Teknologi dan Sistem Komputer*, vol. 8, no. 2, pp. 94–99, Apr. 2020, doi: 10.14710/jtsiskom.8.2.2020.94-99.

[16] A. Andreansyah, R. F. Gusa, and M. Jumnahdi, "Pengenalan Pola Sidik Jari Menggunakan Multi-Class Support Vector Machine," *ELKHA: Jurnal Teknik Elektro*, vol. 11, no. 2, pp. 79–84, 2019.

[17] C. Wijaya, H. Irsyad, and W. Widhiarso, "KLASIFIKASI PNEUMONIA MENGGUNAKAN METODE K-NEAREST NEIGHBOR DENGAN EKSTRAKSI GLCM," *Jurnal Algoritme*, vol. 1, no. 1, pp. 33–44, Oct. 2020, doi: 10.35957/algoritme.v1i1.431.