CONVOLUTIONAL NEURAL NETWORK METHODS FOR EDGE DETECTION OF DENTIN TERTIARY

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ABSTRACT

Oral and dental health has increased in the last century, but the prevalence of dental caries remains a significant clinical problem. Dental caries disease can be treated by doing pulp caping. Evaluation of the treatment of pulp caps is by observing radiographic photographs. Observations were made by comparing x-ray results before treatment with x-ray result after treatment for pulp caping. To observe the tertiary dentin section at this time, it still uses manual marking by medical personnel. In this study, one of the architectures of deep learning was used, which is Convolutional Neural Network (CNN) for the detection of tertiary dentin edges through the image processing process. The first thing to do is to cut the image x-ray of the patient, cut the image to 20 images for each category with a size 5 pixels. The category is headed of variant edge and non edge. There are 8 category for edge and 3 category for non edge. The process of cut image which aims to be prepared for training data and testing data. The image has been cut will be trained and tested to test the success of the deep learning that has been made. The next step is for the automatic edge detection, which is the process is formed from the image replacement the edge that has been cut for 5 pixels and then the image that want to be detect each 5 pixels will classified to the image replacement the edge. This method [roved to be very efficient in classifying images. Comparison of Canny, Sobel, and Prewitt the best match from original image is edge detection from deep learning.

Key words : deep learning; convolutional neural network; edge detection

INTRODUCTION

Oral and dental health has increased in the last century, but prevalence of dental caries cases remains a significant clinical problem (Angela, 2005). The pulp cap is one of the treatments for teeth that can still be maintained in the oral cavity. The pulp cap is done by adding protective material or treatment ingredients on top of the exposed pulp to stimulate the growth of tertiary dentin. Evaluation of this treatment is done by observing the result of dental x-ray. The evaluation will obtain information on the condition of the spillage, whether there is leakage at the edge and the delay in the thickness of tertiary dentin (Puspita, 2016). The medical staff evaluates the success rate of treatment pulp caping is comparing the results of x-ray before and after the treatment. If treatment is success the pulp caping will be seen in the teriary dentin that thicker than before (Hakim, 2017).

The thing related to tertiary dentin observation, at this time to calculate the thickness of tertiary dentin, medical personnel still using a system that must do the marking with manually. For this problem to evaluate the pulp caping it will take a long time because the medical personnel have to mark the x-ray by they self.

Deep learning is a branch of machine learning based on artificial neural networks (ANN) or it can be said that the development of ANN. The difference between deep learning with ANN is the number of hidden layers that have been model in various ways, so that it can provide more optimal output. The thing where we will teach computers to do something natural like humans and have several algorithms can be called deep learning. Convolutional neural network is one of the algorithms used in this study, which is capable of processing 2-dimensional data, for example images. This convolutional neural network is claimed to be the best and most widely used algorithm for detecting objects from digital image data (Mathwork, 2018).

Deep learning method with convolutional neural network architecture used in this study to detect the edge of tertiary dentin which is expected to help the medical personnel to see differences in the tertiary dentin area and shorten the time while have to mark the tertiary dentin with manually. For this, it can be an opportunity for deep learning technology to contribute in helping medical personnel to automatically mark the tertiary dentin area.

MATERIALS AND METHODS

The material used in this study is x-ray photographs of the teeth of patients who treated pulp caping at the RSGM UMY with *jpg

format. In this study, used x-ray photographs that have been standardized from the hospital. Each patient have three x-ray which is Indication, Control 1, and Control 2. Indication image is the first photo taken by patient before do treatment pulp caping, control 1 image is a photo of a patients who has treated pulp caping, and control 2 image is a photo of the patient within a certain period after treatment of pulp caping.

There are several steps to conducting this research, which is:

1. Image Taking

The image needed in this study was x-ray images of patients taken from RSGM UMY and had ethical approval. The images obtained from each patient have three images, which is indication, control 1, and control 2.

a. Indication Image

The indicative image is the image taken the first time that is carried out on the patient before treatment.

Indication image

b. Control 1

Control 1 image is an image taken of a patient who have treated pulp caping.

Control 1

c. Control 2

Control 2 image is the image of a patient taken within a certain period of time (approximately one month) after treating the pulp caping.

Control 2

2. Classification Sampling

Classification sampling is process by cutting the edge of tertiary dentin area in the x-ray image. Cutting the x-ray image is still done manually because to find out the edges that are in line with the edge and non edge categories. There are 8 categories for edge and 3 categories for non edge.

Edge and non edge categories

In this research, the edge category will be replaced with a self made image.

Kategori	Citra pengganti *edge*
1	
2	
3	
4	
5	
6	
7	
8	
10	

Image of an edge replacement

For the non edge category, no substitute image is made except for the non edge that category 10, because to see the final result, a black image is needed which is useful when validating other methods.

After cutting the edge replacement image, then cut the x-ray image of the patient in the tertiary dentin area to make it easier to retrieve training and testing data.

Patient's x-ray

In the pictures marked in red, it will be cut. It will be cut because that part of the tertiary dentin area. Cutting is done so that the image can be used as material when determining the edge of tertiary dentin, in addition to making it easier for the writer at the time of cutting which will be used as training and testing data.

Tertiary dentin area

That is x-ray images that only remain part of the tertiary dentin. The size of the image is 150 pixels. Then to create training and testing data, cutting is done at the edge that fits the edge category.

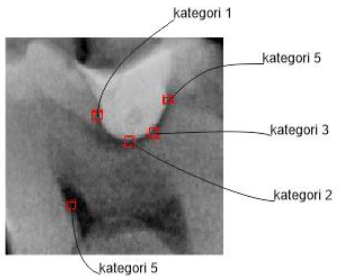


Illustration of images to be cut for training and testing data

The image used for training and testing data is searched for the edges. For size, in this study using size 5 pixels in cutting the edges, because this study uses the CNN classification method it requires the same size in the image that will be use. Within each edge and non edge category, 20 images are needen. Each x-ray images does not necessarily cover all existing edge categories, because there are some images that are difficult to see the different colors that make it an edge.

The image that have been cuts it will be created folders named according to the edge and non edge categories.

3. training data

In the training process, the image for data trained used 15 images from each category. There are several parameters that are changed in the layer variable and the trainingOption function. The layer variable is an array of possible layers to use. The layer parameters that were changed in this study consisted of convolution2dLayer size, maxPooling2dLayer size, and reluLayer. As for the trainingOptions function the parameters that are changed consist of MaxEpoch and MiniBatchSize. In the parameters layer variable tested with size, which is :

- Size of filter width 2 and filter number 10
- Size of pooling 2 and stride 2

But in this study doesnt use reluLayer. For trainingOption function, the parameters that will be tested are MaxEpoch with a value of 50 and MiniBatchSize with a value of 5. The parameters that have been set in such a way because the parameters of accuracy generated by deep learning are quite high.

4. Testing Data

Testing process is a classification process using weights and biases from the results of the training stage. In this testing phase, the image data that will be testes are 5 images from each categories. From each of the images will be tested with training image data to produce true and false image classification. From the results of the classification can be known how much accuracy the success of deep learning.

5. Determination of Edges

The process of determining the edge is the process which is the replacement of the original image with the edge image that has been made. The image that want to be tested only focuses on the tertiary dentin area. Size of the image is 150 pixels, and for each 5 pixels will be classified from the training result and made a new image that has automatically marked by the image of an edge replacement.

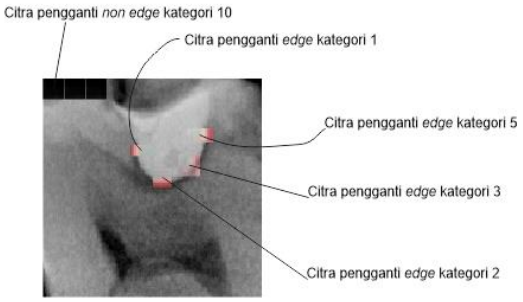


Illustration of the process of determining the edge

Each image in the edge area will be classified every 5 pixels and will be replaced with an edge replacement image. Non-edge parts will be replaced with category 10 because they are intended for the validation process where all methods use black background as well.

6. Validation

The purpose of validation is to see the accuracy of a model that built by a visual. Validation is done manually by comparing the edge image results using Canny, Sobel, Prewitt method and the result of the edge image created by the expert will find out how successfully the image processed from deep learning is done.

RESULTS

1. Image Taking

Image data that will be used for this research is X-ray images of patients who will treat pulp caping at the Muhammadiyah University Hospital Yogyakarta, then the X-ray image in the form of files will be submitted to the Faculty of Engineering, University of Muhammadiyah Yogyakarta to conduct the research that will be conducted.

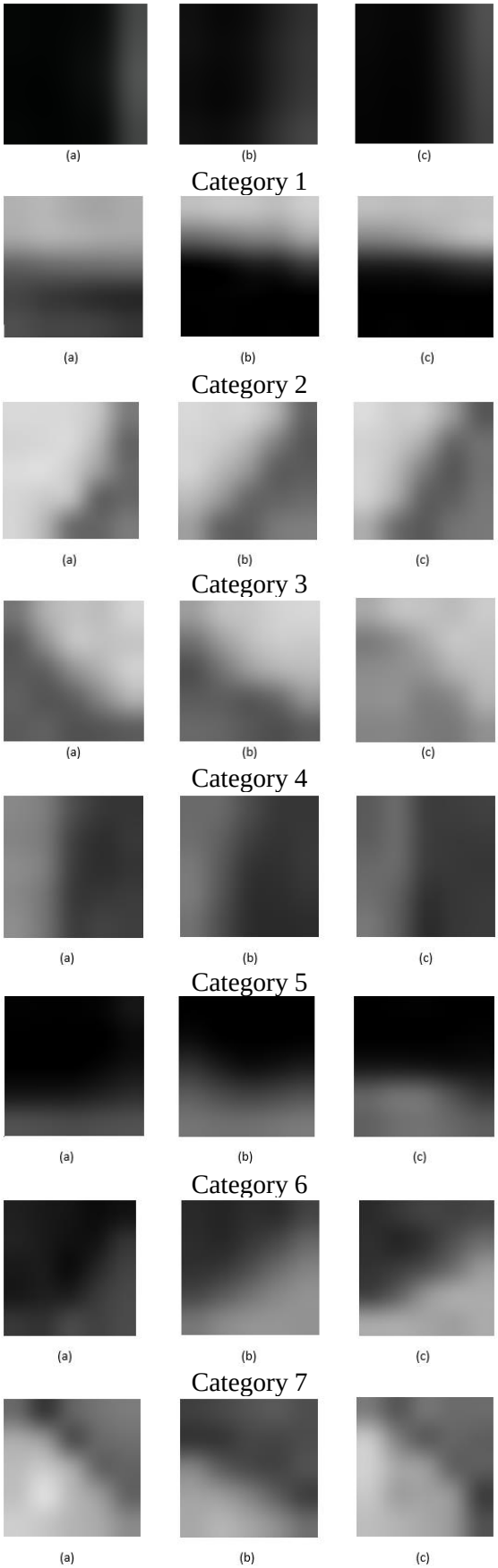
The data that has been obtained is then selected for the images that will be used as research material, because not all image data are contained in each indication, K1, and K2. The total images obtained were 237 images taken from 79 patients.

2. Classification Sampling

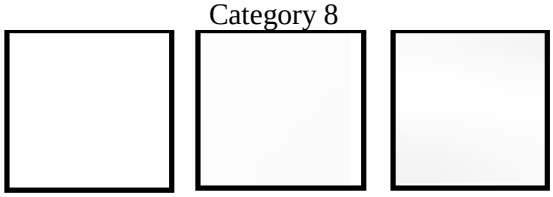
Classification sampling is a process where the image that has been obtained is cut in the tertiary dentin section according to the edge and non edge category. The cropped image is still done manually because if it is done by the system the results of the grouping of each category are definitely not suitable. For research data, each edge and non edge category will require 20 images. Each type of treatment X-ray (indication, K1, K2) is cut into different images because each type of X-ray that has been carried out will experience a change in color.

Each treatment x-ray has 11 folders where all of them are folders that correspond to the edge and non-edge categories. So in the study there are 660 images that have been cut according to the edge and non edge categories for each type of treatment X-ray. Each image that is cropped must be the same size of 5x5 pixels because it uses the CNN classification method. The cutting and grouping of this image aims to be used as data when the training process is carried out.

In the X-ray, the indication is cut in the dental caries section to cut the edge and non-edge categories. Edge and non edge are 11 categories so that the folder is created in 11. Each folder is filled with 20 images obtained from cutting the image based on edge and non edge categories.



Category 8



Category 9

Category 10

Category 11

3. Training Data

Data training in this study was conducted to train deep learning in order to classify the image of the sample category during the testing process. In the training stage, the number of layers used consists of the input layer image that is used as the input layer, the layer immediately after the input layer is also called the convolution layer because it is formed from the input layer convolution, the next layer is the max layer layout where the information is simplified is the output of the convolutional layer, then there is a layer of fully connected layer obtained from each matrix component of the convolution layer output matrix, softmax layer as the activation layer, and the output output layer as output.

In addition, in this study using the same training setting parameters, the maximum value of epoch is 50, which means that the deep learning cycle of all training data and the mini batch size is 5.

In this study there are 20 images where 15 images are used as training data the training process is carried out by training 15 images that have been cropped and entered into a special folder for training. Where the folder itself is only made to train image data. Folders are created according to the number of edge and non edge categories. So there are 11 folders to be trained in each type of X-ray.

The training process is carried out using each folder of the type of pulp treatment x-ray treatment. Each X-ray type folder will go through the process of 1-time exercise along with testing. Classification carried out in the test process is the result of the learning process at the training stage.

a. Result of training indication

Epoch	Iteration	Time Elapsed (seconds)	Mini-batch Loss	Mini-batch Accuracy	Base Learning Rate
1	1	17.26	2.5043	0.00%	1.00e-04
2	50	19.34	2.1109	0.00%	1.00e-04
3	100	20.60	1.7138	80.00%	1.00e-04
4	150	21.44	0.5930	80.00%	1.00e-04
5	200	22.30	0.4171	100.00%	1.00e-04
6	250	23.36	1.4871	60.00%	1.00e-04
7	300	24.40	0.7685	80.00%	1.00e-04
8	350	25.35	0.6475	60.00%	1.00e-04
10	400	26.20	0.1838	100.00%	1.00e-04
11	450	27.00	0.2320	100.00%	1.00e-04
12	500	27.82	0.5806	80.00%	1.00e-04
13	550	28.74	0.5466	100.00%	1.00e-04
14	600	29.53	0.4429	80.00%	1.00e-04
15	650	30.31	0.0756	100.00%	1.00e-04
16	700	31.10	0.8092	80.00%	1.00e-04
18	750	31.94	0.3380	100.00%	1.00e-04
19	800	32.87	0.1122	100.00%	1.00e-04
20	850	33.68	3.3788	60.00%	1.00e-04
21	900	34.48	0.2130	100.00%	1.00e-04
22	950	35.28	0.4964	80.00%	1.00e-04
23	1000	36.24	0.1688	100.00%	1.00e-04
24	1050	37.22	0.3552	80.00%	1.00e-04
25	1100	38.21	0.1356	100.00%	1.00e-04
27	1150	39.24	0.3282	80.00%	1.00e-04
28	1200	40.28	1.5369	80.00%	1.00e-04
29	1250	41.53	0.2958	100.00%	1.00e-04
30	1300	42.64	0.1033	100.00%	1.00e-04
31	1350	43.61	0.6240	60.00%	1.00e-04
32	1400	44.78	0.1976	100.00%	1.00e-04
33	1450	45.84	0.2135	100.00%	1.00e-04
35	1500	46.85	0.0577	100.00%	1.00e-04
36	1550	47.97	0.1900	100.00%	1.00e-04
37	1600	48.77	0.3129	80.00%	1.00e-04
38	1650	49.60	0.4625	100.00%	1.00e-04
39	1700	50.38	1.3902	60.00%	1.00e-04
40	1750	51.24	0.1108	100.00%	1.00e-04
41	1800	52.02	0.4395	60.00%	1.00e-04
43	1850	52.80	0.6079	80.00%	1.00e-04
44	1900	53.56	0.1434	100.00%	1.00e-04
45	1950	54.44	0.0348	100.00%	1.00e-04
46	2000	55.23	0.1828	100.00%	1.00e-04
47	2050	56.12	0.1082	100.00%	1.00e-04
48	2100	56.93	0.1047	100.00%	1.00e-04
49	2150	57.75	0.1466	100.00%	1.00e-04
50	2200	58.58	0.0348	100.00%	1.00e-04

Result of process training indication

In this training phase, for the 50th epoch produced 2200 trained iterations. Epoch 50 means that each training process will go through fifty feedforward processes, in this stage it produces unstable accuracy. Low accuracy is obtained because training data is unable to present the model being trained. This accuracy is the accuracy of training in accordance with the accuracy of the mini batch in the given iteration.

b. Result of training control 1

Epoch	Iteration	Time Elapsed (seconds)	Mini-batch Loss	Mini-batch Accuracy	Base Learning Rate
1	1	0.06	2.3294	40.00%	1.00e-04
1	50	0.72	2.0709	20.00%	1.00e-04
2	100	1.39	1.5555	50.00%	1.00e-04
3	150	2.07	1.5982	50.00%	1.00e-04
4	200	2.74	2.7174	20.00%	1.00e-04
5	250	3.43	3.5636	0.00%	1.00e-04
6	300	4.11	0.8210	80.00%	1.00e-04
7	350	4.80	1.5123	60.00%	1.00e-04
8	400	5.47	1.2086	60.00%	1.00e-04
9	450	6.15	0.8349	80.00%	1.00e-04
10	500	6.83	1.4991	40.00%	1.00e-04
11	550	7.50	1.1699	80.00%	1.00e-04
12	600	8.18	1.2462	80.00%	1.00e-04
13	650	8.85	2.1917	20.00%	1.00e-04
14	700	9.53	1.4560	60.00%	1.00e-04
15	750	10.20	0.4257	100.00%	1.00e-04
16	800	10.88	1.4729	60.00%	1.00e-04
17	850	11.57	0.3406	100.00%	1.00e-04
18	900	12.26	1.2098	80.00%	1.00e-04
19	950	12.95	0.7397	80.00%	1.00e-04
20	1000	13.66	1.6940	80.00%	1.00e-04
21	1050	14.39	0.6368	100.00%	1.00e-04
22	1100	15.08	2.5468	60.00%	1.00e-04
23	1150	15.76	1.9585	80.00%	1.00e-04
24	1200	16.44	0.3322	100.00%	1.00e-04
25	1250	17.13	1.8159	60.00%	1.00e-04
25	1300	17.80	1.1316	80.00%	1.00e-04
26	1350	18.48	0.5677	100.00%	1.00e-04
27	1400	19.16	0.8649	100.00%	1.00e-04
28	1450	19.85	0.6882	80.00%	1.00e-04
29	1500	20.54	2.8806	60.00%	1.00e-04
30	1550	21.22	3.2810	20.00%	1.00e-04
31	1600	21.91	0.5889	80.00%	1.00e-04
32	1650	22.60	1.1091	80.00%	1.00e-04
33	1700	23.28	0.8489	60.00%	1.00e-04
34	1750	23.98	0.6853	80.00%	1.00e-04
35	1800	24.71	1.3903	40.00%	1.00e-04
36	1850	25.40	0.9683	60.00%	1.00e-04
37	1900	26.08	1.0575	80.00%	1.00e-04
38	1950	26.80	1.9817	20.00%	1.00e-04
39	2000	27.50	1.3347	60.00%	1.00e-04
40	2050	28.19	0.2818	100.00%	1.00e-04
41	2100	28.90	1.2057	60.00%	1.00e-04
42	2150	29.61	0.1962	100.00%	1.00e-04
43	2200	30.30	1.0348	80.00%	1.00e-04
44	2250	31.00	0.5973	80.00%	1.00e-04
45	2300	31.69	1.3959	80.00%	1.00e-04
46	2350	32.38	0.6630	100.00%	1.00e-04
47	2400	33.07	2.1259	60.00%	1.00e-04
48	2450	33.77	1.5550	80.00%	1.00e-04
49	2500	34.46	0.2824	100.00%	1.00e-04
50	2550	35.15	1.5715	60.00%	1.00e-04
50	2600	35.84	0.9914	80.00%	1.00e-04

Result of process training control 1

In this training phase, for the 50th epoch produced 2600 iterations were trained. Epoch 50 means that each training process will go through fifty feedforward processes, in this stage it produces unstable accuracy. Low accuracy is obtained because training data is unable to present the model being trained. This accuracy is the accuracy of training in accordance with the accuracy of the mini batch in the given iteration.

c. Result of control 2

Epoch	Iteration	Time Elapsed (seconds)	Mini-batch Loss	Mini-batch Accuracy	Base Learning Rate
1	1	0.04	2.3936	0.00%	1.00e-04
1	50	0.70	1.5118	40.00%	1.00e-04
2	100	1.38	1.8281	40.00%	1.00e-04
3	150	2.09	1.6759	60.00%	1.00e-04
4	200	2.77	1.4254	60.00%	1.00e-04
5	250	3.46	1.2989	80.00%	1.00e-04
6	300	4.14	1.1923	80.00%	1.00e-04
7	350	4.83	0.5302	80.00%	1.00e-04
8	400	5.51	0.7677	80.00%	1.00e-04
9	450	6.22	0.9105	80.00%	1.00e-04
10	500	6.91	0.8505	80.00%	1.00e-04
11	550	7.60	0.4454	80.00%	1.00e-04
12	600	8.29	1.0606	60.00%	1.00e-04
13	650	8.99	0.6746	80.00%	1.00e-04
14	700	9.68	0.4625	100.00%	1.00e-04
15	750	10.37	1.5999	60.00%	1.00e-04
16	800	11.07	1.5980	60.00%	1.00e-04
17	850	11.77	0.5206	100.00%	1.00e-04
18	900	12.47	1.5829	60.00%	1.00e-04
19	950	13.17	1.7925	60.00%	1.00e-04
20	1000	13.88	1.2243	80.00%	1.00e-04
21	1050	14.57	0.4501	100.00%	1.00e-04
22	1100	15.28	2.4359	20.00%	1.00e-04
23	1150	15.97	0.9990	80.00%	1.00e-04
24	1200	16.67	2.4197	40.00%	1.00e-04
25	1250	17.36	0.9463	80.00%	1.00e-04
25	1300	18.05	1.3175	60.00%	1.00e-04
26	1350	18.75	0.2039	100.00%	1.00e-04
27	1400	19.44	0.8023	80.00%	1.00e-04
28	1450	20.15	1.0439	60.00%	1.00e-04
29	1500	20.84	1.1200	60.00%	1.00e-04
30	1550	21.54	0.6130	100.00%	1.00e-04
31	1600	22.24	0.3573	100.00%	1.00e-04
32	1650	22.95	0.3171	80.00%	1.00e-04
33	1700	23.65	0.4579	80.00%	1.00e-04
34	1750	24.35	0.6185	80.00%	1.00e-04
35	1800	25.05	0.6089	80.00%	1.00e-04
36	1850	25.76	0.3314	80.00%	1.00e-04
37	1900	26.45	0.6099	80.00%	1.00e-04
38	1950	27.19	0.4291	80.00%	1.00e-04
39	2000	27.89	0.2034	100.00%	1.00e-04
40	2050	28.61	1.2916	60.00%	1.00e-04
41	2100	29.31	1.0546	60.00%	1.00e-04
42	2150	30.03	0.3543	100.00%	1.00e-04
43	2200	30.73	1.3649	60.00%	1.00e-04
44	2250	31.50	1.4227	60.00%	1.00e-04
45	2300	32.20	0.9854	80.00%	1.00e-04
46	2350	32.91	0.3537	100.00%	1.00e-04
47	2400	33.61	2.0631	20.00%	1.00e-04
48	2450	34.33	0.4221	80.00%	1.00e-04
49	2500	35.04	1.7853	40.00%	1.00e-04
50	2550	35.75	0.7532	100.00%	1.00e-04
50	2600	36.45	1.1303	60.00%	1.00e-04

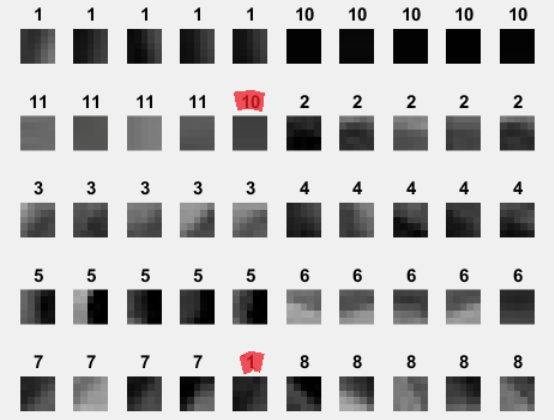
Result of process training control 2

In this training phase, for the 50th epoch produced 2600 iterations were trained. Epoch 50 means that each training process will go through fifty feedforward processes, in this stage it produces unstable accuracy. Low accuracy is obtained because training data is unable to present the model being trained. This accuracy is the accuracy of training in accordance with the accuracy of the mini batch in the given iteration.

4. Testing Data

At the data testing stage is the stage where classification uses weights and biases from the results of the training stage. This stage is not much different from the training stage but what distinguishes it is that there is no backpropagation process after the feedforward process. So that the final result of this process results in the accuracy of the classification carried out.

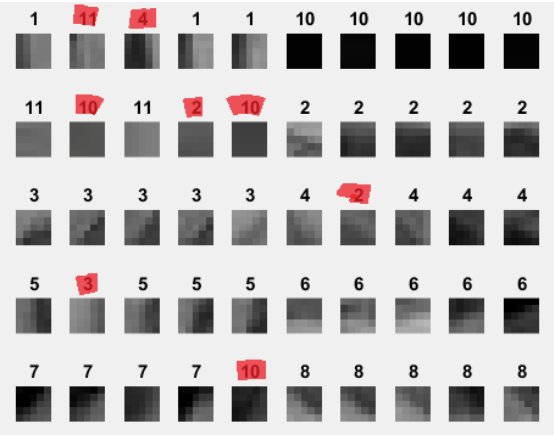
a. Result of testing indication



Result of testing indication

Can be known of 55 training images there were 2 errors that occurred while classifying training data. The first mistake is in category 7 which should be categorized as deep learning classification also shows category 7 but the above is classified as category 1. The second error is indicated when classifying category 11 which is supposed to be category 11, but when the classification process becomes category 10. From the results obtained the amount of accuracy is 96% for testing indications.

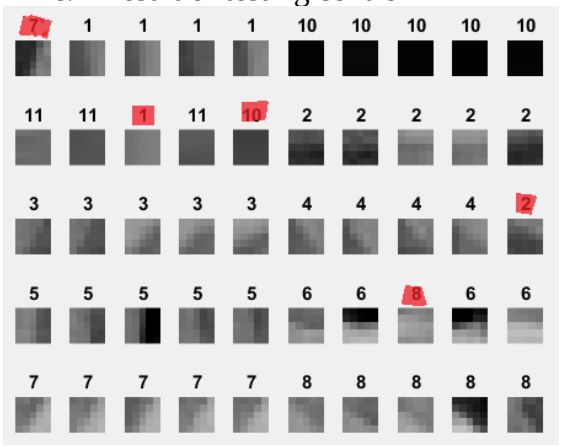
b. Result of testin control 1



Result of testing control 1

Can be known from 55 training images there are 8 errors that occur when classifying training data. The first mistake is in category 1 which should be categorized as deep learning classification also shows category 1 but the above is classified as category 11 and 4. The second error is shown when classifying category 5 which is supposed to be category 5, but when the classification process becomes category 3. The third error can be seen when classifying category 7 which should remain a category 7, but it is classified into category 10. The fourth error is in category 4 which should remain category 4, but classified into category 2. Errors to five, six, and seven at the time of classification in category 11 which should be filled with category 11, but instead read 1 category 2 and 2 category 10. From the results obtained the amount of accuracy was 85% for testing K1.

c. Result of testing control 2



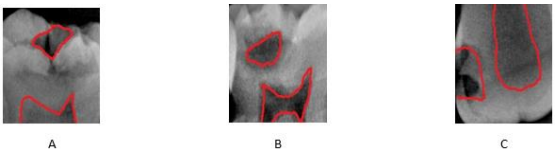
Result of testing control 2

Can be known of 55 training images there were 5 errors that occurred while classifying training data. The first mistake is in category 1 which should be categorized as deep learning classification also shows category 1 but the above is classified as category 7. The second error is indicated when classifying category 4 which should be category 4, but when the classification process becomes category 2. The third mistake can be seen when classifying category 6 which should remain a category 6, but it is classified into category 8. Error to be empirical and five are at the time of classification in category 11 which should be filled with category 11, but instead read category 1 and category 10. From the results obtained the amount of accuracy is 90% for testing K2.

5. Determination of Edges

The stage of determining edge is where the system will automatically detect at the edges of tertiary dentin. The image that you want to detect is then read per every 5 pixels to classify that the image snippet includes part of the edge category where it will be replaced by the image of the category sample until the image has been detected.

a. Indication



Original image

As is known, that is the original picture of tertiary dentin that is marked from the expert.

A B C

Result of indication deep learning

The results of the indication that has been processed can detect the part that is considered to have color differences so that it can form an edge on a prominent line. For parts of the teeth that have a distinct color will be detected perfectly perfectly on the edges. Because the edge detection at the stage of determining the edge will be classified according to the sample category which has 2 different colors to mark the edges of the image.

b. Control 1

A B C

Original image

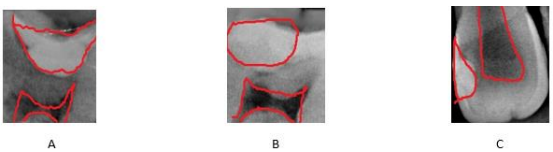
As is known, that is the original picture of tertiary dentin that is marked from the expert.

A B C

Result of control 1 deep learning

The results of the indication that has been processed can detect the part that is considered to have color differences so that it can form an edge on a prominent line. For parts of the teeth that have a distinct color will be detected perfectly perfectly on the edges. Because the edge detection at the stage of determining the edge will be classified according to the sample category which has 2 different colors to mark the edges of the image.

c. Control 2



A B C

Original image

As is known, that is the original picture of tertiary dentin that is marked from the expert.

A B C

Result of control 2 deep learning

The results of the indication that has been processed can detect the part that is considered to have color differences so that it can form an edge on a prominent line. For parts of the teeth that have a distinct color will be detected perfectly perfectly on the edges. Because the edge detection at the stage of determining the edge will be classified according to the sample category which has 2 different colors to mark the edges of the image.

6. Validation

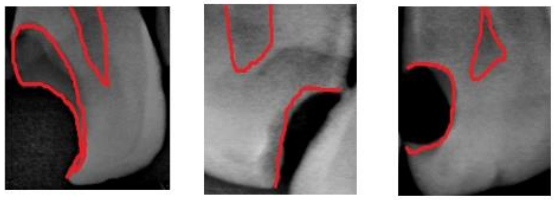
The last stage is the validation stage, where the aim is to assess the accuracy of a model that is built based on certain sets. At this stage it is done manually by comparing the results of the edge using deep learning with edge sobel methods, edge Canny, and edge prewitt as well as edge-made experts.

A. Metode *deep learning*

B. Metode Prewitt

C. Metode *sobel*

D. Metode *Canny*



E. Hasil *expert*

Comparing between several methods where A is the edge image of deep learning outcomes. At B is the image that uses the Prewitt method. Figure C is the edge image resulting from the Sobel method. D is the result of the edge using the Canny method. And in picture E is the edge image created by the expert. From the results of this comparison it can be said that deep learning methods are almost similar to expert results, because this method makes the learning system in which the classified edges will be in accordance with the original form. From deep learning methods can also be known which part is the root of the tooth and which part of the tooth is hollow so that experts can determine the area of tertiary dentin. Because of the three methods that have been processed from Matlab with the same image that produces an unclear image, it is advisable to use a deep learning method that can resemble the shape of the original tooth, because this method can be seen where the edges are.

CONCLUSION

From this study it can be concluded that several things in the application of image processing use deep learning methods to detect the edge of tertiary dentin, namely:

1. Deep learning methods can be implemented directly on the image to automatically mark the tertiary dentin part of the tooth.
2. The parameters used to detect tertiary dentinal edges are using the convolution layer with a filter length 2 and the number of filters 10 and subsampling layers with pool size 2 and Stride 2. As well as training settings with a maximum of 50 epoch and batch size 5.

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