

Home Dental Check-Up Device Using Machine Learning and Image Processing Through Python

Pratham Papneja¹; Reetu Jain²; Shekhar Jain³; Radhakrishna Madas⁴

Singapore International School, Mumbai¹; On My Own Technology Private Limited, Mumbai^{2,3,4}

Abstract- *Maintaining good oral health is extremely important in our lives. With good oral health, we can prevent the formation of plaque, tartar, dental cavities, and periodontal diseases on our teeth. In our busy lifestyle, we often neglect dental check-ups because we cannot find time in our schedule to visit dental check-up facilities. Bad oral health can potentially lead to life threatening diseases, such as sepsis. Worldwide, billions of people face oral health diseases. My project, DENTIN provides an inexpensive, efficient, and portable solution to these problems. DENTIN uses a raspberry pi camera to analyse our oral health by detecting plaque, tartar, and cavities in our mouth. DENTIN does this by using image processing and machine learning through python. The DENTIN system has been trained with thousands of images of different severities of plaque, tartar, and cavities. The DENTIN screen shows you a live feed of the teeth and after analysing your mouth, it creates a Tooth Health Report which consists information about the severity of plaque, tartar, and cavities in your mouth. The DENTIN GUI assists you in deciding the type of treatment through online consultancy with your dentist.*

Index Terms- Image Processing, Raspberry pi, python, machine learning.

I. INTRODUCTION

Dental caries is one of the most common preventable diseases in the world. According to WHO, it has been identified as the primary cause for oral pain and tooth loss. It affects people of all age groups. According to WHO, the problem is persisting even though there have been many advancements in the field of oral

health, and they also claim that poor oral health can have a large impact on the quality of life of people. Over time, changing lifestyles have kept people busy and because of this, people have started eating fast food more often. Fast food can cause the formation of plaque, tartar, and dental caries on your teeth, which can further progress into chronic diseases over time. Oral hygiene is being neglected in 60%-90% of school children and most adults. Worldwide approximately 2.43 billion people have dental caries in their permanent teeth. In baby teeth, it affects 620 million people. Oral diseases are prominently prevalent in Latin American countries, countries in the middle east, and south Asian countries. It is least prevalent in China.[1]

Dental caries are five times more common than asthma. Cavities can be classified according to classes. This practice of classification started over 100 years ago. They are classified from class I to class IV. In class I, it is tooth decay that your dentist can see easily. This type of cavity includes cavities in your molars, premolars, and front and back surfaces of the front teeth. In class II, the cavities occur on surfaces between the molars and premolars. These are not visible to the human eye. Class III cavities occur on the surfaces of the front teeth, and they are not visible to the human eye either. Class IV cavities occur on the surfaces and edges of the front teeth and these are visible. Class V cavities appear on the front and back of either the front or back teeth, near the gumline.

Class VI cavities is when the decay is on the top surfaces of the teeth, incisal edges of the front teeth, or on the cusp of the back teeth.[2]

Dental plaque is biofilm that attaches itself to your teeth. If left undisturbed, it can pose a serious threat to your oral health. Plaque is rich in different types of bacteria. Around 1000 different species of bacteria have been identified in plaque through modern techniques. These bacteria are prominently leukocytes, neutrophils, macrophages, and lymphocytes. Approximately 80%-90% of plaque is made of water. 70% of the plaque's dry weight is bacteria and the rest 30% of the dry weight consists of polysaccharides and glycoproteins. There are two different types of plaque that form on the teeth. Supragingival biofilm, and subgingival biofilm.

Supragingival biofilm is dental plaque that forms above the gums and is the first kind of plaque to form after the brushing of the teeth. It commonly forms in between the teeth, in the pits and grooves of the teeth and along the gums.

Subgingival biofilm is plaque that is located under the gums. It occurs after the formation of the supragingival biofilm by a downward growth of the bacteria from above the gums to below.

Teeth tartar, also called dental calculus, is a crusty deposit that can trap stains on the teeth and cause discoloration. It creates a strong bond that can only be removed by a dental professional. If plaque is not removed regularly, and completely, then minerals in your saliva combine with plaque to form crystals that harden into tartar.

II. RESEARCH

We have all heard about how important it is to eat a well-balanced diet and watch our sugar intake to keep

ourselves healthy and fit. But did you know that your diet has a pronounced effect on your oral health or that your teeth and gums often show the first signs of poor nutrition?

The types of foods you eat and even when you eat them can have a dramatic effect on your teeth and gums. Certain types of food have been linked to higher levels of cavity-causing bacteria. Vitamin and mineral deficiencies caused by a poor diet affect your overall health, as well as increase your risk for needing gum disease treatment. [3]

Cavity Classification System

According to Dentistry IQ, classifying cavities began over 100 years ago, when Dr. G.V. Black, an American dentist, developed a system that is still used by dentists today. [4]

Class I

This describes tooth decay that occurs on tooth surfaces your dentist can see easily. This category includes cavities on the chewing surfaces of the back teeth, such as your molars and premolars, and decay on either the front or back surfaces of the front teeth.

Class II

These cavities occur on the surfaces between the molars and premolars and are not visible to the human eye.

Class III

This decay occurs on the surfaces between the front teeth, but it does not involve the cutting edges of the teeth. Like Class II, this classification of decay is not visible.

Class IV

This decay also occurs on the surfaces between the front teeth, but it involves the cutting edges of the teeth.

Class V

These cavities appear on the front or back of teeth of the gumline.

Class VI

This decay is found on the top surfaces of the teeth, either the incisal edges of front teeth or on the cusp tips of back teeth.

III. METHODOLOGY

The python program for DENTIN is divided into two parts: -

- i. The GUI
- ii. image processing.

In the GUI, we are using PYQT5 library. In the GUI, we have 3 fields where we take an input from the user. These 3 fields are name, age, and gender. There are 3 buttons as well: - start, stop, and generate report. We imported the cavity detection file as "CD". We also used the "if" condition where "if there is a null value in any of the fields, there will be a pop-up asking you to fill the fields". After the start button is pressed, it checks validation and if the validation is true, it starts detecting cavities. Then it calls CD and starts running the program. In the CD program, we take the photo and take it as RGB value and then convert it to HSV (hue saturation value). We convert it to HSV because it allows more details of the picture to be uncovered. We have set a range of upper and lower to find plaque and cavities under different lighting conditions. [5]Then we take the value of the cavity as HSV value and the rest as 0. This is done using dilate, canny, and threshold functions. The dilate function takes the pixels around the detected color range and removes pixels that are not part of the majority. Canny function makes the area around the cavity linked through edges. In threshold, it takes the HSV value and converts it to grayscale. It then

performs the same task as canny function. Then these edges are applied to the original photo and are shown on the screen. We used the contour function for tracking of the plaque and caries when the camera is being moved throughout the mouth. It is a function for shape analysis and recognition. For tracking plaque, we used the "if" function where if the yellow part is more than 300 pixels in one area, a rectangle will be formed around the area, using the "cv2.rectangle" function. We are also finding the area of the plaque using w*h formula and the area is being found in pixels. We are doing the same thing for caries detection but the "if" statement for the caries detection is "if the black frame is greater than 150 pixels and lesser than 800 pixels." The rectangle is formed around the caries area and the area is found out in pixels using width*height. After the caries and plaque have been detected, the camera takes a photo. After you click on the generate report, the information that was taken in from the GUI will be inserted in the cells. This information is the name, age, date, and gender. The other information that will be displayed in the PDF will be the information found through the caries detection program. This information will be plaque scale, cavity size, and tartar scale. The images of where the cavity and plaque was detected will also be shown in the PDF. This device is a cost-efficient home affordable device that can be used anywhere and will have the best use to detect the cavity, plaque and tatar. This way it will reduce the problems of the tooth. We have used a raspberry pi that can withstand any processing and can run machine learning and image processing of python with a flow and can give you accurate results.

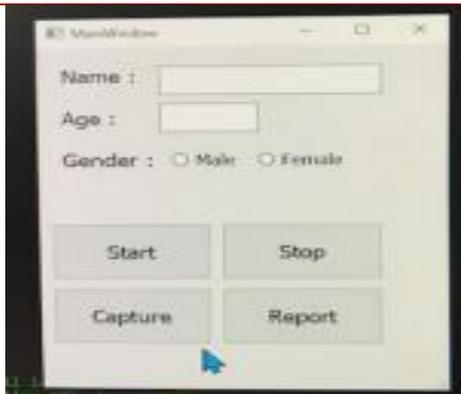


Figure 1: The GUI used to collect the data.

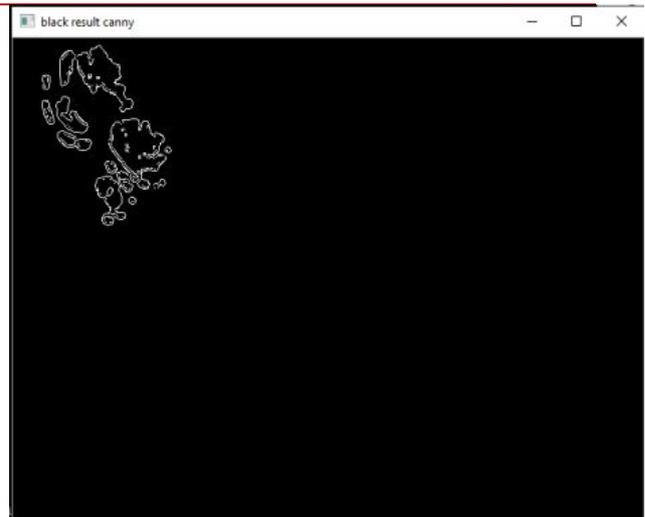


Figure 4: Detection of Cavities



Figure 2: Research Analysis for data collection.

IV. RESULT

Cavity Recognized	Cavity Not recognized	Good Teeth recognized as No Cavity	Good Teeth recognized as Cavity	False Positive	False Negative	Overall Accuracy
Class I Black on the surface	Mainly due to lighting problems	It does not communicate anything	Any black area on the tongue or darkness is taken as cavity			
38 out of 40	2 out of 40	37 out of 40	3 out of 40	7.5%	5%	95%

Figure 5: Cavity analysis



Figure 3: Edge Detection of plaque

Plaque recognized	Plaque Not recognized	Good Teeth recognized as No Plaque	Good Teeth recognized as Plaque	False Positive	False Negative	Overall Accuracy
Lower to high yellow colour with area in pixels at a specified distance	If the area is less than specified	It does not communicate anything	Any yellow light on the teeth will disturb the reading			
35 out of 40	5 out of 40	36 out of 40	4 out of 40	10%	12.5%	87.5%

Figure 6: Plaque analysis

Tartar Recognized	Tartar Not recognized	Good Teeth recognized as No Tartar	Good Teeth recognized as Tartar	False Positive	False Negative	Overall Accuracy
High yellow colour to brown with area in pixels at a specified distance	Mainly due to lighting problems	It does not communicate anything	Any yellow light on the teeth will disturb the reading			
30 out of 40	10 out of 40	28 out of 40	12 out of 40	30%	25%	75%

Figure 7: Tartar analysis

This analysis data can help doctor to understand the cavity problem by only sitting at home.

V. CONCLUSION

Oral manifestations are the first sign or the most significant signs of systematic disease. Thus, it becomes important for the dentist to acquire familiarity with systematic conditions that can affect the oral cavity, so that they can infer the overall impact on the body. Thus, it becomes important for the physician to understand the complaint, its frequency, the relationship to the causes and then draw a parallel to the potential systematic disease. Thus mouth presents a window for easy observation of signs and symptoms of many systematic diseases.

DENTIN records and reports

- Doctors have access to regular data and therefore can draw a pattern to the changes in the oral hygiene of the patient.
- They have access to the data since inception to evolution, thus allowing them to make inferences.
- Since the system is getting aware of the symptom and cause, it is learning and self-training to recognize cues thus deepening its understanding in all three areas of Cavity, Plaque and Tartar
- Research has shown that there are oral manifestations of various other diseases such as diabetes, cardiovascular disease, thyroid disease, and cancer.
- The bacterial plaque in our mouths, decay in our teeth, cancer of the oral tissues, salivary gland conditions, allergies in the mouth, and the fact that the mouth is the organ that begins the digestion process have strong

relationships systemic diseases — either causing or exacerbating them

are governed by an Intellectual body and they select the most suitable paper for publishing after a thorough analysis of submitted paper. Selected paper get published (online and printed) in their periodicals and get indexed by number of sources.

References

- [1] "American Dental Association," [Online]. Available: <https://www.ada.org/en/press-room/news-releases/2015>.
- [2] "National Library of Medicine," [Online]. Available: <https://pubmed.ncbi.nlm.nih.gov/25923691/>.
- [3] J. Randzio, "[Oral cavity--mirror of health and disease in humans]," no. PMID: 3252318.
- [4] P. D. B. J. Vishal M, "Mouth as a Mirror of Systemic Diseases," *Gomal Journal of Medical Sciences*, Vols. vol-8, no. July-December, pp. No-2, 2010.
- [5] J. H. M. S. Jufriadif Naam, "Detection of Proximal Caries at The Molar Teeth Using Edge Enhancement Algorithm," *International Journal of Electrical and Computer Engineering (IJECE)*, Vols. Vol-8, no. No. 5, 2018.

AUTHORS

FIRST AUTHOR: PRATHAM PAPNEJA



Completed secondary education from Singapore International School), Mumbai. Currently 11th grade in the same school (IBDP Board).

Second Author: Reetu Jain



Chief-Mentor and Founder of On My Own
Technology Private Limited Mumbai,
reetu.jain@onmyowntechnology.com

Third Author: Shekhar Jain



Chief Executive Officer and Co-founder of On My
Own Technology Private Limited Mumbai,
shekhar.jain@onmyowntechnology.com

Fourth Author : Radhakrishna Madas

Senior Research Analyst

On MY Own Technology Pvt Ltd, Mumbai

iJournals