Multifarious Techniques for AI Enabled Dentistry

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ABSTRACT

With rapid development in field of AI for healthcare, it is Crucial that the gap between AI technological advancement and usability for the healthcare professionals must be bridged. The goal of our tool is the bridge this gap in the fieldof healthcare starting with Dentistry.
In dentistry, the field which we are working closely on development of multifarious AI powered solutions, lacks the basic infrastructure, for us engineers to develop and deploy it to them, which brought into light two major issues.
1. Generation and collection of data for a specific diagnostic task.
2 .Deployment of the developed AI Algorithm with ease of usage for the dental professionals.
As a solution we built a web-based portal. To address the issue of data collection, custom annotation tools were built for the different projects/departments, which provided the dentist a simple platform to annotate the images with less efforts and providing us the data needed in the desired formats. This platform also provided us‘the opportunity to give the dentist access to the AI tools at the click of a button for different diagnostic analysis and research.

Keyword- multifariousAI, web-based portal

1. INTRODUCTION

The world of AI revolves around executing the basic tasks through machines which make human work simpler and more time-effective by using various technologies. The actual use of AI now is beyond one’s wildest dream. But the discussion of AI also brings up the topic of its impact on society, economy, healthcare and politics as well. One of the upcoming fields for implementations of AI in healthcare is Dentistry. AI in dentistry is used to detect many teeth related issues such as jaw fractures, bone loss, bone cysts, gum related issues and many more diseases. By using AI the speed of diagnosis can be improved without compromising on accuracy.

At the moment we have collected around two thousand training images. These include four hundred lateral cephalograms for CVS staging and four hundred IOPA images. These will be used to train our AI model for predictions. The feedback from the dentists has been very positive. They expressed that the tool helped them save a lot of time compared to previously used annotation tools such as AutoCAD and ImageJ.

2. LITRATURE REVIEW

The use of AI in different dental specializations include applications in Orthodontics, Conservative dentistry and prosthodontics, Periodontology, Temporomandibular joint disorders, Endodontics, Maxillofacial surgery [1].
There was also a study [2] to retrospectively assess radiographic data and to prospectively classifyradiographs, comparison was made between three deep learning architectures for their classification performance. Convolutional neural networks, a residual network, and a capsule network for classification. . Results: All three models showed high accuracy (>98%). ResNet achieved the best performance at small variance and fastest convergence.

PLAINSIGHT [3] is an AI powered annotation tool that has been developed with the idea of selecting and annotating with ease. It is capable of auto annotation, label tracking, label classification, customization options for the labels and it also lets one to export the annotated image and it also supports a vast format of images for Computer Vision.

The paper [4] Deep learning for early dental caries detection in bitewing radiographs Shinae Lee1 talk about how DL can be effectively used on images for detection of a dental decay. By using U-NET CNN model it was made possible to help dentist to locate cavities using Bitewing radiographs. Training was done on 340 radiographs and performance evaluation was done using 50 radio graphs.

Image classification is the process of segmenting images into different categories based on their features. A feature could be the edges in an image, the pixel intensity, the change in pixel values, and many more.

Some techniques which are used in digital image processing include:
Anisotropic diffusion, Hidden Markov models, Image editing, Image restoration, Independent component analysis, linear filtering, neural networks, Partial differential equations.
Using keras: Keras is an open-source software library that provides a Python interface for artificial neural networks. Keras acts as an interface for the TensorFlow library.
Using openCV: It can process images and videos to identify objects, faces, or even the handwriting of a human. When it is integrated with various libraries, such as Numpy which is a highly optimized library for numerical operations.

3. METHODOLOGY

The AI-enabled dental assistance tool is integrated as a web application. Our tool aims at helping dental professionals/ practitioners by using AI technology to make their everyday tasks easier. Meticulous care has been taken to provide a smooth and user-friendly UI which makes it easy even for someone without technical expertise to use the various features of our tool

Methodology: Our project is developed and focused based on multiple surveys with dental professionals and studying about what is currently being used in terms of software technology for diagnostics. Currently in the field of Dental diagnostic there has not been any commercial incorporation of AI enabled Diagnostic. Our project aims to achieve a platform for Ai enabled diagnostics that can be commercially by the dental industry.

Method: We have developed a platform that serves two purposes for AI enables dentistry.

We have an in-house annotation tool developed and deployed for the sole purpose of collection of data based on our and the dentists custom requirements.

The data generated from this platform can be used for training and development of AI models which will be deployed on the same platform as a diagnostic tool.

The tool developed is focused and customized based on the project in consideration. The main focus of the tool if to provide us with annotated images as ground Truth and a CSV file that contains the data required for the training of models with the original images.

The AI tool on the same platform focuses on removing human error and saving time for the diagnosis.

The tool is again custom designed based on the requirements of the particular diagnostic focus.

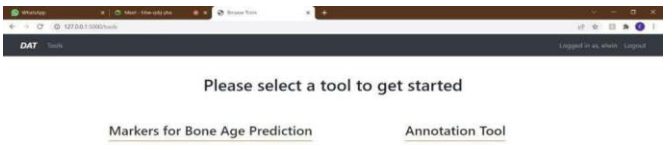

Figure 1: Annotation tool - Data Collection (i)

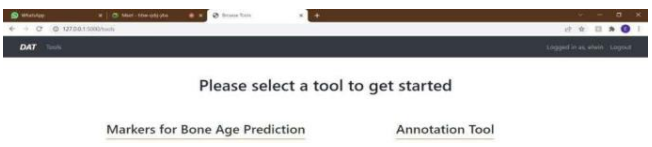

Figure 2: Annotation tool - Data Collection (ii)

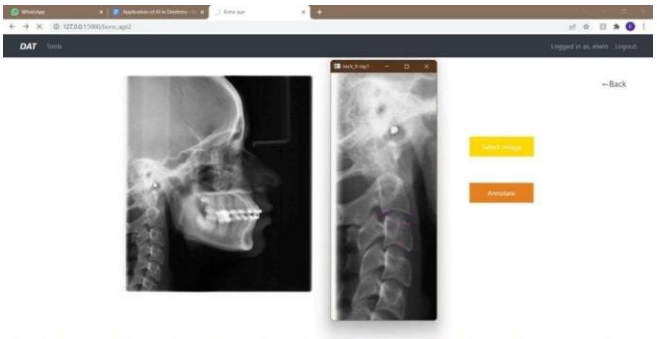

Figure 3: Annotation tool - Data Collection(iii)

Figure 4: Annotation tool - Data Collection (iv)

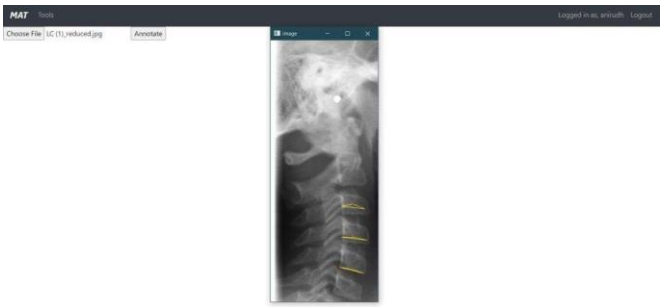

Figure 5: Annotation tool - Data Collection (v)

Existing data

All data used for this project is real time. It has been collected by our own in-house tools which are custom designed based on the use case. Since we are working with dentists the main data type we are working are X-Ray images of the following types.

1. IOPA
2. Lateral Cephalograms
3. OPG

Following data Collection all the required preprocessing image enhancement and augmentation techniques have been used to make the dataset more versatile for training robust models

Functionalities: Image annotation is the process of labeling images of a dataset to train a machine learning model. Therefore, image annotation is used to label the features you need your system to recognize. Our tool uses cv2 to automatically annotate cervical vertebrae on cephalograms. This annotation feature can be extended to work on other images as per requirements.

Landmark detection using a stacked hourglass architecture On IOPA and Lateral Cephalogram with Region of interest classifiers are integrated. This architecture is used due to its high special awareness and good functionality of landmark localization.

Among deep neural networks, the convolutional neural

network has demonstrated excellent results in computer vision tasks, especially in image classification. We use image classification to detect various dental diseases.

Modules and Features:

Login – The user will be required to login to access the various tools in the application. Each dental department will have its own unique features on the site. The registration, login authentication and session management are achieved using the Flask web framework which a micro-framework is written in Python.

The Database – We have used SQLite for our database. User table stores all user information. We also store the original, annotated images and CSV (Comma separated Values) file as a way of collecting data.

Annotation Tool: - This is a CV2 based tool designed with the dentist's requirements in mind and the idea of data collection for us engineers. This tool provides the dentist with user-friendly software for annotation and for us engineers the coordinates and other data which can be used for training our AI/ML models.

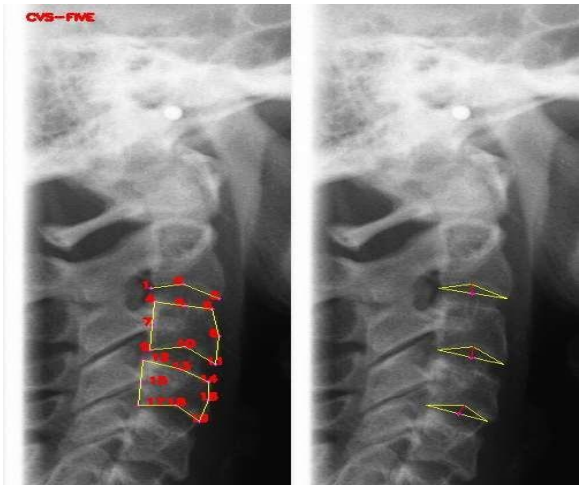

Figure 6: Annotation tool - Data Collection (vi)

Landmark detection – The concept of landmark localization is one with vast application in the field of dentistry. Currently, our tool has deployed three AI-powered landmark localization tools for Cephalometric analysis, Bone Age prediction (CVS-Cervical Vertebrae Staging) and early prediction of Bone Loss in IOPA images.

4. RESULT ANALYSIS

Stacked Hourglass Network has a stack of multiple hourglass modules instead of forming a giant encoder and decoder network. The Hourglass module produces a full heat map for landmark prediction. Thus, the following Hourglass module learns from the landmark predictions of the previous Hourglass module.

On interaction with the Dental Professionals, the IOPA radiographs which are used to detect periodontal bone loss are very likely to be missed in the early stages through the naked eye. To accomplish the goal of early detection, we developed a tool that can annotate the image which gives a region of interest and as it is an annotated image, it gives a clear look at the radiograph which will help in our next stage. The next stage is, the radiographs are fitted into a model where automatic landmark detection takes place.

The results of automatic landmark detection on an IOPA gives us four, eight or twelve points on an IOPA of two teeth, three teeth or four teeth respectively. The points are marked on bone levels (Bone level left and bone level right) and cementoenamel junction (CEJ left and CEJ right) between two teeth. Once the landmark is confirmed, the distance between bone level points and CEJ points is calculated to reach a conclusion on the analysis.

The second type of radiograph we worked on is Lateral Cephalogram where approximately thirty two points are automatically detected as each point is marked under its unique name to have a better understanding of what and where the points are. These points are later used to do the necessary calculations which can help the dental professionals to sort the results into eleven possible analyses.

After an image is annotated, the original image and the annotated image is saved in the same file along with a CSV file which gives all X and Y coordinates of each point. The study comes with a number of strengths and limitations. Our limitations can be categorized into two parts. First, the generation and collection of data is labor intensive and time-consuming. Second, Deployment of the developed AI algorithm with ease of usage for dental professionals.

For which a web-based portal is created using Flask for different departments to annotate and store the images in a database. In future research, the ongoing addition of training data will be added, which will improve the accuracy of automatic landmark detection of the CNN model using Stacked Hourglass Network. As the accuracy increases, more clinicians can count on our dental assistance tool to give a specific diagnostic task, or at the minimum, have a second opinion on their analysis.

TESTING AND RESULTS

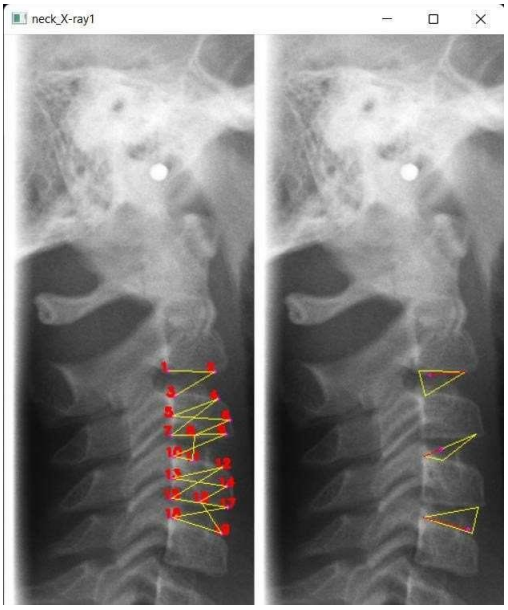

Figure 7: Annotation tool (i)

	X	Y	annotations---LC_1.jpg-----CVS-FOUR
1	X	Y	annotations---LC_1.jpg-----CVS-FOUR
2			
3	164	335	1
4			
5	210	336	2
6			
7	170	360	3
8			
9	213	363	4
10			
11	168	380	5
12			
13	225	384	6
14			
15	167	399	7
16			
17	190	399	8
18			
19	221	398	9
20			
21	169	420	10
22			
23	188	424	11
24			
25	218	431	12
26			
27	168	442	13
28			
29	222	450	14
30			
31	167	462	15
32			
33	196	465	16
34			
35	223	471	17
36			
37	168	481	18
38			
39	217	497	19
40			

Figure 8: Annotation tool (ii)

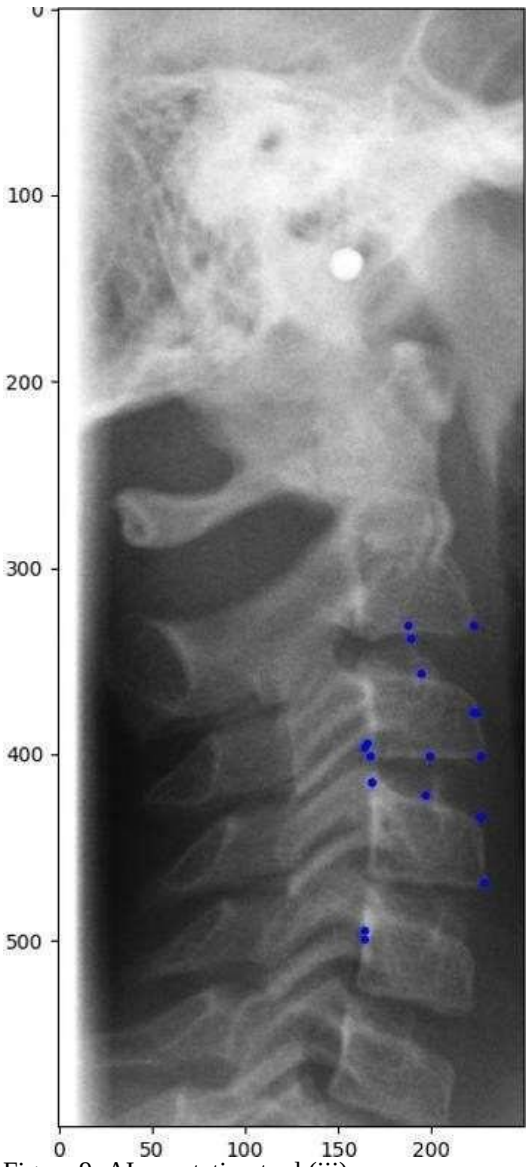

Figure 9: AI annotation tool (iii)

5. CONCLUSION

In this study, we developed a web-based tool that performs image annotation on IOPA and Lateral Cephalogram. These dental Radiographs are subsequently used with CSV files as inputs to the Stacked Hourglass Network for landmark detection, which provides a satisfactory detection performance which will certainly ease the work of Dental professionals.

6. REFERENCES

[1] Raymond P. Danks, Sophia Bano, Anastasiya Orishko, Hong Jin Tan, Federico Moreno Sancho, Francesco D'Aiuto, Danail Stoyanov.Automating Periodontal bone loss measurement via dental landmark localisation. International Journal of Computer Assisted Radiologyand Surgery (2021) 16:1189–1199

[2] Classification of Dental Radiographs Using Deep Learning Jose E. Cejudo ,Akhilanand Chaurasia , Ben Feldberg , Joachim Krois and Falk Schwendicke.

[3] The ways of using machine learning in dentistry Monika Elżbieta Macho, Liliana Szyszka-Sommerfeld, Andras Vegh, and Tomasz Gedrange Krzysztof Woźniak

[4]Deep learning for early dental caries detection in bitewing radiographs Shinae Lee1, Sang-il Oh2, Junik Jo2, Sumi Kang3, Yooseok Shin3 & Jeong-won Park1dental landmark localisation. International Journal of Computer Assisted Radiology and Surgery (2021) 16:1189–1199