Teeth Segmentation & Disease Prevention

1

Problem Statement

Problem Overview & Technical Solution

The Growing Importance of Dental Health

The importance of dental health as an integral part of daily human functioning:

Functional aspect

The structure of an individual's teeth affect the process of digestion.

Visual aspect

The appearance influences other people's perception and contributes to social status.

Problem Overview/Statement

Requirements of successful orthodontic treatment:

1. Collection of various data, such as X-rays, photographs, etc.
2. Analysis of data to generate accurate diagnosis
3. Devise optimal treatment plan for patients

Traditional Approach

Traditionally, the analysis of teeth shape, number and position from collected data was conducted solely with trained eye of dentists. This is **time-consuming**, **error-prone**, and requires **high professional aptitude**.

AI-Based Approach

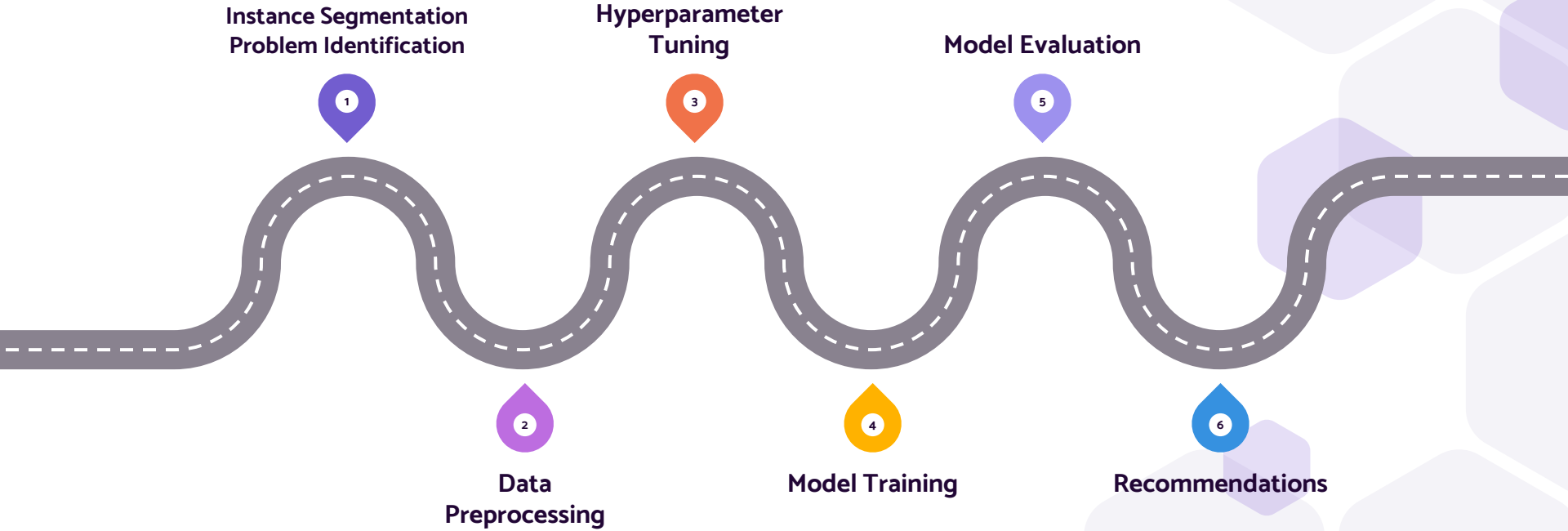
In recent years, advancement of AI has made computer-aided diagnosis become popular. When implemented in dentistry, this can potentially **save time** and **reduce the impact of fatigue** from clinical decision making.

2

Analytical Approach

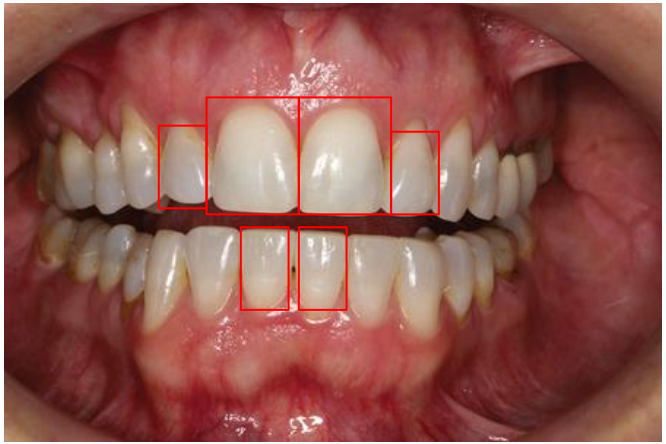
Approach Overview

Analytical Approach



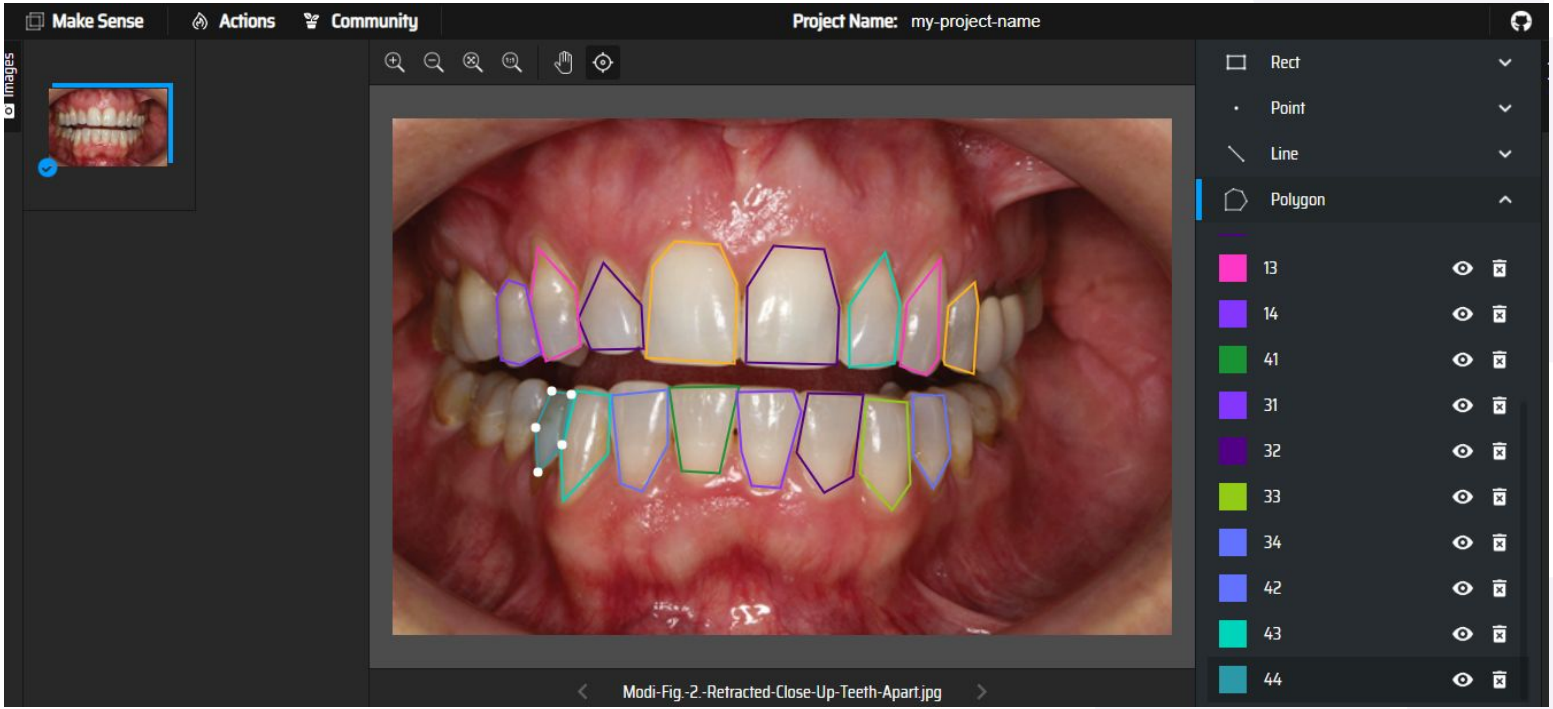
Instance Segmentation

Object Detection



Instance Segmentation

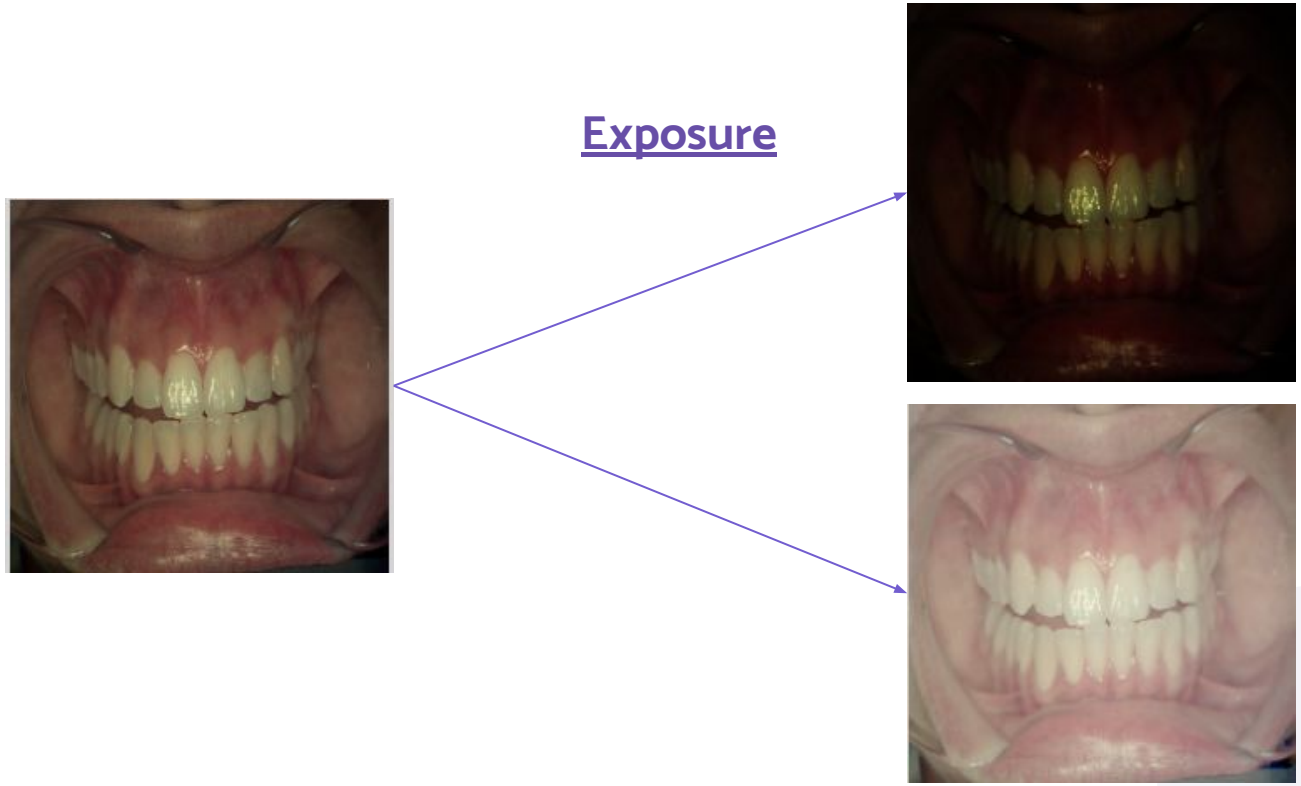
Data Preprocessing - Annotation



Data Preprocessing - Augmentation

Rotation

Data Preprocessing - Augmentation



Data Preprocessing - Augmentation

Blur

3 Models

SOLO (Segment Objects by LOcations)

Limitations by traditional algorithm

Top-down approach

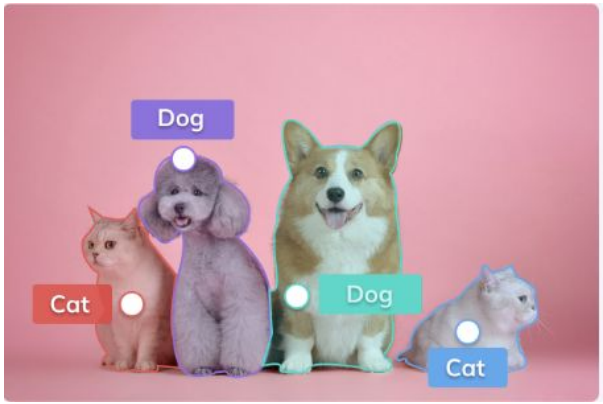
1. ‘Detect-then-segment’ approach
2. Detect bounding boxes around the object(s)
3. Segment the instance mask in each bounding box to distinguish separate instances of the object

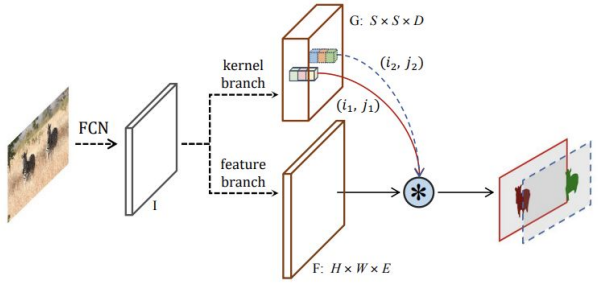
Bottom-up approach

1. Pull close pixels of the same instances and push away the pixels of different instances
2. Creating an affinity relationship between them and assigning an embedding vector to each pixel.
3. Then group similar pixels to delineate instances.

SOLO (Segment Objects by LOcations)

Dynamic and direct approach based on notion of instance categories





(b) SOLOv2

Assigns each pixel within an instance of an object to a category based on its

- **Location**
- **Size**

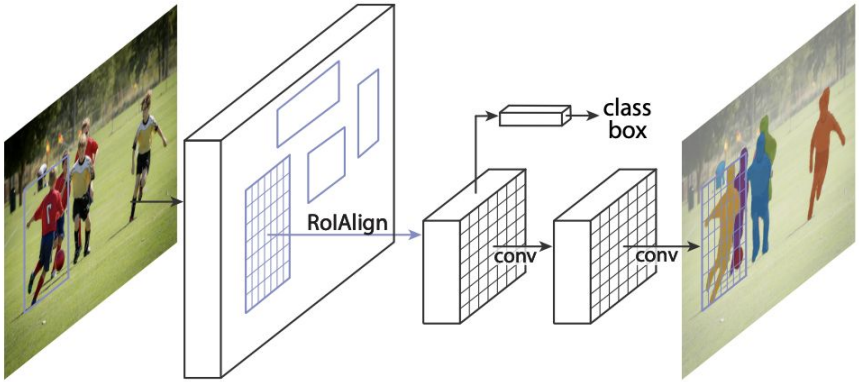
It divides the mask learning process into two parts

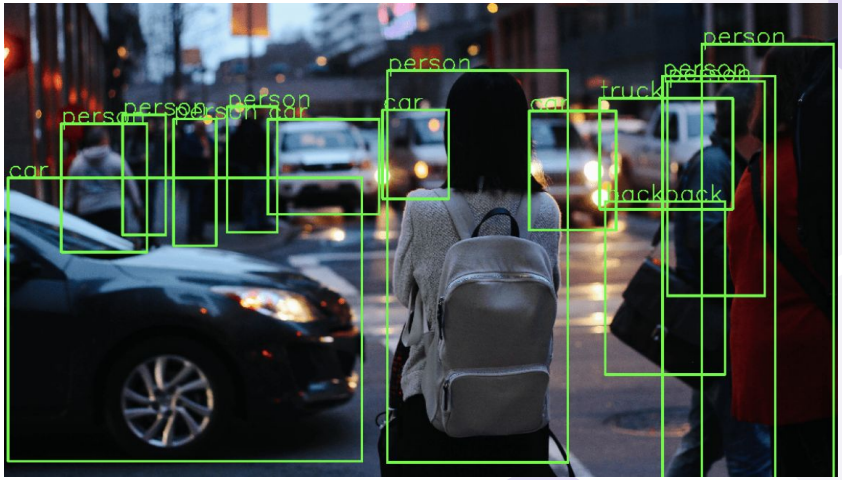
- **Convolution kernel learning**
- **Feature learning**

Strengths of SOLOv2

- SOLO is not restricted by box locations and scales and hence benefits from the inherent advantages of Fully Connected Networks (FCNs)
- SOLO takes an image as input, directly outputs instance masks and the corresponding semantic class probabilities in a fully convolutional, box-free and grouping-free paradigms

Mask R-CNN

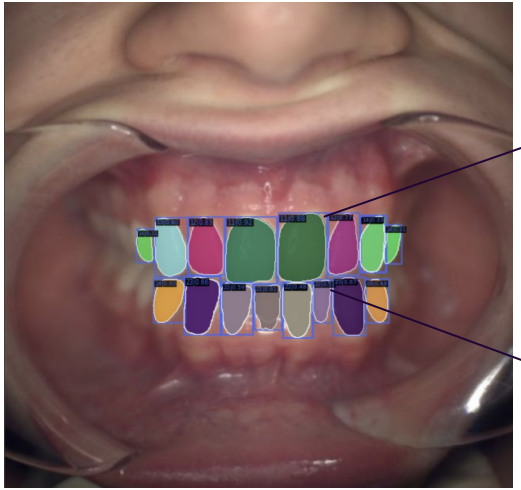




Region-Based Convolutional Neural Network is a type of instance segmentation model

Mask R-CNN

1. Region Proposals
2. Bounding box recognition and prediction of object class
3. Output predicted object class and probability



Strengths of Mask R-CNN

- **Simplicity**

  Mask R-CNN is simple to train.

- **Performance**

  Mask R-CNN outperforms all existing, single-model entries on every task.

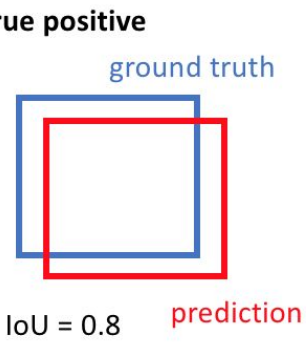
- **Flexibility**

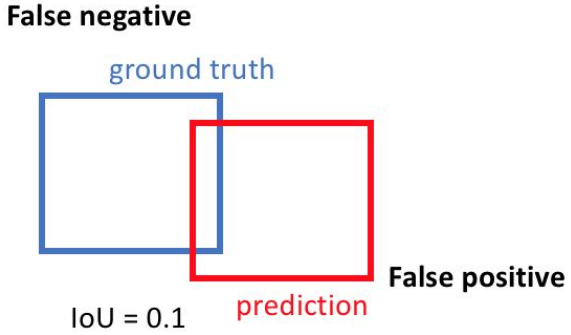
  Mask R-CNN is easy to generalize to other tasks.

4 Results

Metrics in instance segmentation problems

Example
Threshold: 0.5





IoU (Intersection over Union)

Results

Evaluation

- Average Precision
- Average Recall

Hyperparameter tuning

- Number of epochs
- Classification loss metrics

Average Precision (%)				
	8 Epochs		16 Epochs	
	Cross Entropy Loss	*Focus Loss*	*Cross Entropy Loss*	*Focus Loss*
Mask-R-CNN	84.9	85.3	83.9	85.0
SOLOv2	79.6	80.1	85.1	86.8

Average Recall (%)				
	8 Epochs		16 Epochs	
	Cross Entropy Loss	*Focus Loss*	*Cross Entropy Loss*	*Focus Loss*
Mask-R-CNN	84.9	85.6	84.4	85.1
SOLOv2	80.2	82.0	85.3	86.8

Limitations

Dataset

Absence of cheek retractor

Presence of orthodontic appliances

Picture quality

Unusual teeth shapes and orientations

Missing teeth

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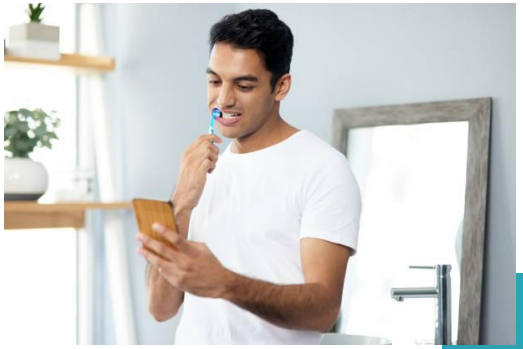
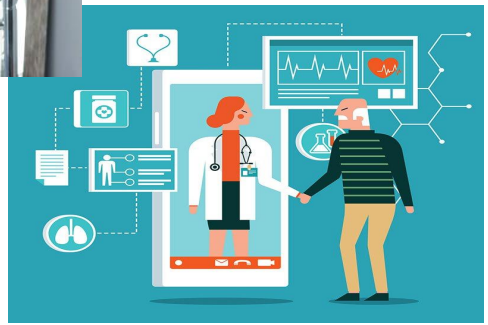
Business Opportunity

Telemedicine - Remote Dental Diagnosis

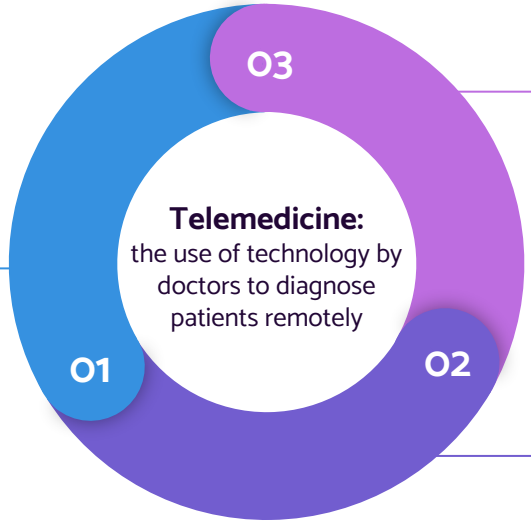
Telemedicine in Dentistry





"The Asia Pacific telemedicine market is expected to increase from USD 10.33bn in 2022 to USD 27.24bn by 2027" - Asia Telemedicine Market Report

Benefits of Telemedicine



Improved Access

Bridge the constraints of distance, time and cost

Limit Spread of Contagious Diseases

Limited contact with healthcare professionals since you can conduct check-ups from home

24/7 Access

Access to an online tool available at all hours of the day with no set working hours.

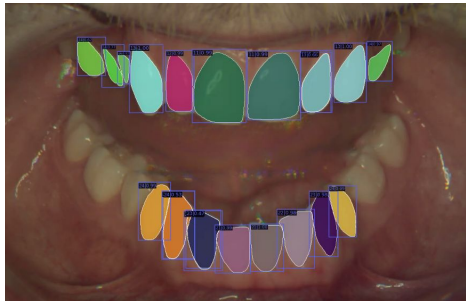
6

Product

Dental Feedback from the Comfort of Home

Building a Viable Product

Current Work:



Additional Models to Build

1. Anomaly Detection
2. Treatment Suggestions
3. Length of Treatment
4. Estimated Costs of Treatment
5. Before & After Treatment Picture

Develop Mobile App

Solution-oriented, comprehensive mobile phone application for reliable preliminary dental diagnosis

MOBILE APP

Let users snap a picture of their teeth and provide recommendations if a disease is detected.

The app shows before & after results of the treatment (if needed).

7

Conclusion

True VA's thoughts & Key Takeaways

“The NTU team was able to help us progress with our CV development by suggesting alternative methods to approach the modeling.”

- *TrueVA*

Key Takeaways

1. Label Data

Labelled 500 images for TrueVa + 50 images from a public dataset: drew bounding boxes around the front 16 teeth

2. Build Model

Built two computer vision models based on instance segmentation.
Objective: Segment Teeth (get position of each tooth)

3. Product

Impact Telemedicine & Dentistry: Users can snap a picture of their teeth and get an instant analysis of their teeth via an app

Thank You for Listening

- Team 1 x TrueVA