# AlphaDent

## TEETH MARKING

Ahmed Hesham Emara
Ali Mahmoud Sobhy
Mustafa Elkaranshawy

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# Problem Recap

In this task, participants are given a collection of high-resolution intraoral dental photographs with the objective of performing instance segmentation. The images are to be annotated into nine predefined classes, each representing a distinct dental structure or condition. To support this process, example annotations and representative samples of each class are provided as reference.

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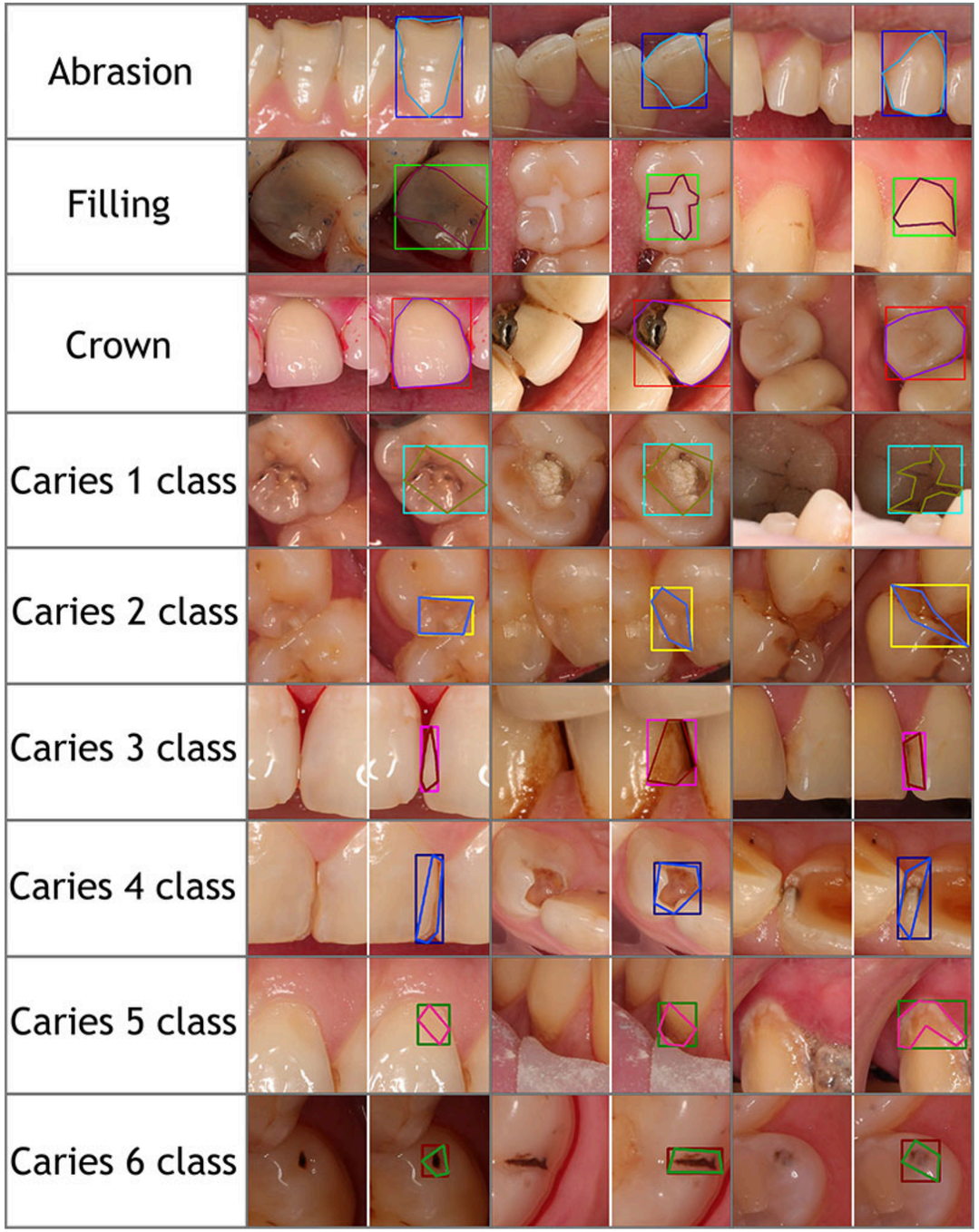
Abrasion
Filling
Crown
Caries 1 class
Caries 2 class
Caries 3 class
Caries 4 class
Caries 5 class
Caries 6 class

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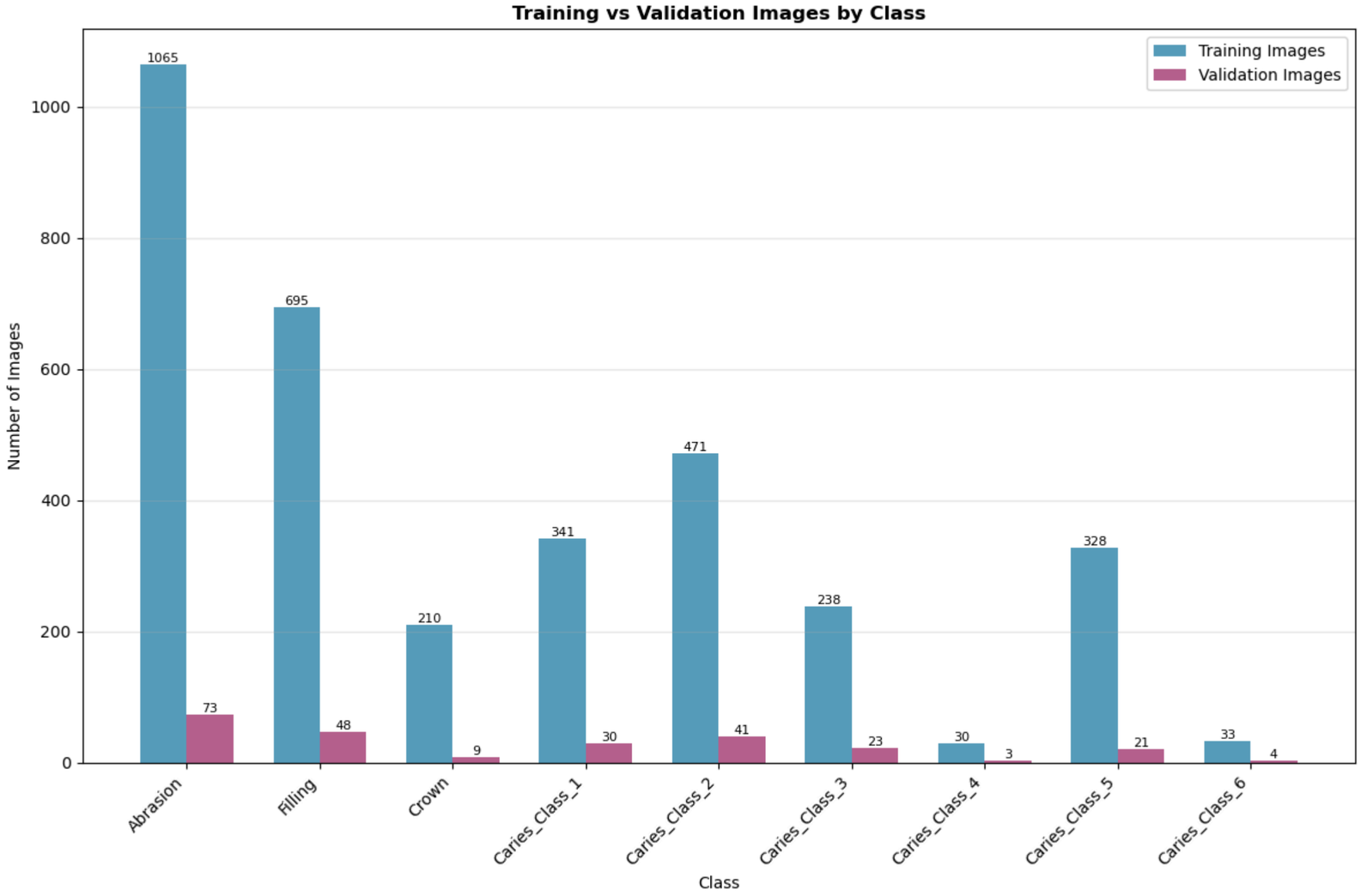
# Data Distribution

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# Last Two Weeks Work Recap

After evaluating several approaches over the past two weeks, we finalized the method described here, which achieved the best results and placed us at the top of the competition leaderboard.

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- Yolov8x-seg + resNet Classifier

# Yolov8x-seg + resNet Classifier

The model evolved from an initial approach, where YOLO was trained directly on the dataset to classify all nine classes, to a **more refined strategy incorporating an external classifier**. The motivation for this shift came from the poor performance observed when classifying the six caries-related classes, largely due to their low representation in the dataset. To address this imbalance, the caries subclasses were merged into a single "Caries" category, enabling the model to learn higher-level features of caries. This adjustment allowed us to train YOLO on four broader classes instead of nine, leading to improved performance.

# Yolov8x-seg + resNet Classifier

In this stage, the system refines caries classification by first using YOLO to detect "Caries" regions, which are then cropped from the original images. The **PolygonCariesDataset** class automates this process by reading YOLO's polygon annotations and preparing the cropped patches as **(crop, label)** pairs. These samples are used to train a ResNet18 model, which classifies the crops into one of six caries subclasses. Unlike YOLO, ResNet focuses solely on fine-grained subclass differentiation, restoring the detailed caries types that were merged into a single category during YOLO training.



# Work Flow

Yolov8x-seg

Abrasion

Filling

Crown

Caries

Customized Dataset
[4 Classes]

Caries Cropped Images

ResNet18

Caries 0

Caries 1

Caries 2

Caries 3

Caries 4

Caries 5

Original Dataset
[9 Classes]

Re label the Cropped image

Customized Dataset
[6 Classes]

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# Yolov8x-seg + resNet Classifier Results

## On Validation Set

| Class | Images | Instances | Mask P | Mask R | mAP@50 | mAP@50-95 |
|---|---|---|---|---|---|---|
| Abrasion | 73 | 409 | 0.620 | 0.919 | 0.840 | 0.676 |
| Filling | 48 | 186 | 0.719 | 0.683 | 0.720 | 0.372 |
| Crown | 9 | 19 | 0.588 | 0.752 | 0.778 | 0.631 |
| Caries | 64 | 258 | 0.503 | 0.302 | 0.375 | 0.116 |
| **All** | 83 | 872 | 0.607 | 0.664 | 0.678 | 0.449 |

## On Test Set

| Class | Images | Instances | Mask P | Mask R | mAP@50 | mAP@50-95 |
|---|---|---|---|---|---|---|
| Abrasion | 109 | 588 | 0.690 | 0.827 | 0.806 | 0.646 |
| Filling | 60 | 203 | 0.601 | 0.616 | 0.629 | 0.313 |
| Crown | 19 | 52 | 0.538 | 0.865 | 0.762 | 0.631 |
| Caries | 81 | 297 | 0.605 | 0.327 | 0.389 | 0.128 |
| **All** | 124 | 1140 | 0.608 | 0.659 | 0.657 | 0.429 |

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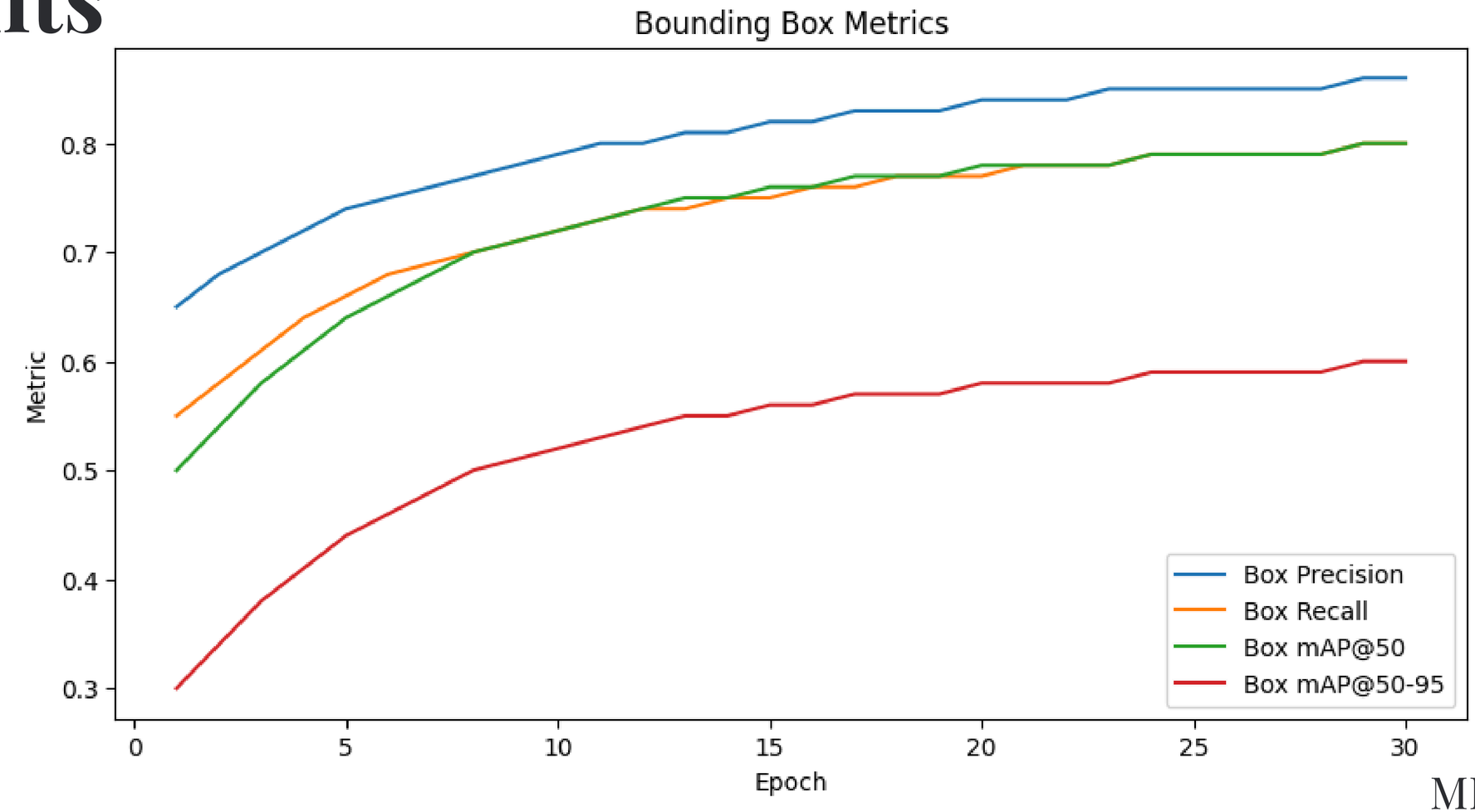
# Yolov8x-seg + resNet Classifier Results

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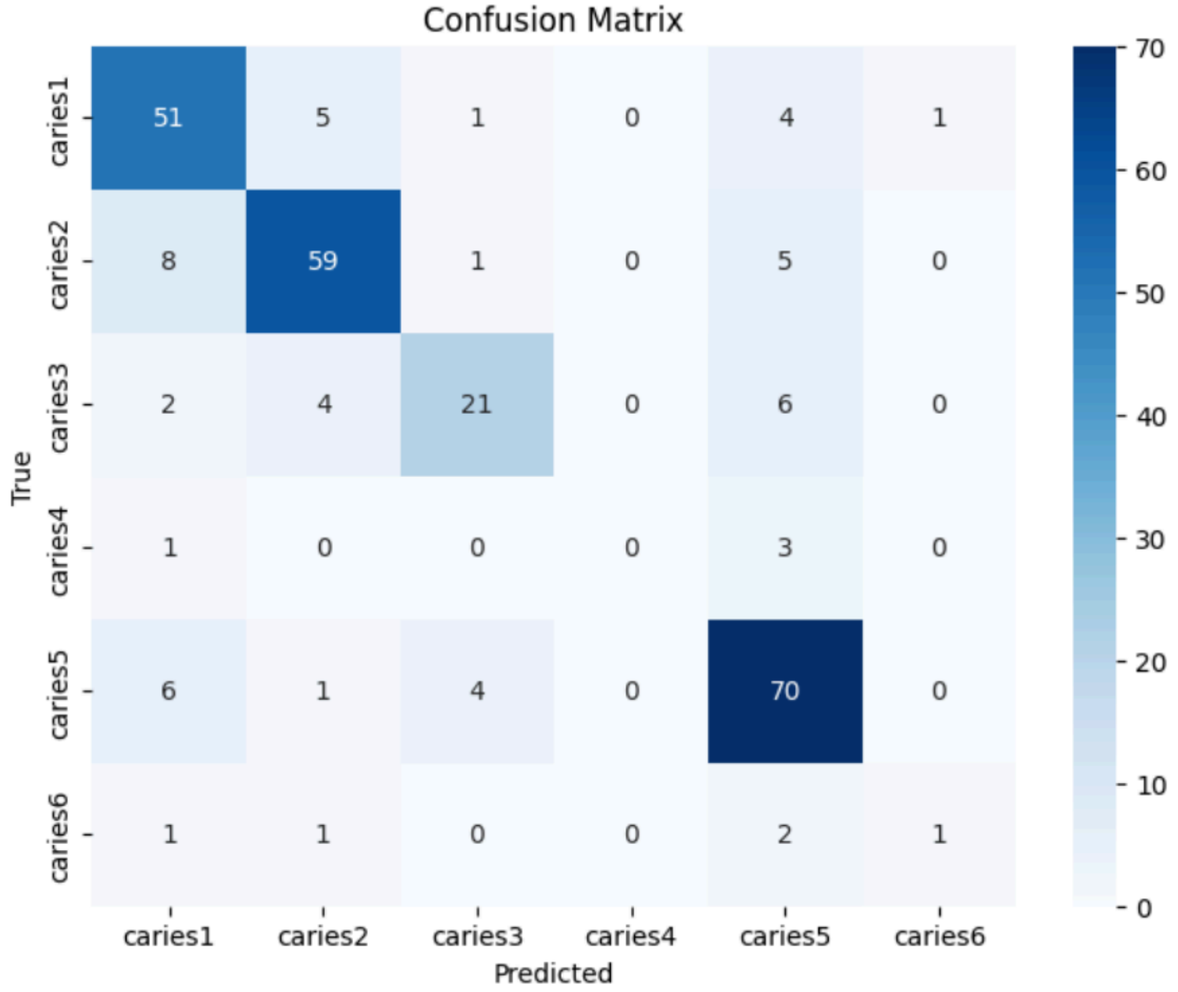
# Yolov8x-seg + resNet Classifier Results

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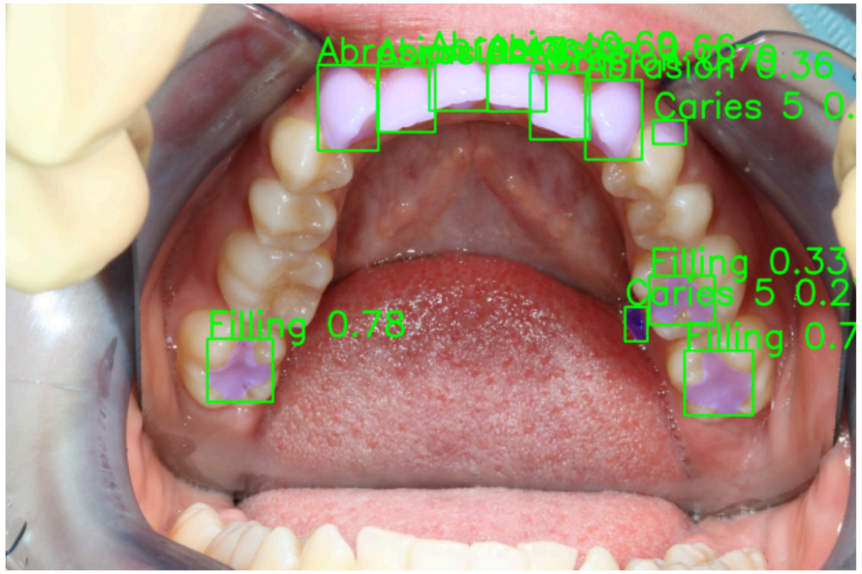
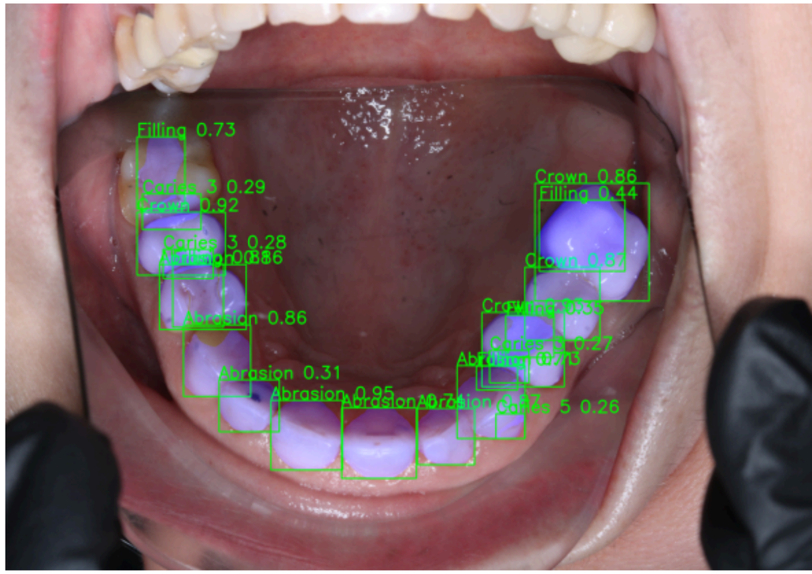
# Yolov8x-seg + resNet Classifier Classification Samples

Prediction for test_052.jpg


Prediction for test_041.jpg




Prediction for test_043.jpg

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# Yolov8x-seg + resNet Classifier Competition Leaderboard

We held the first-place rank for several days, but then dropped to second with an extremely close score to the new leader.

| # | Team | Members | Score | Entries | Last | Join |
|---|---|---|---|---|---|---|
| 1 | Sheeza Shabbir |  | 0.26674 | 6 | 5d | |
| 2 | Mustafa Elkaranshawy |  | 0.26657 | 9 | 15h | |

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# How To Improve These Results ?

- Use Yolov11x-seg

- Use another classifier [with V11 and V8]
  - ConvexNet Small
  - ConvexNet Base

- Use Mask-RCNN

# Yolov11x + ResNet Classifier

We Changed only Yolov8x-seg with the newest version of it [Yolov11x-seg] and we got these results

# Yolov11x + ResNet Classifier

| CLASS | IMAGES | INSTANCES | BOX METRICS | | | | MASK METRICS | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | P | R | MAP50 | MAP50-95 | P | R | MAP50 | MAP50-95 |
| **all** | **83** | **872** | **0.686** | **0.584** | **0.656** | **0.468** | **0.679** | **0.581** | **0.649** | **0.416** |
| Abrasion | 73 | 409 | 0.632 | 0.861 | 0.832 | 0.745 | 0.634 | 0.863 | 0.834 | 0.670 |
| Filling | 48 | 186 | 0.677 | 0.607 | 0.686 | 0.383 | 0.667 | 0.597 | 0.683 | 0.334 |
| Crown | 9 | 19 | 0.733 | 0.724 | 0.748 | 0.617 | 0.733 | 0.722 | 0.748 | 0.552 |
| Caries | 64 | 258 | 0.702 | 0.146 | 0.358 | 0.128 | 0.682 | 0.141 | 0.329 | 0.108 |

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# Yolov11x + ResNet Classifier

After Submission this work we got score of

0.22981

And this doesn’t introduce an improvement of the Elder Submission Score that got a score of

0.26657



# Yolov11x + ConvexNet small Classifier

We Changed only ResNet18 with the ConvexNet small Classifier instead of it and we got these results

# Yolov11x + ConvexNet small Classifier

We Changed only ResNet18 with the ConvexNet small Classifier instead of it and we got these results

| EPOCH | LOSS | ACCURACY |
|---|---|---|
| 1 Epoch 1/5 | 0.7425 | 73.39% |
| 2 Epoch 2/5 | 0.3960 | 86.74% |
| 3 Epoch 3/5 | 0.2418 | 91.38% |
| 4 Epoch 4/5 | 0.1341 | 95.60% |
| 5 Epoch 5/5 | 0.1238 | 95.93% |

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# Yolov8x + ResNet Classifier

This is the best submission stats

| EPOCH | PROGRESS | LOSS |
|---|---|---|
| 1 Epoch 1 of 10 | 0.7766 | 72.97% |
| 2 Epoch 2 of 10 | 0.3923 | 86.14% |
| 3 Epoch 3 of 10 | 0.2287 | 93.07% |
| 4 Epoch 4 of 10 | 0.1625 | 94.67% |
| 5 Epoch 5 of 10 | 0.1085 | 96.65% |

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# Yolov11x + ConvexNet small Classifier

After Submission this work we got score of

0.23341

And this doesn’t introduce an improvement of the Elder Submission Score that got a score of

0.26657

# Yolov11x + ConvexNet base Classifier

We Changed only ResNet18 with the ConvexNet base Classifier instead of it and we got these results

# Yolov11x + ConvexNet base Classifier

After Submission this work we got score of

0.26274

And this doesn’t introduce an improvement of the Elder Submission Score that got a score of

0.26657



The Closure of the results seems like if we used back yolov8x with convexNet base model will Enhance Results more



# Yolov8x + ConvexNet base Classifier

We Changed only ResNet18 with the ConvexNet base Classifier instead of it and we got these results and used the trained model yolov8x

# Yolov11x + ConvexNet small Classifier

After Submission this work we got score of

0.26575

And this doesn’t introduce an improvement of the Elder Submission Score that got a score of

0.26657

# **Yolov8x** + **Mask-RCNN** + **ResNet18**

We tried the approach used in segment any tooth and that is using Yolo for enumeration and then segment these boxes uses instance segmentation model (RCNN), and we got these results.

# Yolov8x + Mask-RCNN + ResNet18

**Speed:** 0.4ms preprocessing, 112.5ms inference, 0.0ms loss, 3.3ms postprocess per image
**Validation mAP50:** 0.4310 | **Validation mAP50-95:** 0.2538

| Class | Images | Instances | BOX DETECTION | | | | MASK SEGMENTATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | P | R | mAP50 | mAP50-95 | P | R | mAP50 | mAP50-95 |
| **all** | **83** | **872** | **0.491** | **0.441** | **0.438** | **0.288** | **0.491** | **0.440** | **0.431** | **0.254** |
| **Abrasion** | 73 | 409 | 0.507 | 0.922 | 0.794 | 0.698 | 0.506 | 0.921 | 0.792 | 0.610 |
| **Filling** | 48 | 186 | 0.643 | 0.409 | 0.495 | 0.201 | 0.633 | 0.403 | 0.473 | 0.186 |
| **Crown** | 9 | 19 | 0.395 | 0.316 | 0.271 | 0.189 | 0.390 | 0.316 | 0.271 | 0.175 |
| **Caries** | 64 | 258 | 0.417 | 0.117 | 0.192 | 0.063 | 0.433 | 0.122 | 0.188 | 0.044 |

**Performance Legend:**

≥0.70 Excellent | 0.40-0.69 Good | <0.40 Needs Improvement

# Yolov8x + Mask-RCNN + ResNet18

After Submission this work we got score of

0.20548

And this doesn’t introduce an improvement of the Elder Submission Score that got a score of

0.26657

# **Yolov8x + Mask-RCNN + ResNet18**

But to be honest, it’s not a Mask-RCNN problem, as it’s been shown as one of the best segmentation models ever.

The main problem was our lack of resources

- Low images sizes
- Small number of epochs
- It’s a two-stages pipeline, so Yolo and RCNN don’t share the same training signal and this leads to under segmentation problem

# Conclusion

We explored a wide range of architectures throughout the competition. While we may not have achieved the very top results, we gained invaluable experience from the process. Experimenting with different models, evaluating their performance, and comparing outcomes provided us with deep insights into the end-to-end construction of a machine learning project—from researching and conducting EDA, to building architectures, and finally evaluating models.

# Finally

Don’t forget to brush your teeth, to avoid being one of our model’s clients

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