

Pre Processing

- **Standard Size:** Resize images to 640x640 pixels for uniform input.
- **Center Cropping:** Crop to highlight sutures, preserving key features.
- **Aspect Ratio Preservation:** Ensured no distortion during resizing.
- **Batch Size:** Set to 16 for efficient training.
- **Hyperparameter Tuning:** Adjusted learning rate, momentum, and other hyperparameters to optimize model performance.

Labeling Data Sets with Roboflow

Increase Training Data Set Size

15 to 60 images!

How?

- Rotated image 90°
- Added 1% noise to image

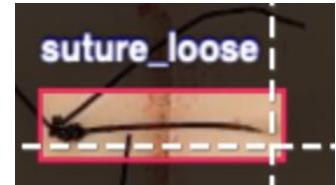
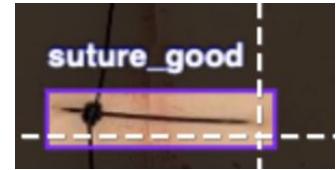
Limited to upload 47 images

Suture Classes:

Suture_good

suture_tight

Suture_loose



Split of original data

- 15 for training
- 2 for validation
- 1 for testing

- Nadia

Training and Validation- Setup

Model training parameters:

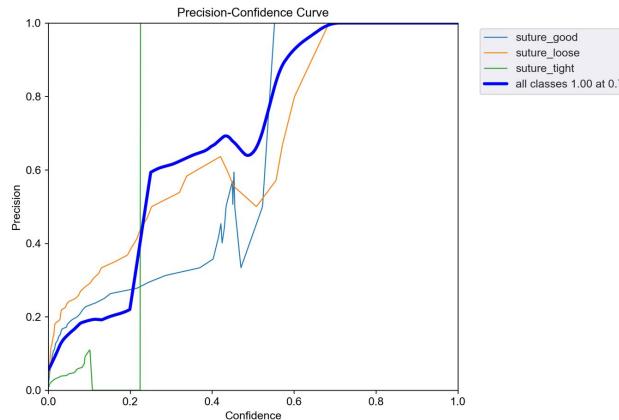
1. Image size- 640 x 640
2. Batch size- 16
3. Epoch- 100

Model Validation & Testing parameters:

1. Image size- 640 x 640
2. Weights obtained from training.

Key Metrics:

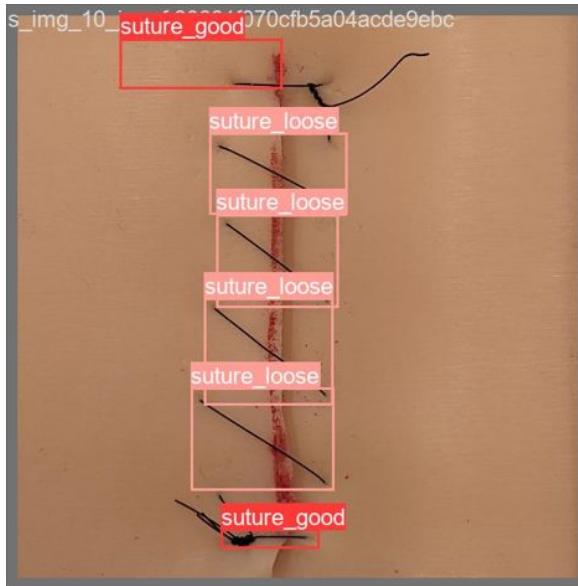
1. Precision: 0.659
2. mAP: 0.473



```
Model summary: 157 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
      Class   Images  Instances       P        R    mAP@50   mAP@95: 100%|██████████| 1/1 [00:00<00:00,  4.63it/s]
      all      2       15     0.659     0.571    0.473    0.304
      suture_good  2       7     0.355     0.714    0.465    0.282
      suture_loose 2       7     0.623     1.000    0.842    0.57
      suture_tight 2       1       1       0.000    0.111    0.0594
```

Training and Validation- Output

Below are the expected output (suture quality) generated by the model.



Feature Understanding - Shakir Ahmed

Domain understanding & application into coding:

- Types of classes (suture, knot, tail).
- Overall scope of work.

Metrics to track:

- Acceptable accuracy, precision, recall and F1 scores.
- Hardware availability and time to train.

Potential challenges & mitigation plan:

- Quality data availability.
- Subjective data labeling.
- Performance optimization (model hyper-parameter tuning).

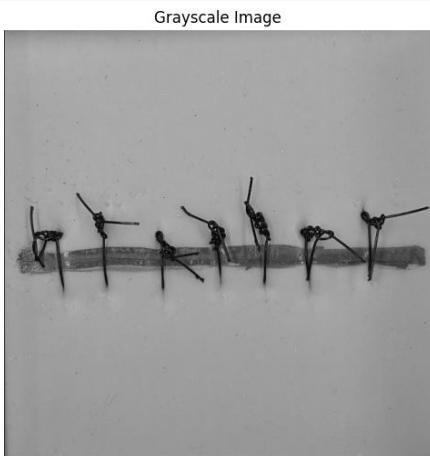
Additional cost involved:

1. Roboflow premium subscription for data labeling.

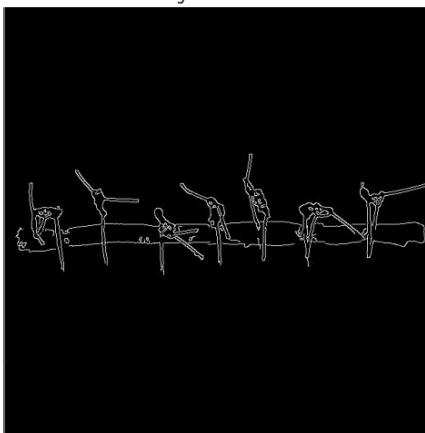
Contours In Image - Surajit Pal

Getting Contours:

- Grayscale Image
- Edges Detected
- Contours on Original Image

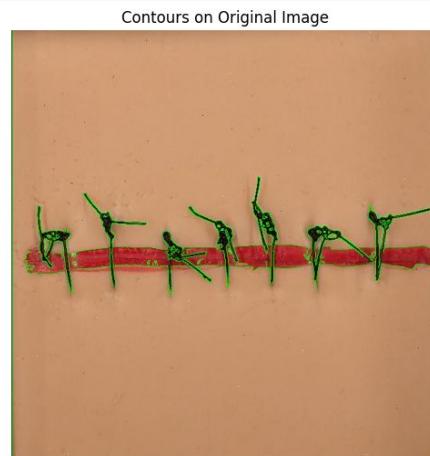


Edges Detected



Potential for Automated Parameter Detection:

- Knot Detection
- Tail Size Measurement
- Suture Placement Quality



The **Edges Detected** image is the most suitable for knot detection.

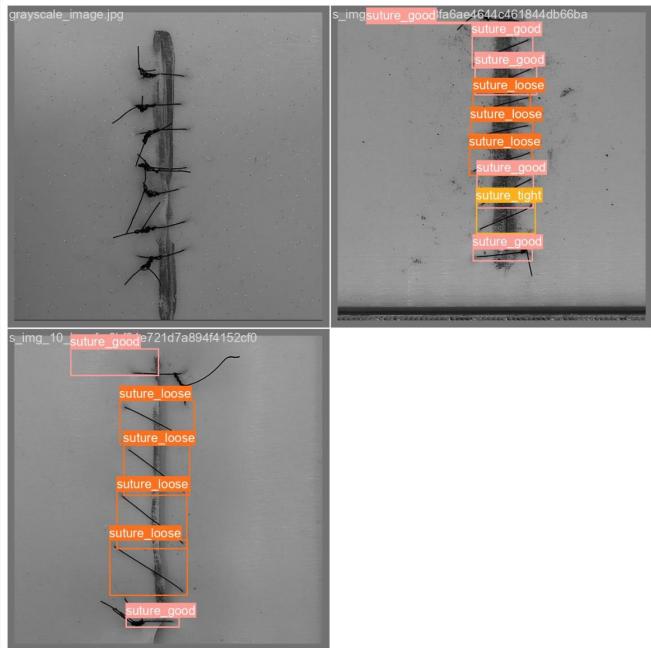
Tails appear as long, extending lines in the **edge-detected** image, also having less noise.

The **contours on the original image** provide the best basis for evaluating the **placement quality** of sutures in terms of alignment, straightness, and consistency of spacing with the wound line.

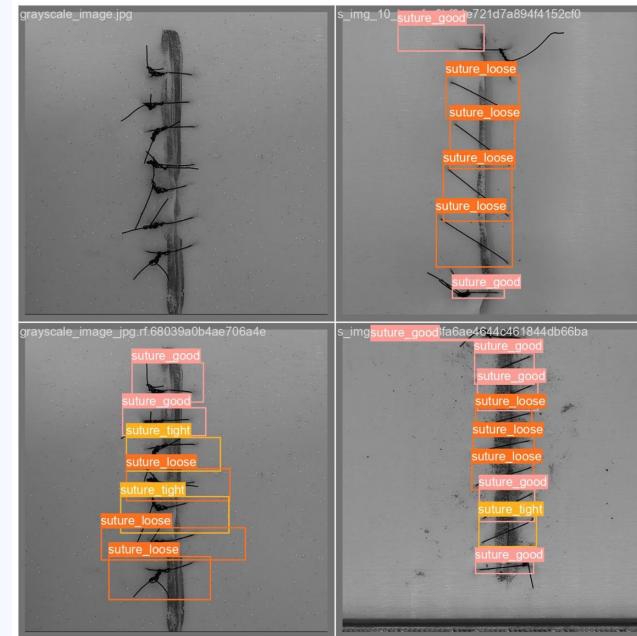
Future work - Maria Nikitha Suresh

- Channel manipulation
- Object padding
- Artifact removal
- Image sharpening

Greyscale Dataset- Surajit

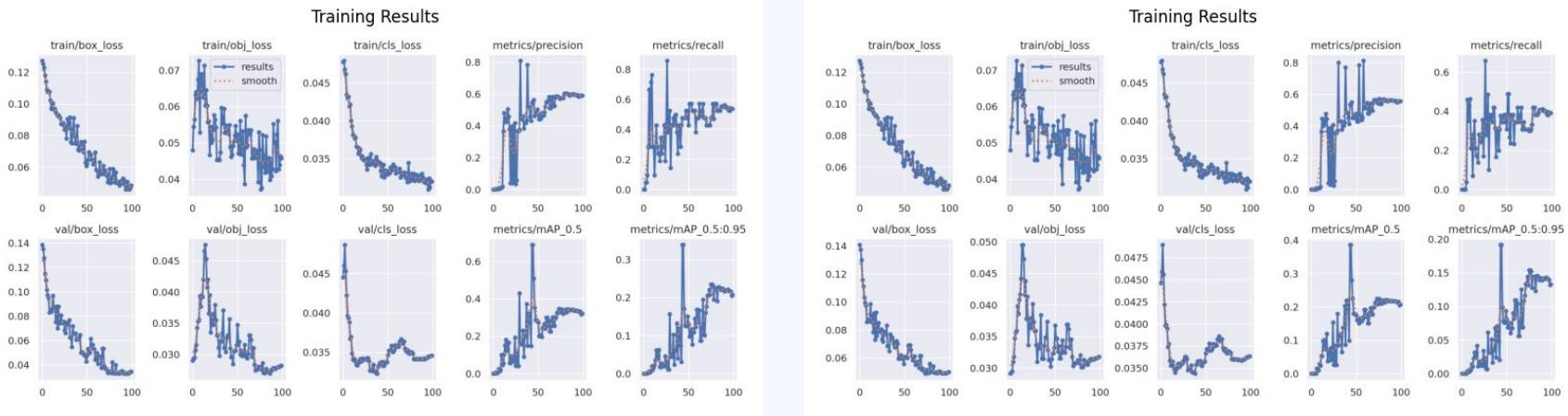


Without Labelling



With Labelling

Performance Metrics

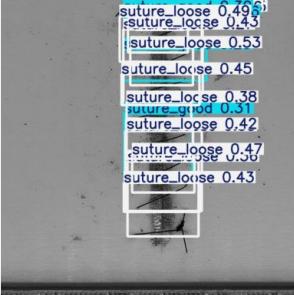


Without Labelling

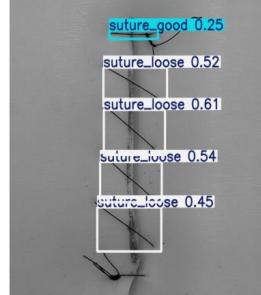
With Labelling

Without Labelling

Detected Sutures: s_img_12.jpg.rf.a8fa6ae4644c461844db66ba74418560.jpg



Detected Sutures: s_img_10.jpg.rf.a6bf94e721d7a894f4152cf0c6904d61.jpg

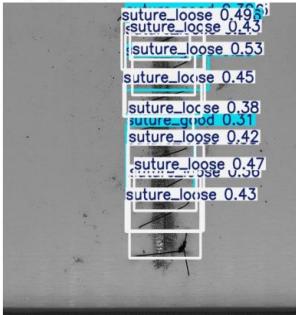


Detected Sutures: grayscale_image.jpg

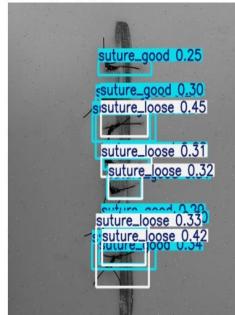


With Labelling

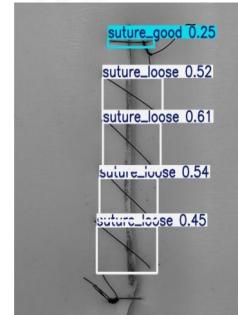
Detected Sutures: s_img_12.jpg.rf.a8fa6ae4644c461844db66ba74418560.jpg



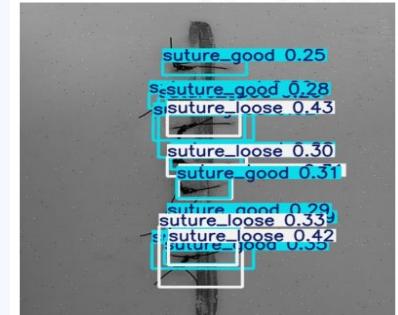
Detected Sutures: grayscale_image.jpg.rf.68039a0b4ae706a4eb95ee51fc50026.jpg



Detected Sutures: s_img_10.jpg.rf.a6bf94e721d7a894f4152cf0c6904d61.jpg



Detected Sutures: grayscale_image.jpg



Model Evaluation- Shakir Ahmed

Model fitting (Training) and validation on new data:

Metrics:

1. Accuracy
2. Precision,
3. Recall
4. F1 Curve

Model accuracy improved by ~ 8% to 10%.

Contributing factor:

Reduction in noise (background) through conversion to grayscaling.

Further segmentation -> Better model output.

Model Evaluation- Shakir Ahmed

Further work:

Pre-Processing:

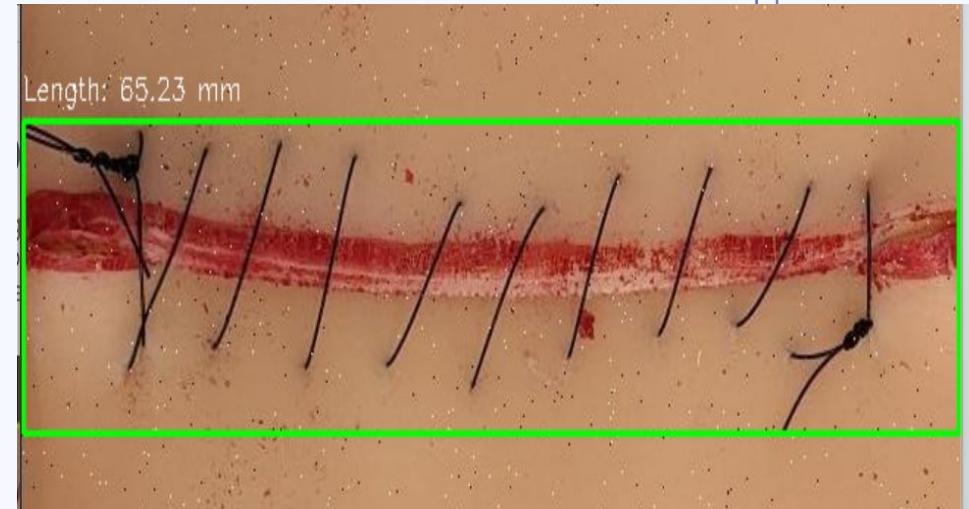
1. Image enhancement.
2. Edge detection.
3. Background removal & training.

Model optimization:

1. NMS for box separation.
2. Hyper-parameter tuning for better classification.
3. Experiment with YOLOv8/v10.

Incision Detection - Maria

- Created bounding boxes
- Performed pre processing
- Calculated Euclidean distance



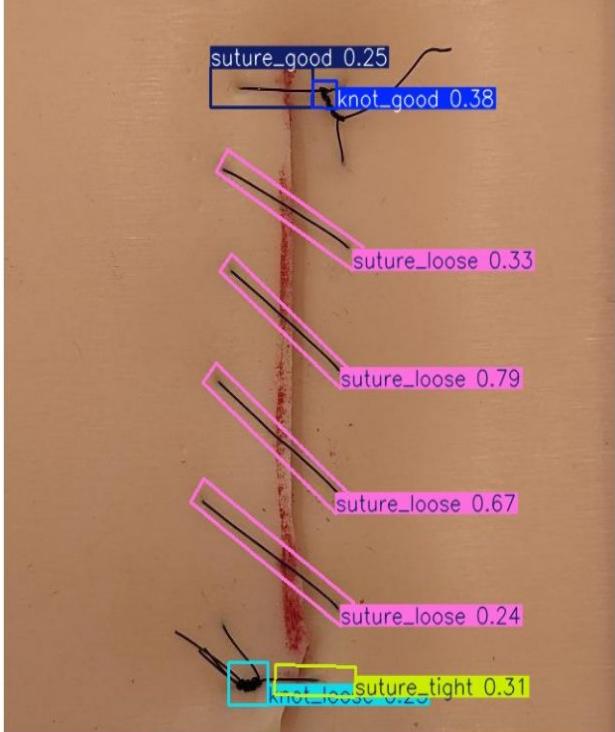
Euclidean Distance and Incision Length- Maria

```
# Calculate the Euclidean distance between the corners of the bounding box
incision_length_pixels = np.sqrt((x2 - x1) ** 2 + (y2 - y1) ** 2)
incision_length_mm = incision_length_pixels / pixel_to_mm_ratio
```

	Image	Euclidean Distance (pixels)	Incision Length (mm)
0	s_img_11.jpg.rf.2303a02f32e1f6a18e7c6bd147719d...	612.582239	61.258224
1	s_img_11.jpg.rf.8bb197a77afe80799ef51d3759a4d8...	642.572953	64.257295
2	s_img_11.jpg.rf.9bb99bf9e48a3fe6e29f2587485628...	614.232041	61.423204
3	s_img_13.jpg.rf.216892e177adc65793194b3f892ebe...	624.580659	62.458066
4	s_img_13.jpg.rf.2365a1b02be104fc3344d8b3e5181b...	625.002400	62.500240
5	s_img_13.jpg.rf.f3d22e9d9368527ec4e1d0c799d47d...	565.894867	56.589487
6	s_img_14.jpg.rf.cc8cbfee61791d7121f433c7fa6d44...	623.388322	62.338832
7	s_img_14.jpg.rf.d15c95bcb996a63376a447907864cf...	623.616870	62.361687
8	s_img_14.jpg.rf.e43e160c7c61b274ae4cd49222c41b...	629.174062	62.917406
9	s_img_15.jpg.rf.54402d7cb5da8d39a4a07f095fd2f5...	602.176884	60.217688

Length of each Stitch of Uninterrupted Suture (Colored) -

Detected Sutures: s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg



Step 1: Convert Normalized Coordinates to Pixel Coordinates

Assume the image resolution is 640 x 640 pixels.

To convert the normalized coordinates to pixel coordinates:

$$\text{Pixel X} = \text{Normalized X} \times 640$$

$$\text{Pixel Y} = \text{Normalized Y} \times 640$$

Now, let's compute:

1. Point 1:
 $(0.338262 \times 640, 0.0935093 \times 640) = (216.48, 59.85)$
2. Point 2:
 $(0.338432 \times 640, 0.147567 \times 640) = (216.60, 94.44)$
3. Point 3:
 $(0.506153 \times 640, 0.147038 \times 640) = (324.00, 94.10)$
4. Point 4:
 $(0.505983 \times 640, 0.0929807 \times 640) = (323.83, 59.51)$

Step 2: Calculate Euclidean Distance

Let's pick Point 1 and Point 3 for the Euclidean distance calculation:

$$\text{Point 1} = (216.48, 59.85)$$

$$\text{Point 3} = (324.00, 94.10)$$

Using the Euclidean distance formula:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$d = \sqrt{(324.00 - 216.48)^2 + (94.10 - 59.85)^2}$$

$$d = \sqrt{107.52^2 + 34.25^2}$$

$$d = \sqrt{11556.57 + 1173.06} = \sqrt{12729.63} \approx 112.91 \text{ pixels}$$

Step 3: Convert Pixels to mm

Using the 17.5 pixels per mm ratio:

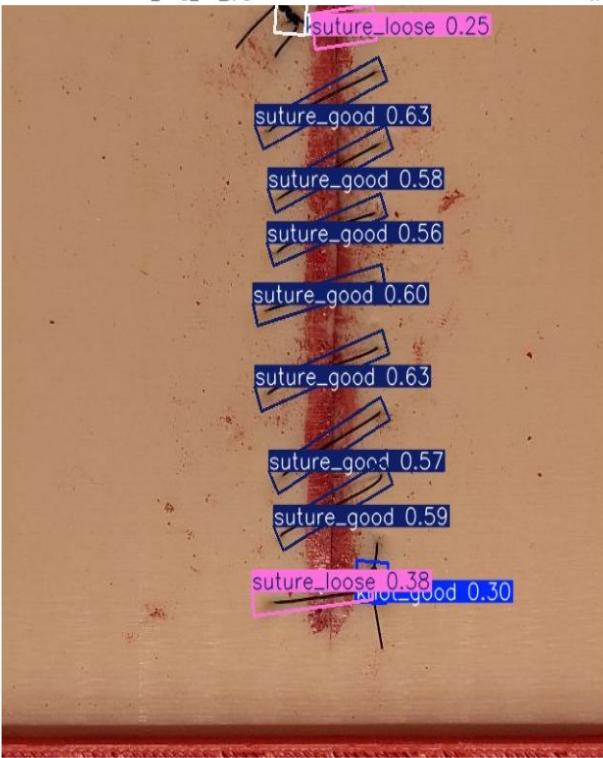
$$\text{Distance in mm} = \frac{112.91}{17.5}$$

$$\text{Distance in mm} \approx 6.45 \text{ mm}$$

Image Name	Class Name	Confidence	Length (Pixels)	Length (mm)	Cropped Image
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_good	0.25	112.78	6.44	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.33	167.49	9.57	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.79	163.20	9.32	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.67	181.39	10.36	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.24	192.01	10.97	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_tight	0.31	88.05	5.03	

Length of each Stitch of Uninterrupted Suture (Colored) -

Detected Sutures: s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg



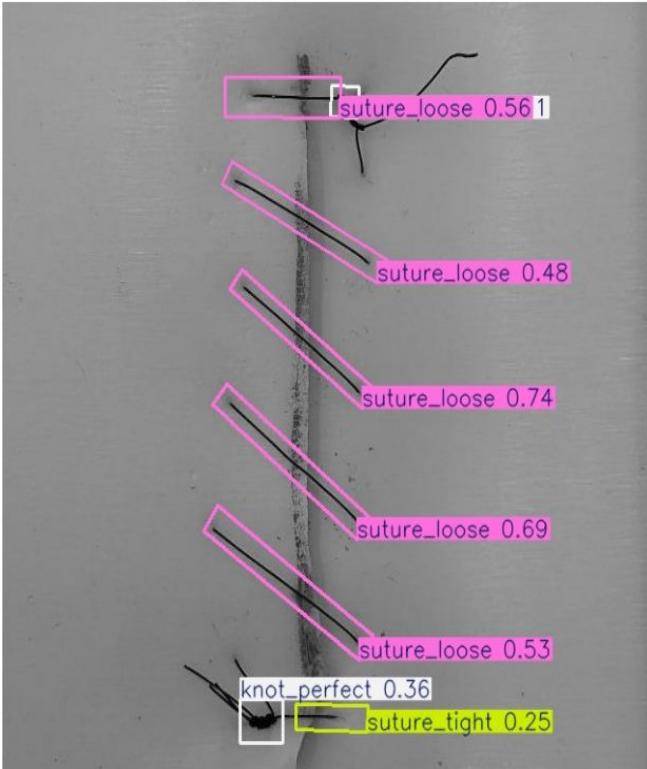
```
1 # Define the image directory and prediction parameters
2 source = "/content/drive/MyDrive/Suture_Analysis.v6i.yolov8-obb/valid/images"
3 results_color = model_color.predict(
4     source=source,
5     save=True,
6     save_txt=True,
7     save_conf=True,
8     conf=0.21,
9     iou=0.2,
10    imgsz=640,
11    agnostic_nms=True, # NMS across all classes
12    project="run-detect",
13    name="exp",
14    exist_ok=True
15 )
```

- ❖ Multiple Detection Bounding boxes issue resolved using "agnostic_nms" (Non Maximum Suppression) parameter while prediction.
- ❖ "iou" (Intersection over Union) parameter kept to give optimum threshold.

Image Name	Class Name	Confidence	Length (Pixels)	Length (mm)	Cropped Image
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_loose	0.25	72.36	4.13	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.63	144.81	8.27	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.58	137.02	7.83	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.56	128.62	7.35	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.60	140.76	8.04	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.63	145.30	8.30	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.57	134.87	7.70	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.59	130.96	7.48	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_loose	0.38	128.51	7.34	

Length of each Stitch of Uninterrupted Suture (Grayscale) -

Detected Sutures: s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg



- ❖ Varied Length of stitch as per detection done with grayscale images.
- ❖ Need more precision with preprocessing to get exact accurate pixel length which can give the length in mm.

Image Name	Class Name	Confidence	Length (Pixels)	Length (mm)	Cropped Image
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.56	118.53	6.77	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.48	175.28	10.01	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.74	164.86	9.42	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.69	182.59	10.43	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_loose	0.53	188.70	10.78	
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738.jpg	suture_tight	0.25	73.87	4.22	

Length of each Stitch of Uninterrupted Suture (Grayscale) -

Detected Sutures: s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg

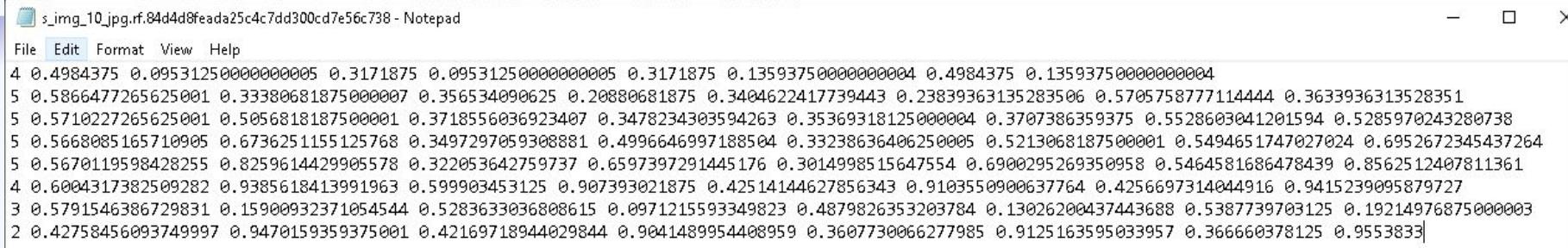


- ❖ Will experiment with Contour and Edges detect images.
- ❖ Distance from knot to incision line calculation to be done next.

Image Name	Class Name	Confidence	Length (Pixels)	Length (mm)	Cropped Image
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_loose	0.23	92.14	5.26	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.64	145.30	8.30	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.56	142.49	8.14	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.56	133.90	7.65	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.70	139.45	7.97	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.71	146.83	8.39	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.63	140.11	8.00	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.48	139.16	7.95	
s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg	suture_good	0.32	123.42	7.05	

Angle Detection- Shakir Ahmed

- Parametric extraction



```
s_img_10.jpg.rf.84d4d8feada25c4c7dd300cd7e56c738 - Notepad
File Edit Format View Help
4 0.4984375 0.0953125000000005 0.3171875 0.0953125000000005 0.3171875 0.1359375000000004 0.4984375 0.1359375000000004
5 0.5866477265625001 0.3338068187500007 0.356534090625 0.20880681875 0.3404622417739443 0.23839363135283506 0.5705758777114444 0.3633936313528351
5 0.5710227265625001 0.5056818187500001 0.3718556036923407 0.3478234303594263 0.3536931812500004 0.3707386359375 0.5528603041201594 0.5285970243280738
5 0.5668085165710905 0.6736251155125768 0.3497297059308881 0.4996646997188504 0.33238636406250005 0.5213068187500001 0.5494651747027024 0.6952672345437264
5 0.5670119598428255 0.8259614429905578 0.322053642759737 0.6597397291445176 0.3014998515647554 0.6900295269350958 0.5464581686478439 0.8562512407811361
4 0.6004317382509282 0.9385618413991963 0.599903453125 0.907393021875 0.42514144627856343 0.9103550900637764 0.4256697314044916 0.9415239095879727
3 0.5791546386729831 0.15900932371054544 0.5283633036808615 0.0971215593349823 0.4879826353203784 0.13026200437443688 0.5387739703125 0.19214976875000003
2 0.42758456093749997 0.9470159359375001 0.42169718944029844 0.9041489954408959 0.3607730066277985 0.9125163595033957 0.366660378125 0.9553833|
```

- Angle calculation using Arccos() function:

angle=arccos[(v1 · v2) | (\| v1 \| \| v2 \|)]

Stitch Distance- Shakir Ahmed

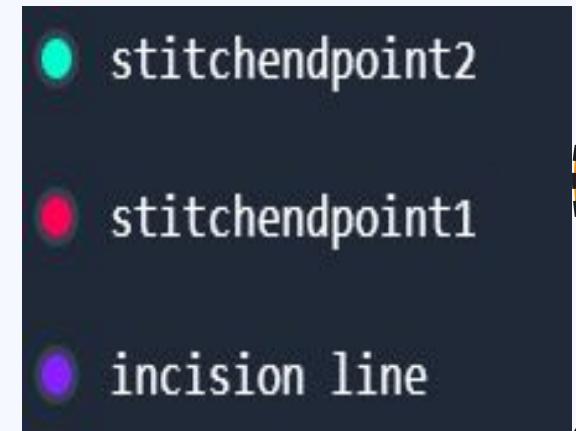
Detected Sutures: s_img_12.jpg.rf.9e6eefdcc679f774be4f872b93e27bba.jpg



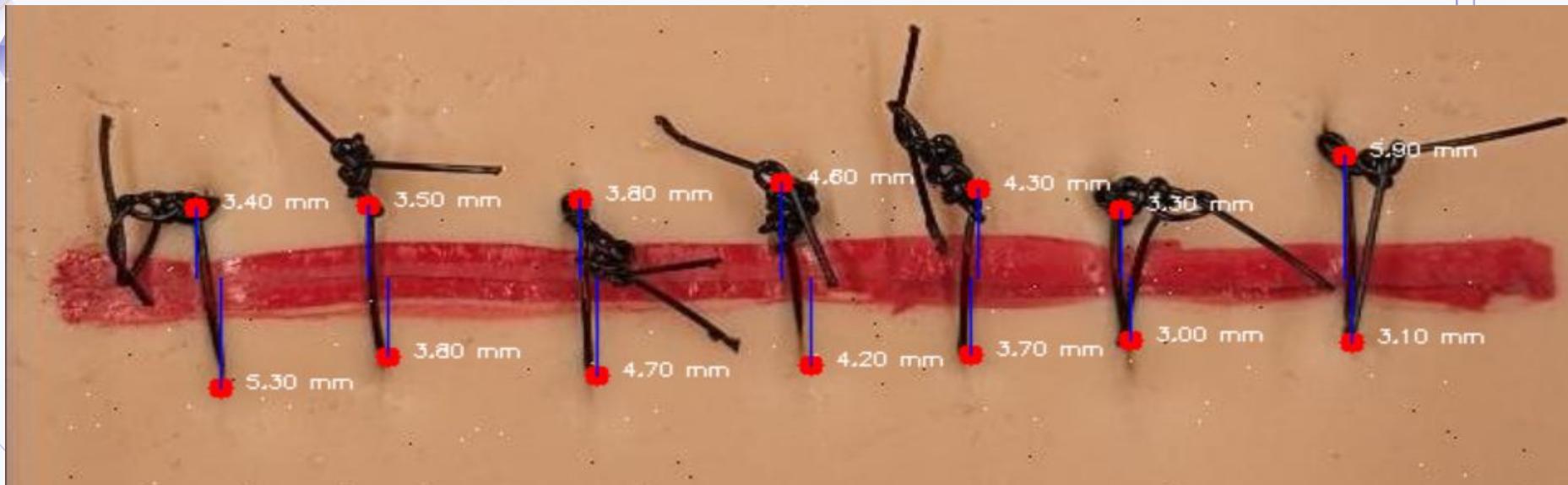
- Euclidean distance (post pixel normalization):
$$\text{distance} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Stitch Length Detection - Maria

- Incision line and stitch endpoints detection
- Vector projection: Find the closest point on the incision line.
- Perpendicular distance: Calculated using Euclidean distance.

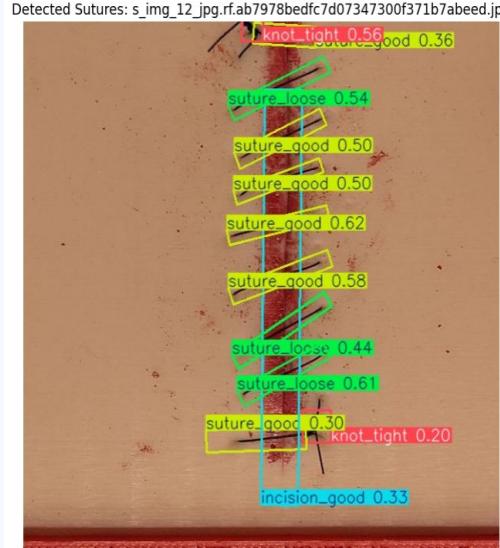


Stitch Length Detection - Maria



Knot to Incision Distance (Colored)- Surajit

- ❖ Manual Labeling: Incision lines are manually labeled in Roboflow.
- ❖ Distance Calculation: Euclidean distance is measured by drawing a perpendicular from knot to incision.
- ❖ Fallback: If the incision line is missing, the average x-coordinate of sutures approximates the incision position.



Suture Image - s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg

Suture Length

Image Name	Class Name	Confidence	Length of Suture (Pixels)	Length of Suture (mm)	Cropped Image
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.36	87.93	5.02	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.54	142.5	8.14	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.50	128.48	7.34	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.50	123.35	7.05	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.62	138.45	7.91	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.58	142.29	8.13	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.44	146.69	8.38	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.61	130.66	7.46	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.30	136.96	7.82	

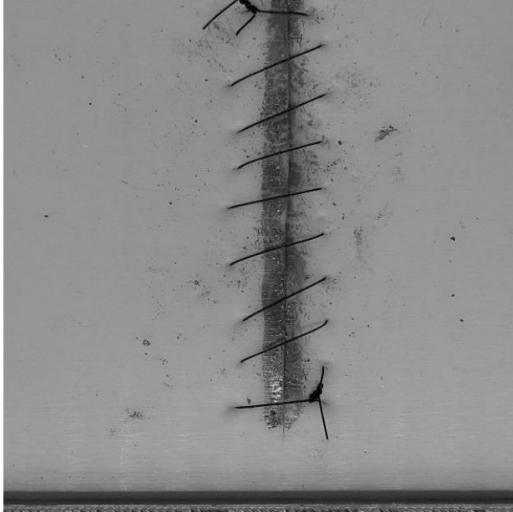
Knot-to-Incision Distance

Image Name	Class Name	Confidence	Length B/W Knot to Incision (Pixels)	Length B/W Knot to Incision (mm)
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	knot_tight	0.56	38.95	2.23
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	knot_tight	0.20	47.31	2.7

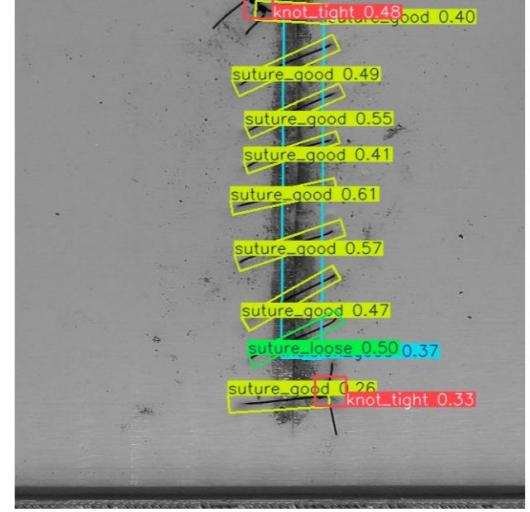
Knot to Incision Distance (Grayscale)

- ❖ Grayscale incision line detection better than colored images.
- ❖ Knot detection also better
- ❖ Difference in distance as compared to Colored images.

Validation Image: s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg



Detected Sutures: s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg



Suture Image - s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg

Suture Length

Image Name	Class Name	Confidence	Length of Suture (Pixels)	Length of Suture (mm)	Cropped Image
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.40	94.22	5.38	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.49	140.53	8.03	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.55	131.39	7.51	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.41	122.18	6.98	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.61	134.57	7.69	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.57	141.63	8.09	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.47	132.38	7.56	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_loose	0.50	126.36	7.22	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.26	127.61	7.29	

Knot-to-Incision Distance

Image Name	Class Name	Confidence	Length B/W Knot to Incision (Pixels)	Length B/W Knot to Incision (mm)
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	knot_tight	0.48	55.04	3.14
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	knot_tight	0.33	34.79	1.99

Knot to Incision Distance (Contours) · Sutures

- ❖ Contours “STAR” of the show with good incision detection.
- ❖ Pretty happy with Knot detections also.
- ❖ Overall Distance accuracy improved.
- ❖ In par with the measurement standards.



Suture Image - s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg

Suture Length

Image Name	Class Name	Confidence	Length of Suture (Pixels)	Length of Suture (mm)	Cropped Image
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.30	93.88	5.36	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_loose	0.61	144.34	8.25	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_loose	0.61	132.2	7.55	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.39	125.13	7.15	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.59	136.56	7.8	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.51	135.42	7.74	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_loose	0.66	127.21	7.27	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_loose	0.62	126.7	7.24	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	suture_good	0.23	134.58	7.69	

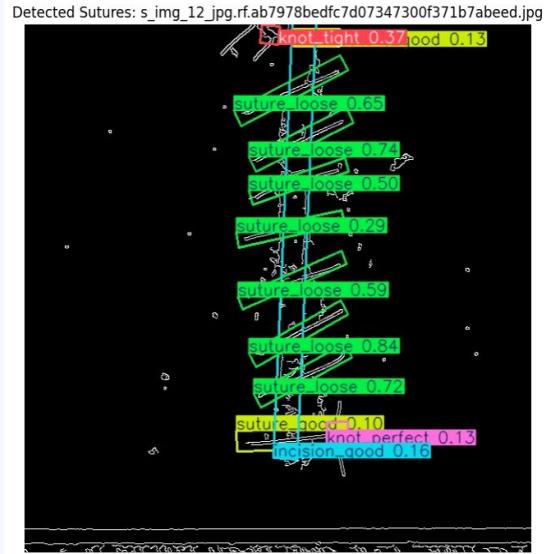
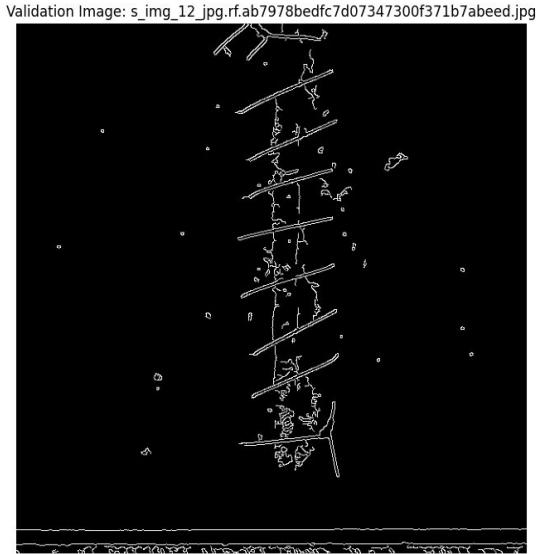
Knot-to-Incision Distance

Image Name	Class Name	Confidence	Length B/W Knot to Incision (Pixels)	Length B/W Knot to Incision (mm)
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	knot_tight	0.56	52.33	2.99
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeeed.jpg	knot_perfect	0.42	33.57	1.92

Knot to Incision Distance (Edge)

Surajit

- ❖ A little disappointment with Edge Detection.
- ❖ Knots detected better with Contours.
- ❖ As expected Edges not good with Suture and Incision line detections.
- ❖ Contours will be my first choice going forward for preprocessing.
- ❖ To work on Tail length for next week.



Suture Image - s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg

Suture Length

Image Name	Class Name	Confidence	Length of Suture (Pixels)	Length of Suture (mm)	Cropped Image
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.13	62.48	3.57	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.65	152.43	8.71	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.74	138.4	7.91	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.50	128.48	7.34	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.29	137.88	7.88	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.59	143.11	8.18	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.84	134.09	7.66	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_loose	0.72	131.45	7.51	
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	suture_good	0.10	128.89	7.36	

Knot-to-Incision Distance

Image Name	Class Name	Confidence	Length B/W Knot to Incision (Pixels)	Length B/W Knot to Incision (mm)
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	knot_tight	0.37	31.92	1.82
s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg	knot_perfect	0.13	52.87	3.02

Distance between sutures- Shakir Ahmed

Approach:

- ❖ Mask using custom line (2 pixel).
- ❖ Draw hough line transform lines with custom parameters for drawing lines.
- ❖ Detect coverage percentage, and then scale to 100% for final pixel to mm conversion.
- ❖ Calculate euclidean distance (in px) and convert to mm using conversion above)

```
# Create a mask for a 2-pixel wide line along the detected suture
line_thickness = 2
mask = np.zeros_like(gray)
cv2.line(mask, (x1, y1), (x2, y2), 255, line_thickness)
```

Average estimated suture width: 5.87 pixels
Average coverage ratio: 34.16%

```
# Detect lines using probabilistic Hough Line Transform with optimized parameters
lines = cv2.HoughLinesP(edges, 1, np.pi / 180, threshold=50, minLineLength=20, maxLineGap=5)
```

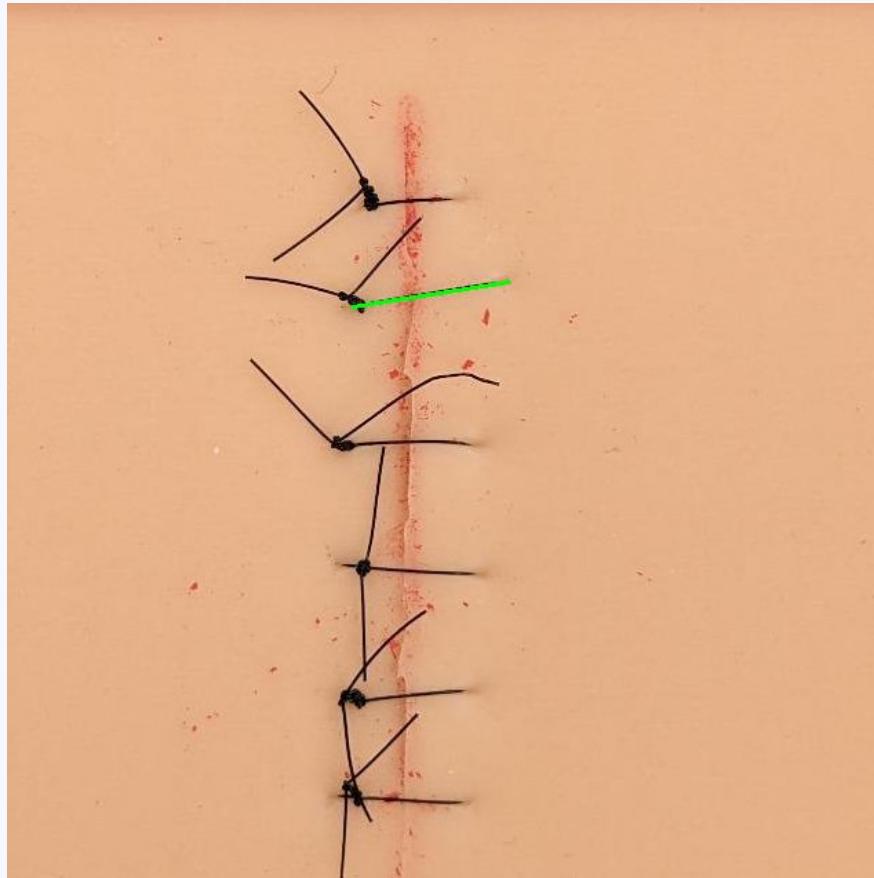
Distance between sutures- Shakir Ahmed (Approach 1)



- ❖ Output from approach 1 gives coverage and pixel to mm conversion.

Average estimated suture width: 5.87 pixels
Average coverage ratio: 34.16%

Distance between sutures- Shakir Ahmed (Approach 2)



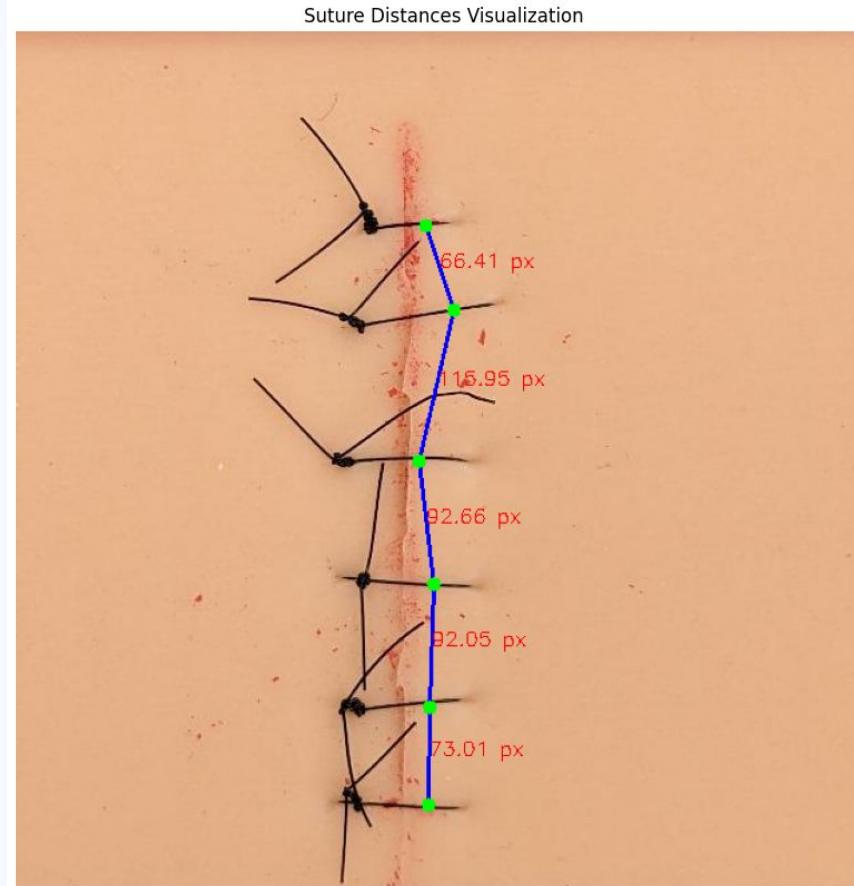
- ❖ Output from approach 2 gives coverage and pixel to mm conversion.

Estimated suture width: 5.98 pixels based on 33.43% coverage

Distance between sutures- Shakir Ahmed

Distance formula (Euclidean px):

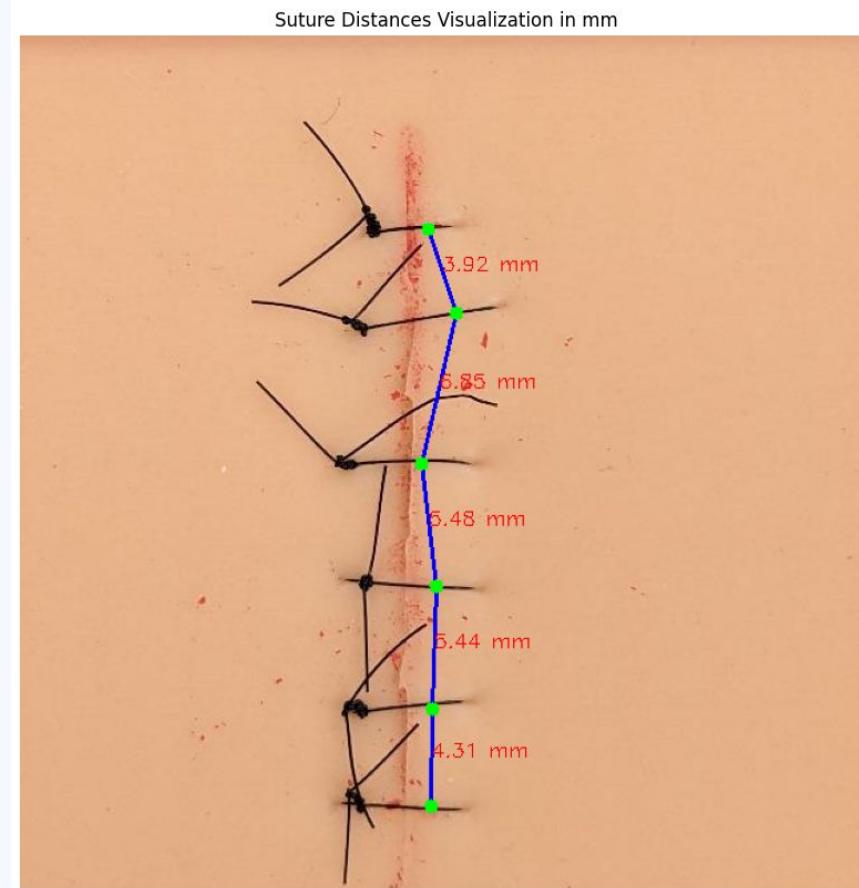
- ❖ From the label file, we obtained centers, width and height of the bounding boxes.
- ❖ Euclidean distance is calculated (in px).
- ❖ Figure shows the px distance between centers.



Distance between sutures- Shakir Ahmed

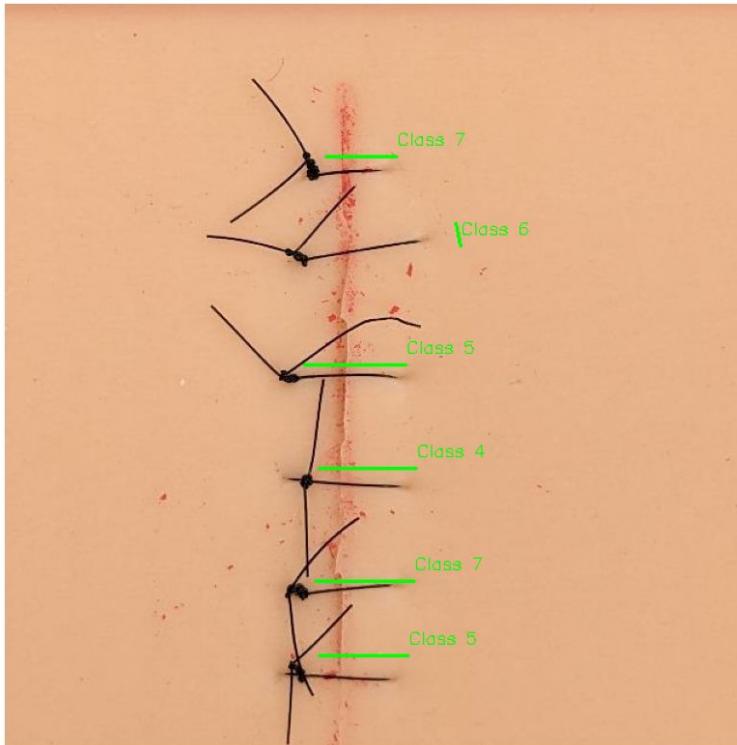
Final mm distance (metric system):

- ❖ After applying px to mm conversion, we get the final measurements.
- ❖ Pros- Works across images, irrespective of zoom / scaling.



Angle of stitch- Shakir Ahmed

- ❖ Orientation of bounding boxes are not captured in label file. Hence, box's orientation is not captured.
- ❖ Experimented with class extraction and tanh angle capturing.



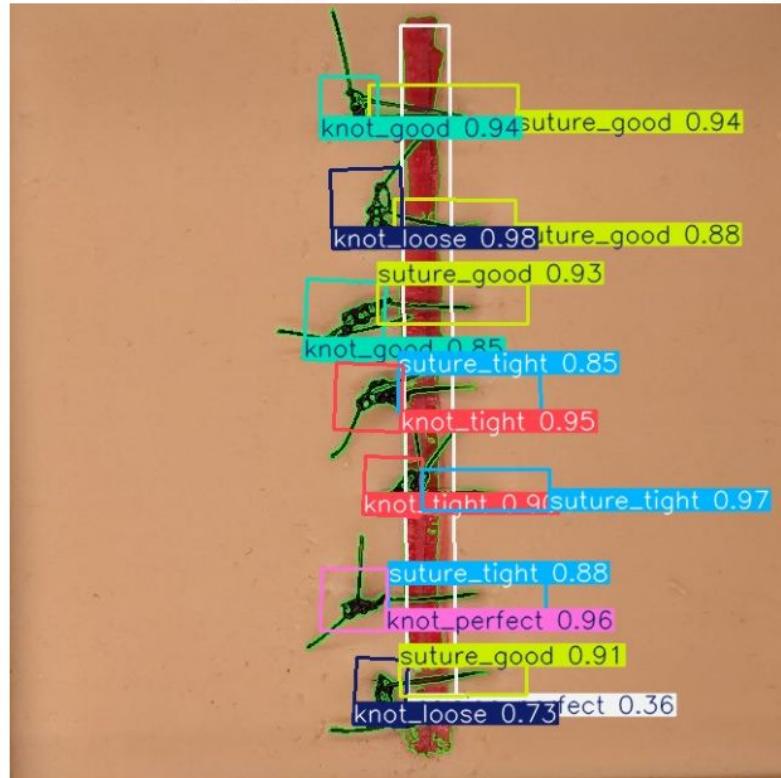
```
Suture 1 (Class 7): Angle to vertical = 90.00 degrees  
Suture 2 (Class 5): Angle to vertical = 90.00 degrees  
Suture 3 (Class 4): Angle to vertical = 90.00 degrees  
Suture 4 (Class 7): Angle to vertical = 90.00 degrees  
Suture 5 (Class 5): Angle to vertical = 90.00 degrees  
Suture 6 (Class 6): Angle to vertical = 189.15 degrees
```

Angle of stitch- Shakir Ahmed

- ❖ Current methods failing due to orientation of bounding boxes (90 degree).
- ❖ Need to further deep dive into parametric extraction and using custom line drawing over sutures.
- ❖ Further exploration of available methods to find orientation of suture.

Hyperparameter Tuning - Interrupted Suture - Surajit

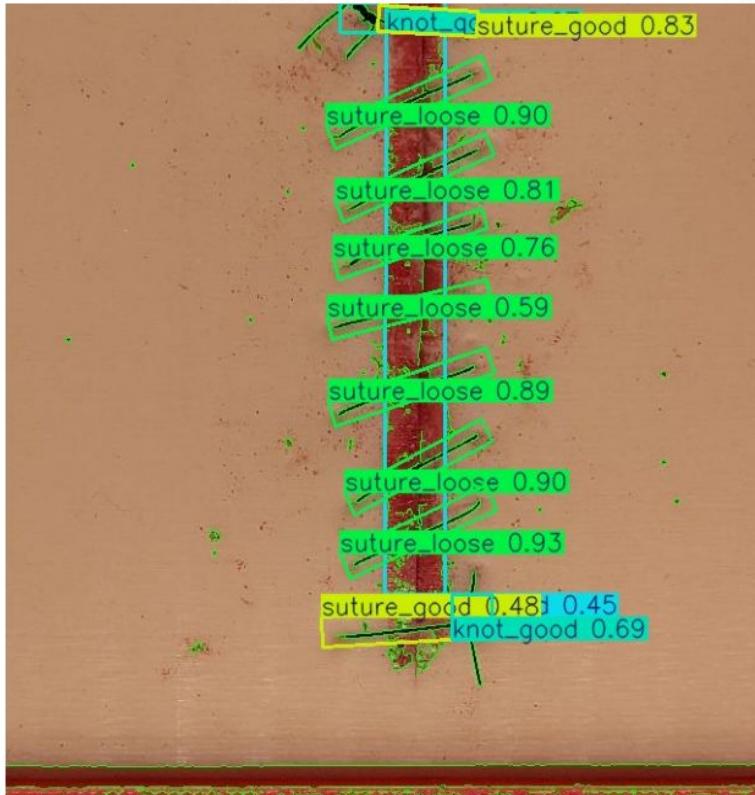
Detected Sutures: s_img_11.jpg.rf.a26c5f104e843ca6b946dd216caa5155.jpg



- Using hyperparameters we are getting confidence more than 50% till 98 %.
- All the classes are detected and confidence for sutures are more than 85%
- Knot detection is very much accurate.

Hyperparameter Tuning - Uninterrupted Suture - Surajit

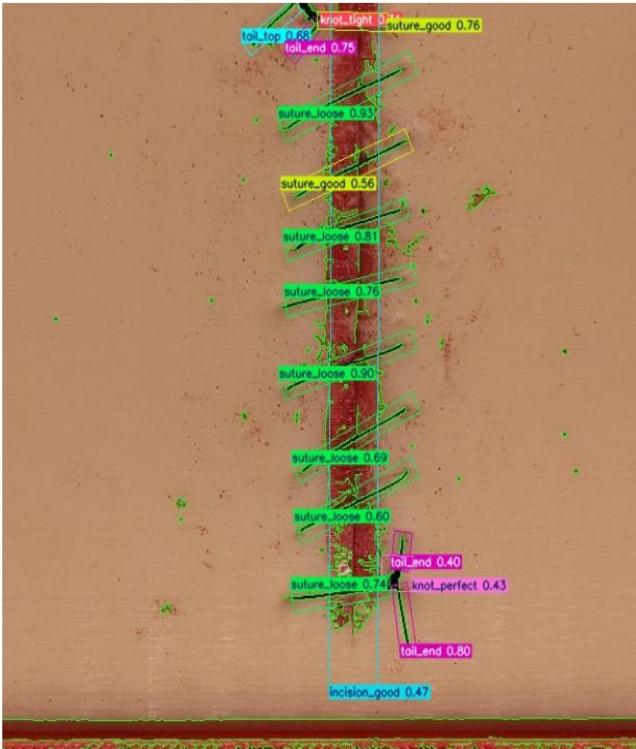
Detected Sutures: s_img_12.jpg.rf.ab7978bedfc7d07347300f371b7abeed.jpg



- The detections have improved really well with hyperparameter tuning.
- Even Incision line confidence has increased.
- We can still keep on tweaking parameters and take more examples of images in validation set to get the results.

Tail Length - Uninterrupted Suture - Suturist

Detected Sutures: s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg



→ Tail length detection seems to vary

→ Tail length distance as per the standards

Suture Image - s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg

Suture Length				
Image Name	Class Name	Confidence	Length of Suture (Pixels)	Length of Suture (mm)
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_good	0.78	70.96	4.05
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.83	144.49	8.25
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_good	0.56	134.54	7.69
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.81	128.24	7.33
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.78	132.0	7.54
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.90	139.48	7.97
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.69	135.4	7.74
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.60	130.28	7.44
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	suture_loose	0.74	99.88	5.71

Knot-to-Incision Distance

Knot-to-Incision Distance				
Image Name	Class Name	Confidence	Length B/W Knot to Incision (Pixels)	Length B/W Knot to Incision (mm)
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	knot_light	0.31	45.41	2.59
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	knot_perfect	0.43	42.63	2.44

Tail Top Length

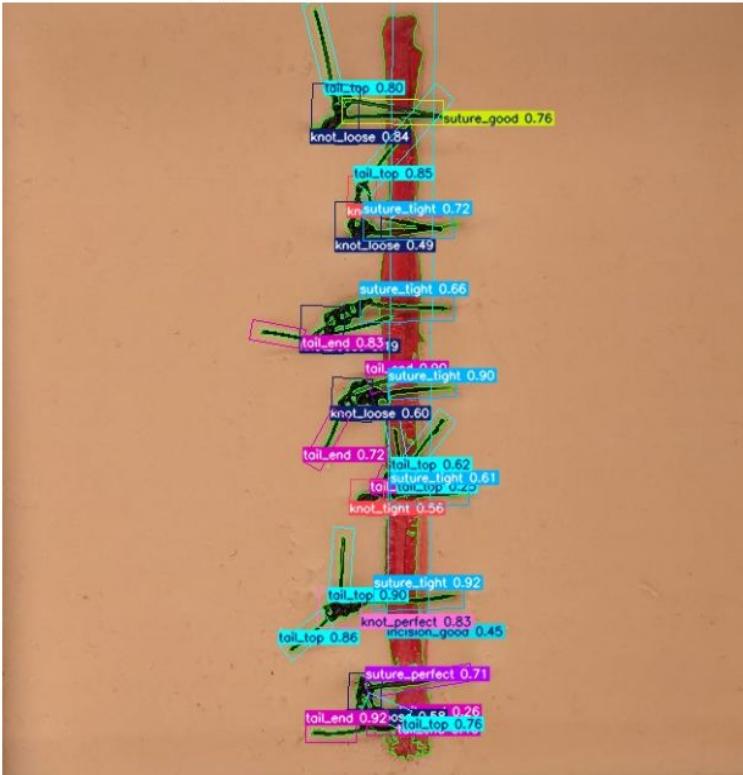
Tail Top Length				
Image Name	Class Name	Confidence	Length of Tail Top (Pixels)	Length of Tail Top (mm)
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	tail_top	0.68	66.13	3.78

Tail End Length

Tail End Length				
Image Name	Class Name	Confidence	Length of Tail End (Pixels)	Length of Tail End (mm)
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	tail_end	0.75	44.33	2.53
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	tail_end	0.40	36.77	2.1
s_img_12.jpg.rf.564c6d9ebd00c943a29d155c125986e3.jpg	tail_end	0.80	63.7	3.64

Tail Length - Interrupted Suture -

Detected Sutures: s_img_11.jpg.rf.077fdd1f27099448e7b660095f19568e.jpg



- Few Tail ends not detected
- Tail length distance as per the standards

Suture Image - s_img_6.jpg.rf.fde18c265d72d2a35402c10d8c019e58.jpg

Suture Length				
Image Name	Class Name	Confidence	Length of Suture (Pixels)	Length of Suture (mm)
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_good	0.46	33.25	5.56
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_loose	0.48	68.77	11.45
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_loose	0.42	63.76	10.95
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_loose	0.44	88.81	15.11
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_loose	0.46	72.25	12.05
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_loose	0.82	71.57	12.06
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	suture_loose	0.87	86.13	14.82

Knot-to-Incision Distance

Knot-to-Incision Distance				
Image Name	Class Name	Confidence	Length B/W Knot to Incision (Pixels)	Length B/W Knot to Incision (mm)
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	knot_tight	0.63	19.23	3.27
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	knot_tight	0.47	13.73	2.20
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	knot_tight	0.57	43.86	7.20
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	knot_tight	0.69	82.1	13.52
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	knot_tight	0.52	38.72	6.38
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	knot_perfect	0.77	68.62	11.31

Tail Top Length

Tail Top Length				
Image Name	Class Name	Confidence	Length of Tail Top (Pixels)	Length of Tail Top (mm)
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.79	100.71	16.8
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.86	95.94	15.88
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.76	88.07	14.00
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.96	144.8	23.4
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.68	101.21	16.79
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.82	75.46	12.31
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.38	43.52	7.28
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_top	0.58	75.24	12.01

Tail End Length

Tail End Length				
Image Name	Class Name	Confidence	Length of Tail End (Pixels)	Length of Tail End (mm)
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_end	0.94	17.48	2.14
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_end	0.96	27.29	3.56
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_end	0.90	55.45	7.14
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_end	0.37	76.15	10.22
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_end	0.76	101.14	13.78
s_img_6.jpg/r/1e1fc265d72d2a35402c10d8c019e58.jpg	tl_end	0.94	103.39	13.20

Using scale in input images

Train Processed Images



- Cropping the original image with the scale.
- Using Roboflow to Label the scale to get unique pixel distance.
- Every image will be having a unique pixel to mm ratio.
- Task for next week.

Distance between sutures- Shakir Ahmed

Approach:

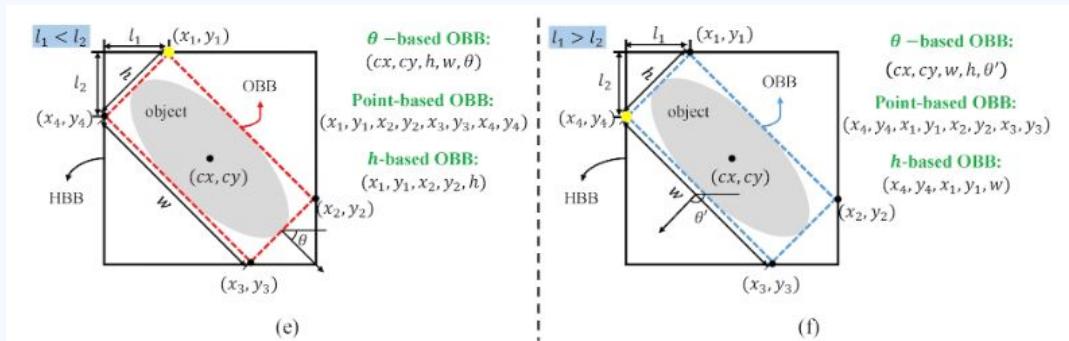
- ❖ Mask using custom line (2 px).
- ❖ Draw hough line transform lines with custom parameters for drawing lines.
- ❖ Detect coverage percentage, and then scale to 100% for final pixel to mm conversion.
- ❖ Calculate euclidean distance (in px) and convert to mm using conversion above)
- ❖ Improving accuracy of scaling.

```
# Create a mask for a 2-pixel wide line along the detected suture
line_thickness = 2
mask = np.zeros_like(gray)
cv2.line(mask, (x1, y1), (x2, y2), 255, line_thickness)
```

```
# Detect lines using probabilistic Hough Line Transform with optimized parameters
lines = cv2.HoughLinesP(edges, 1, np.pi / 180, threshold=50, minLineLength=20, maxLineGap=5)
```

Suture Angle (Update)- Shakir Ahmed

- ❖ Coordinates from OBB YOLO v8 can be extracted.
- ❖ Shift from center orientation to edge orientation.
- ❖ Format - [`<class> <x1> <x2> <x3> <x4>`]
- ❖ Tanh function between 2 points (x_1 and x_2) presents the angle of orientation.



Enhancements for Incision Detection and Stitch Length Detection - Maria

- Labelled more images
- Fixed vertical line detection

Training Improvements - Current

- Implemented necessary code modifications for enhanced results.
- Working on using hyperparameters to improve accuracy.