NON MACHINE LEARNING NAILFOLD CAPILLARY DETECTION AND COUNTING METHOD

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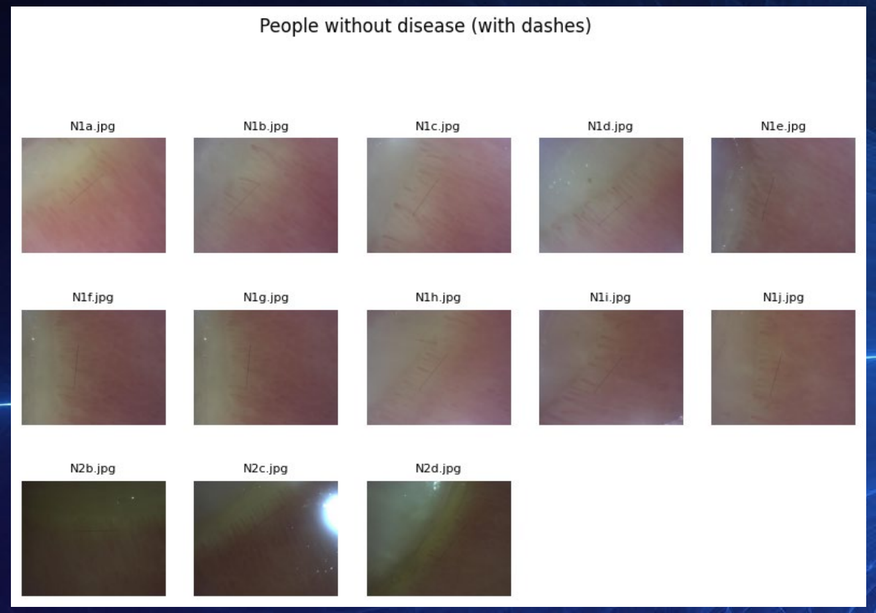
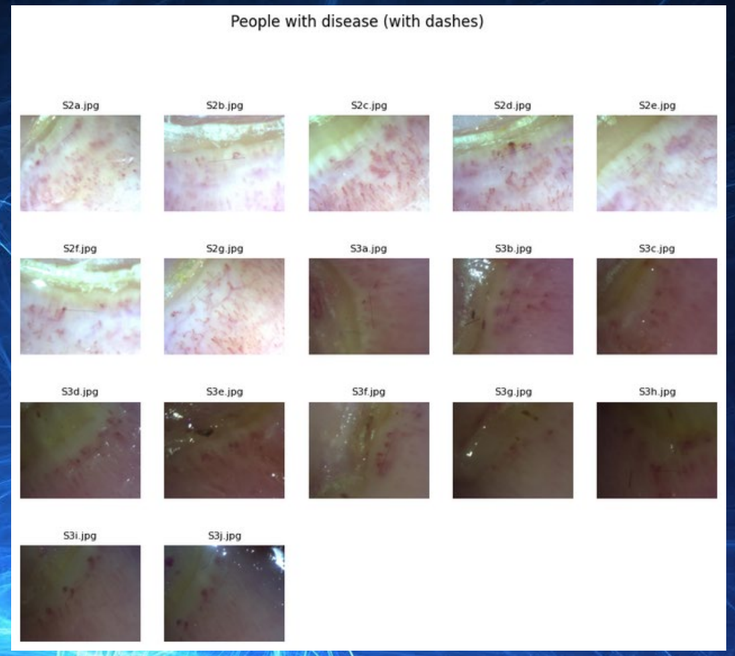
1. AIM

WE PROPOSE AND IMPLEMENT A METHOD FOR COUNTING THE NUMBER OF CAPILLARIES IN IMAGES. THE METHOD INVOLVES SEVERAL STEPS, INCLUDING REGION OF INTEREST (ROI) DETECTION, IMAGE ENHANCEMENT, AND CAPILLARY DETECTION.

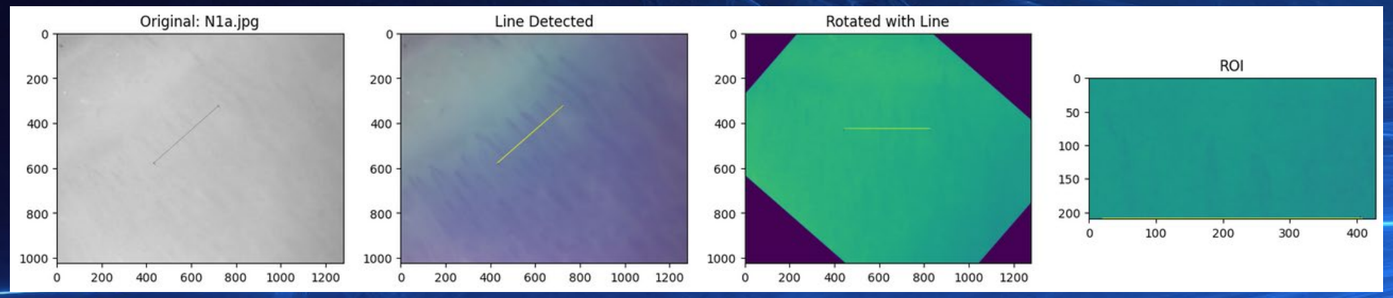
2. DATA

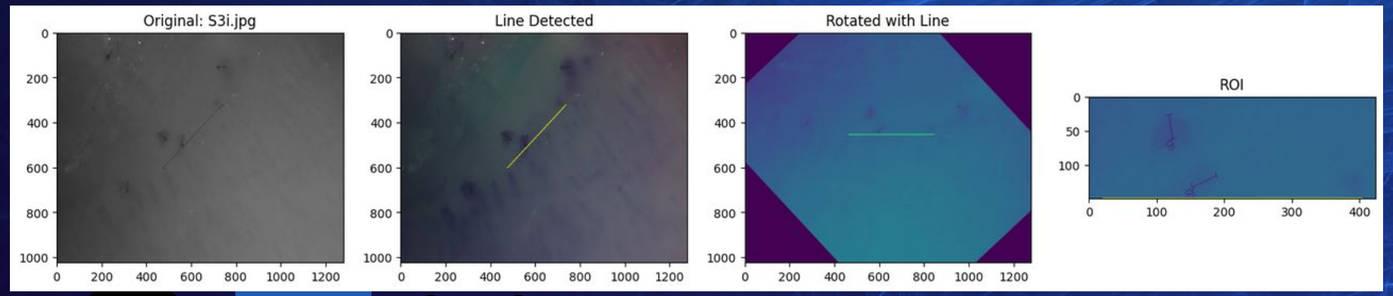




- OUR DATASET IS COMPOSED OF 4 CLASSES OF PERSONS: IMAGES OF THE CAPILLARIES OF 2 PERSONS WITHOUT DISEASE (N1 AND N2) AND IMAGES OF THE CAPILLARIES OF 2 PERSONS WITH DISEASE (S1 AND S2). IN TOTAL WE HAVE 30 IMAGES WITH DIFFERENT ILLUMINATIONS, ROTATIONS, ETC. THAT IS WHY IT IS SO CHALLENGING TO DETECT AND COUNT EACH OF THE CAPILLARIES IN THIS DATASET.

3. METHODS - PREPROCESSING



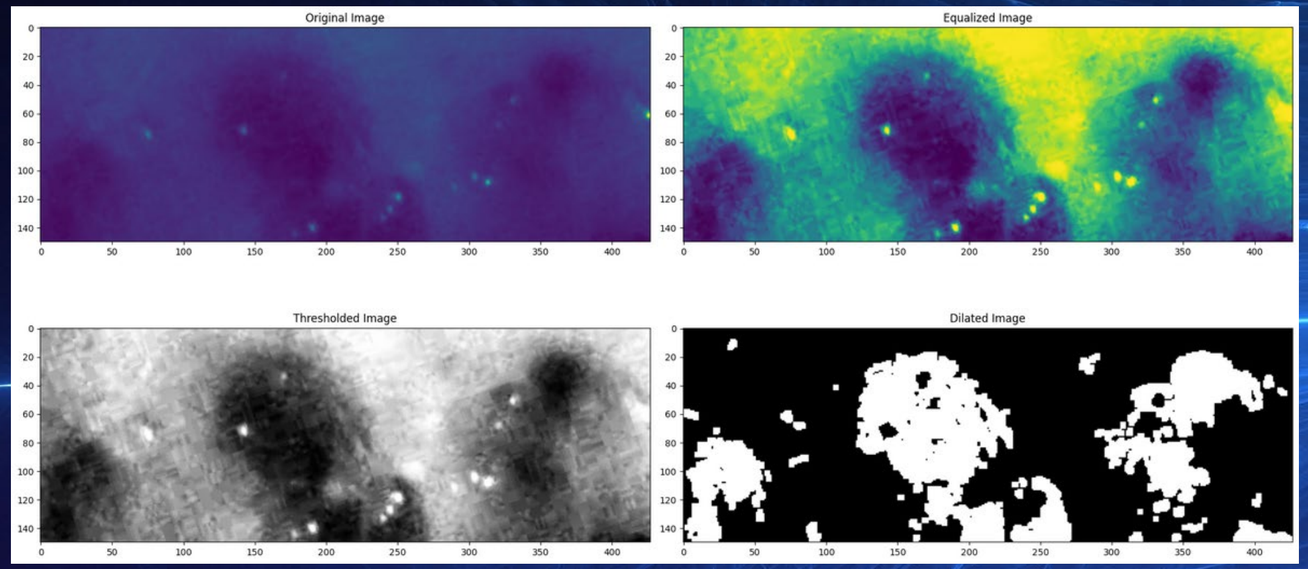


STEP 1 : FIRST WE MUST DETECT THE REGION AND INTEREST.

To do so, a combination of Gaussian blur, Canny edge detection and combination of Gaussian blur, Canny edge detection and Hough's line transform is used.

The longest line detected by the Hough transform is used to rotate the image and extract the ROI. The ROI is extracted from the image

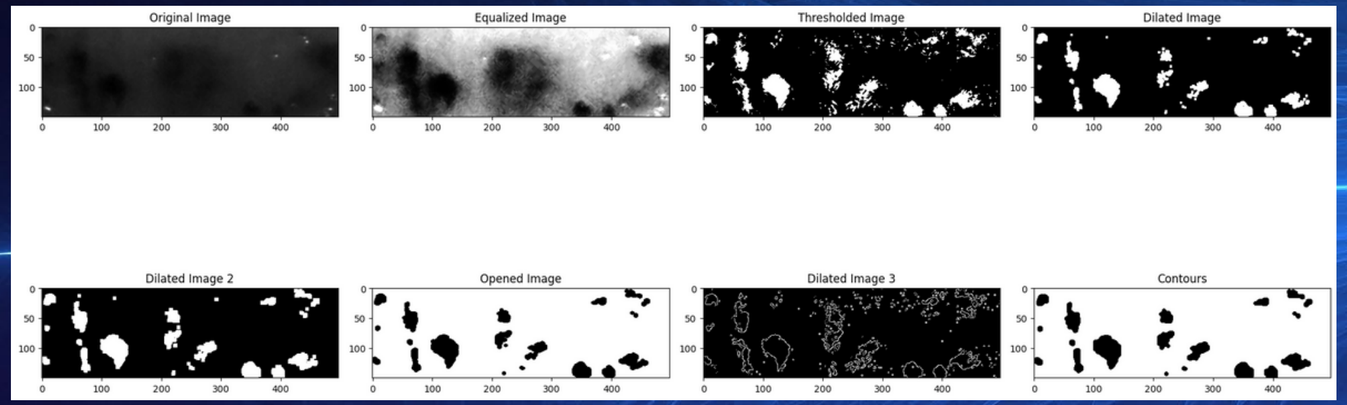
- full color image and only the green channel is selected for further processing.



STEP 2 : ONCE THE ROI IS DETECTED, THE IMAGE IS ENHANCED TO IMPROVE THE VISIBILITY OF THE CAPILLARIES. THIS IS DONE BY APPLYING HISTOGRAM EQUALIZATION AND CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION (CLAHE). THE PARAMETERS FOR THESE OPERATIONS ARE ADJUSTED BASED ON THE LUMINANCE OF THE IMAGE. SPECIFICALLY, IF THE LUMINANCE

- OF THE IMAGE IS LESS THAN 88, A MORE AGGRESSIVE ENHANCEMENT IS APPLIED TO MAKE THE CAPILLARIES MORE VISIBLE

4. METHODS - PROCESSING



STEP 3 :THE PROCESS OF CAPILLARY

DETECTION INVOLVES A SERIES OF MORPHOLOGICAL OPERATIONS AND THRESHOLDING TECHNIQUES APPLIED TO THE ENHANCED IMAGE. THIS PROCESS ALLOWS US TO IDENTIFY AND ANALYZE THE CONTOURS PRESENT IN THE IMAGE.

A CONTOUR IS CLASSIFIED AS A CAPILLARY BASED ON TWO MAIN CRITERIA. FIRST, IT MUST EXHIBIT A TUBULAR SHAPE. SECOND, IT SHOULD NOT BE HORIZONTAL. THESE CONDITIONS ARE DETERMINED BY FITTING AN ELLIPSE TO THE CONTOUR AND EXAMINING THE ANGLE OF THE ELLIPSE'S MAJOR AXIS. IF THIS ANGLE IS CLOSE TO 90 DEGREES, THE CONTOUR IS DEEMED HORIZONTAL AND THUS, IT IS NOT COUNTED AS A CAPILLARY.

FURTHERMORE, THE ALGORITHM ALSO TAKES INTO ACCOUNT THE PROXIMITY AND ORIENTATION OF THE CONTOURS. IF TWO CONTOURS ARE FOUND TO BE CLOSE TO EACH OTHER AND LIE ALONG THE SAME DIAGONAL, THEY ARE CONSIDERED TO BE PART OF THE SAME CAPILLARY. THIS IS DETERMINED BY CALCULATING THE SLOPE AND DISTANCE BETWEEN THE CENTROIDS OF THE TWO CONTOURS. IF THE ABSOLUTE VALUE OF THE SLOPE FALLS BETWEEN 0.5 AND 1.5, AND THE DISTANCE IS LESS THAN A PREDEFINED THRESHOLD, THE CONTOURS ARE CONSIDERED TO BE IN THE SAME DIAGONAL. THIS ENSURES THAT THE ALGORITHM DOES NOT OVERCOUNT CAPILLARIES THAT ARE CLOSE TO EACH OTHER AND ALIGNED ALONG THE SAME DIRECTION.

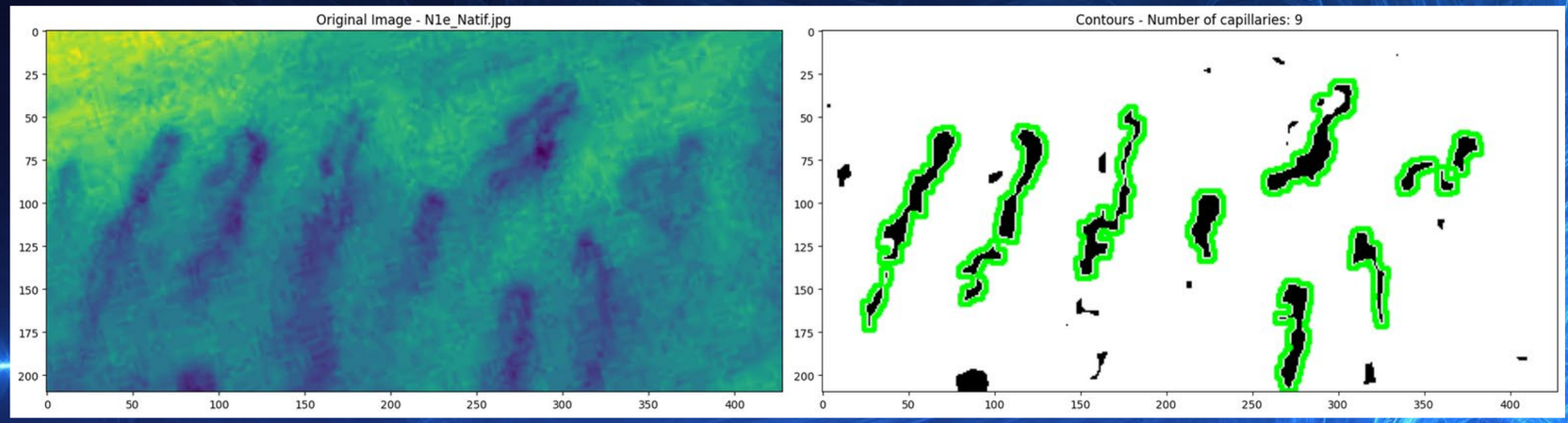
5. RESULTS AND CONCLUSION

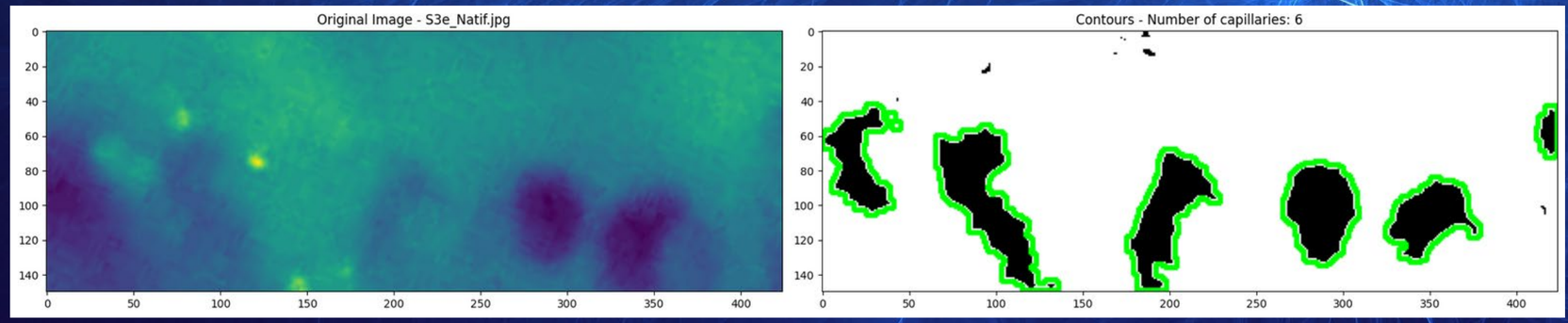
Image	Number of Capillaries
N1a_Natif.jpg	6 capillaries
N1b_Natif.jpg	6 capillaries
N1c_Natif.jpg	9 capillaries
N1d_Natif.jpg	9 capillaries
N1e_Natif.jpg	9 capillaries
N1f_Natif.jpg	3 capillaries
N1g_Natif.jpg	3 capillaries
N1h_Natif.jpg	7 capillaries
N1i_Natif.jpg	5 capillaries
N1j_Natif.jpg	10 capillaries
N2b_Natif.jpg	10 capillaries
N2c_Natif.jpg	10 capillaries
N2d_Natif.jpg	7 capillaries
S2a_Natif.jpg	9 capillaries
S2b_Natif.jpg	4 capillaries
S2c_Natif.jpg	8 capillaries
S2d_Natif.jpg	6 capillaries
S2e_Natif.jpg	6 capillaries
S2f_Natif.jpg	7 capillaries
S2g_Natif.jpg	6 capillaries
S3a_Natif.jpg	1 capillaries
S3b_Natif.jpg	5 capillaries
S3c_Natif.jpg	8 capillaries
S3d_Natif.jpg	8 capillaries
S3e_Natif.jpg	6 capillaries
S3f_Natif.jpg	3 capillaries
S3g_Natif.jpg	6 capillaries
S3h_Natif.jpg	4 capillaries
S3i_Natif.jpg	5 capillaries
S3j_Natif.jpg	3 capillaries

- ACCURACY: 13.333333333333334%
- STANDARD DEVIATION: 3.8616346567512343

- THE PROPOSED METHOD PROVIDES A RELIABLE WAY TO COUNT THE NUMBER OF CAPILLARIES IN IMAGES. THE RESULTS SHOW THAT
- THE METHOD IS ABLE TO DETECT CAPILLARIES EFFECTIVELY, EVEN IN IMAGES WITH VARYING LUMINANCE LEVELS. THE METHOD
- ALSO TAKES INTO ACCOUNT THE ORIENTATION AND PROXIMITY OF THE CAPILLARIES, WHICH HELPS TO AVOID OVER-COUNTING

5. RESULTS

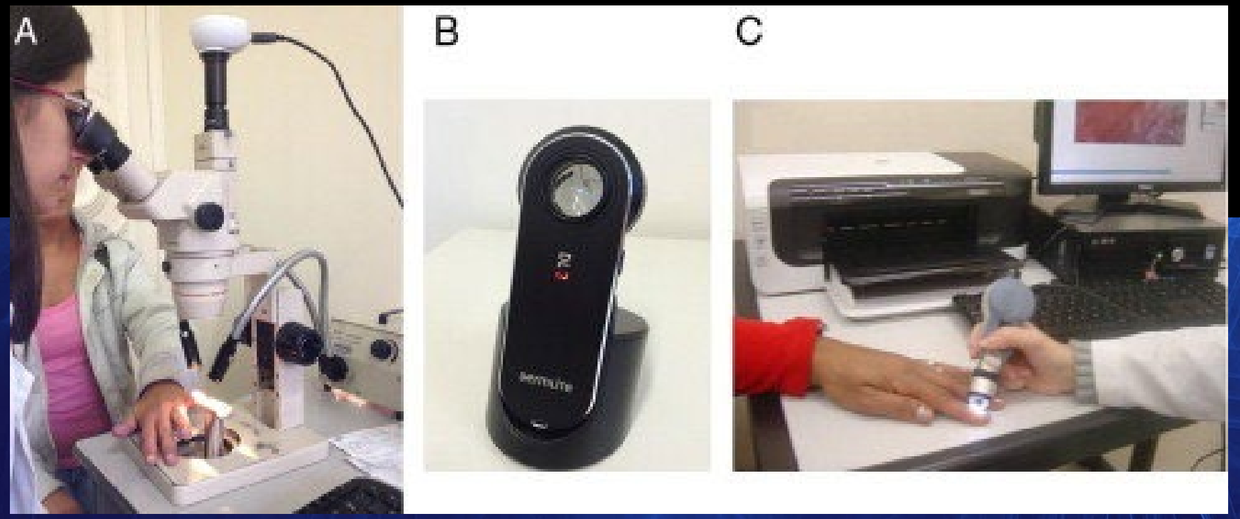

Original Image - N1e_Natif.jpg
Contours - Number of capillaries: 9


Original Image - S3e_Natif.jpg
Contours - Number of capillaries: 6

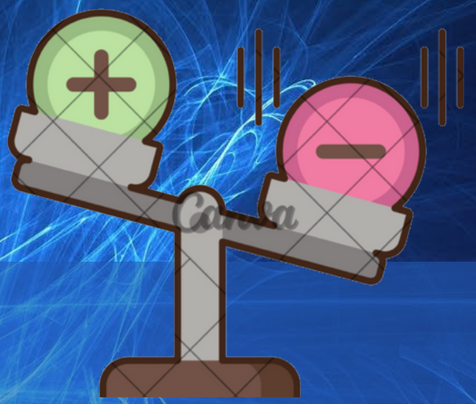
7. ADVANTAGES

- NON -INVASIVE DETECTION TECHNIQUE

- SCALABLE: THE METHOD CAN BE ADAPTED AND FINE-TUNED FOR OTHER MEDICAL IMAGE ANALYSIS TASKS FOR EXAMPLE: VESSELS



8. DRAWBACKS



- DUE TO THE VARIABILITY OF THE IMAGES IN LUMINANCE, AS WELL AS IN THE SHAPE OF THE CAPILLARIES (TUBULAR FOR NORMAL AND CIRCULAR, DEFORMED FOR DISEASED ONES), IT WAS DIFFICULT TO CREATE A PERFECT CLASSIFICATION OF THE CAPILLARIES.
- LABELING ERRORS: THE LABELING PROVIDED TO US MAY BE INACCURATE, IT IS FOR REFERENCE ONLY.
- USING ONLY IMAGE PROCESSING TECHNIQUES LIMITS OUR WORK WHEN LOOKING FOR HIGH "ACCURACY".

9. FUTURE WORK

- INCREASE DATASET SIZE AND DIVERSITY
- INVESTIGATE OTHER TECHNIQUES LIKE DEEP LEARNING ARCHITECTURES OR MACHINE LEARNING.
- EVALUATE THE METHOD IN REAL-WORLD CLINICAL SETTINGS.

THANK YOU