بسم الله الرحمن الرحيم

Prediction of coronary artery disease with tongue image analysis by artificial intelligence. A study protocol

Back ground

- Cardiovascular diseases are the leading cause of global deaths
- Early and precise diagnosis of these disorders can significantly reduce their mortality and morbidity
- Tongue assessment in Traditional Iranian Medicine has been used to determine the patient's condition in many diseases such as heart diseases
- Tongue serves as a reflecting indicator of the body's physiological and clinicopathological status
- objective and standardized evaluation proved to be a difficult task
- Artificial intelligence has gained popularity in recent years are used in variety part of medicine like medical diagnosis
- Computer-assisted tongue diagnosis offers great promise for providing more consistent and objective health evaluations, particularly in fields such as heart disease assessment

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Objectives

- The primary purpose of this study is to determine the high-precision relationship between tongue sign and coronary artery disease by using AI through tongue image analysis
- It is possible to create software that can analyze the status of coronary arteries using tongue image analysis

Methods

- This protocol adheres to the SPIRIT-AI Extension guideline

Definitions and variables

Tongue examination

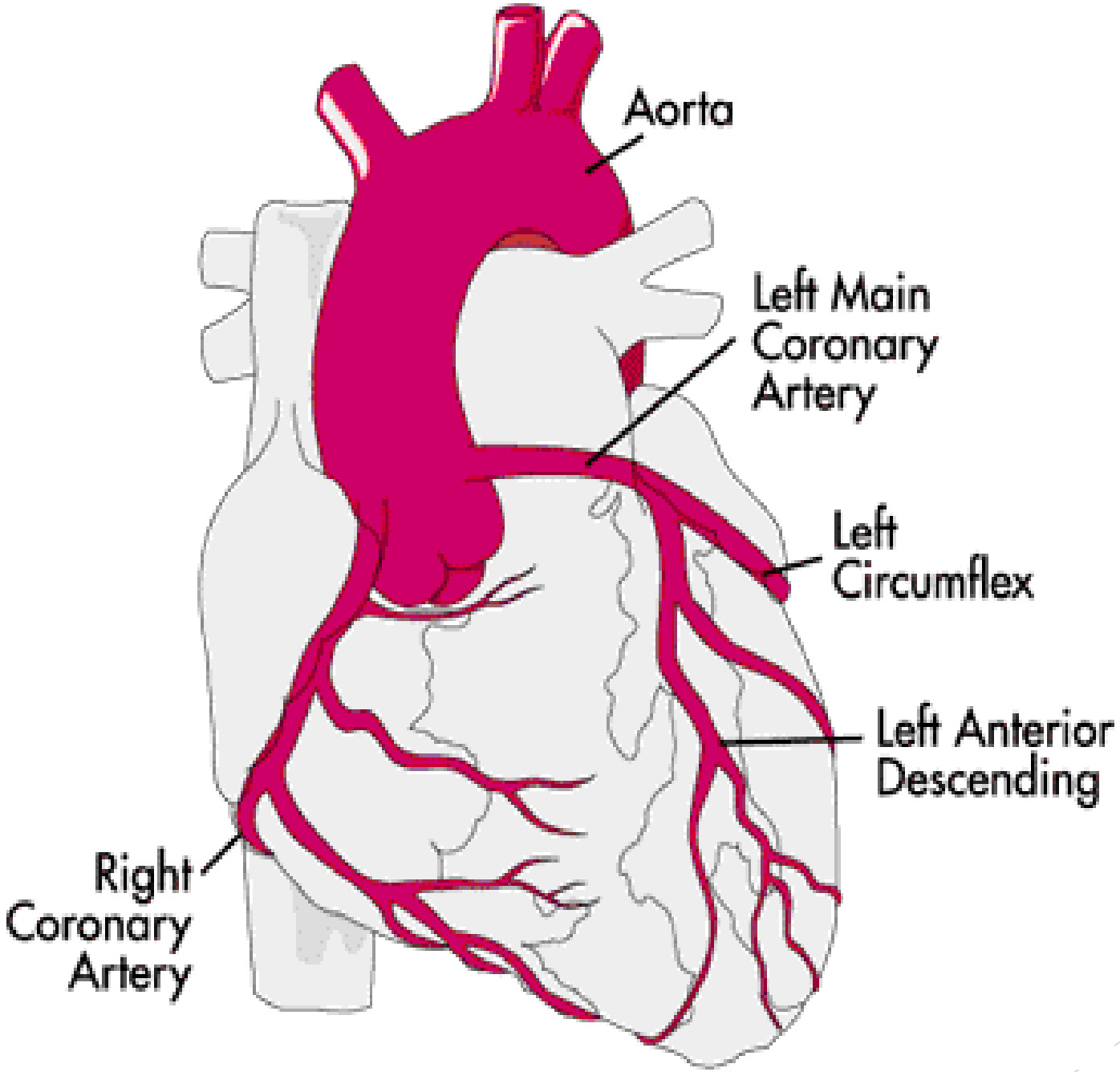
- Contains nine variables: the *size* of the tongue, the *color* of the tongue, *teeth mark*, tongue *fissure*, the distribution of *tongue coating*, the *color of tongue coating*, the *thickness of tongue coating*, *moisture* of tongue, and ***red spot***.

Variable	Scale				
Shape	small	Normal	Large		
Color	Pale	Red pale	Red	Dark red	Blue
Teeth mark	none	Present			
Fissure	None	Present	If present in which part of tongue		
Coating	none	Present	If present in which part of tongue		
Color of coating	Without coat	White	Yellow	gray	black
thickness of coating	Without coat	Thin	Normal	Thick	
Wetness	dry	Normal	Wet		
Red spot	None	Present	If present in which part of tongue		

Angiographic results

In this study, the results of coronary angiography will be evaluated in four parts

- Left main coronary artery (LMCA)
- Left anterior descending artery (LAD) with proximal, middle, and distal segments.
- Left circumflex artery (LCX) with proximal, middle, and distal segments.
- Right coronary artery (RCA) with proximal, middle, and distal segments.


Aorta
Left Main Coronary Artery
Left Circumflex
Left Anterior Descending
Right Coronary Artery

- The angiographic results of diagonal artery 1, 2, and septal branch, from LAD are not considered.
- The angiographic results of obtuse marginal (OM) 1 in the proximal part of LCX, and OM2 and ramus arteries in the middle part of LCX will be considered.
- The angiographic results of posterior descending arteries (PDA), posterior left ventricle (PLV), and RV branch in the distal part of RCA.

The modified Agatston score

No luminal stenosis will be normal, 1- 49% stenosis will be mild, 50-69% stenosis will be moderate, 70-99% stenosis will be sever, and 100 % will be occlude

Outcome

drug treatment, percutaneous coronary intervention (PCI), coronary artery bypass graft (CABG) and others (e.g. Premature Ventricular Contractions ablation, valve replacement, or cancellation of angiography)

Quantitative results of coronary angiography			Qualitative results of coronary angiography used in the research		
Vascular category	vessels	Quantitative value of obstruction	Vascular category	Segment of artery	Qualitative degree of obstruction (modified Agatston score)
LMCA	LMCA		LMCA	LMCA	
LAD	Prox. LAD		LAD	Prox. LAD	
	Mid. LAD				
	Distal. LAD			Mid. LAD	
	Diagonal 1				
	Diagonal 2			Distal. LAD	
	Septal B				
LCX	Prox. LCX		LCX	Prox. LCX	
	Mid. LCX				
	Distal. LCX			Mid. LCX	
	OM 1				
	OM 2			Distal. LCX	
	Ramus				
RCA	Prox. RCA		RCA	Prox. RCA	
	Mid. RCA				
	Distal. RCA			Mid. RCA	
	RV Branch				
PDA	PDA			Distal. RCA	
PLB	PLB				

Artificial intelligence

Procedure of tongue images analyzing

-Extraction of tongue region from facial images

Use the Segment Anything Model (SAM)

-Tongue visual characteristics

Apply a combination of classical image processing methods and deep neural networks

Utilize a Convolutional Neural Network (CNN) to extract high-level features

-Semi-supervised extraction of visual features

-Use a UNet autoencoder architecture to extract features

Study setting

1- Data sheets containing demographic and past medical information, lab data, and for each participant will be prepared

2- A form for entering the results of the tongue examination by the researcher during imaging is prepared.

Name and Surname: Phone: Address:

Sex: Age: Weight: Height: BMI:

Number of breaths per minute: Number of pulses per minute: Blood pressure while attending the ward:

Initial diagnosis:

Do you have chest pain during the week? Number of attacks per week/day:

Duration of attacks:

type of pain (stabbing, pressing, shooting, others: to be explained)

shortness of breath (while moving, while resting, during chest pain)

Medicines used and its duration:

Smoking and its type: duration and quantity:

Alcohol consumption: duration and amount:

: Results of clinical tongue examination

1	Size (shape) of tongue	Large	Medium	Small		
2	The color of the tongue	Pale red	Red	Deep red	Purple	Blue
3	Teeth mark	Has	Has not	Which side of tongue		
4	Tongue fissure	Has	Has not			
5	Which area of tongue, if has fissure	Front of tongue	Left side	Middle of tongue	Right side	Root of tongue
6	Wetness of tongue	Excess	Normal	Less than normal		
7	Red spot on tongue	Has	Has not			
8	Scattering of red dots	front of tongue	left side	middle of tongue	right side	root of tongue
9	Tongue coating	Has	Has not			
10	Color of the coating on the tongue	No coating	White	Yellow	Gray	Black

11	Place of tongue coating	Front of tongue	Left side	Middle of tongue	Right side	Root of tongue
12	Thickness of the tongue coating	No coating	Thin	Normal	Thick	
13	Speed of speech	Fast	Normal	Slower than normal		
14	Feeling heavy in tongue	Yes	No			
15	Taste changes	Yes	No			
16	Special taste sensation	Yes	What a taste	NO		
17	Deviation of tongue	Yes	What side	NO		
18	Trembling in tongue	Yes	Up and down	Left and right	No	
19	Presence of lesion on tongue	Yes	Which area	No		
20	Appearance of tongue	Ellipse	Round	Rectangle	Square	Hammer
		Triangular	Open Triangular			

Eligibility criteria

Inclusion criteria: Patients hospitalized in the angiography department who are hemodynamically stable will be included in the study

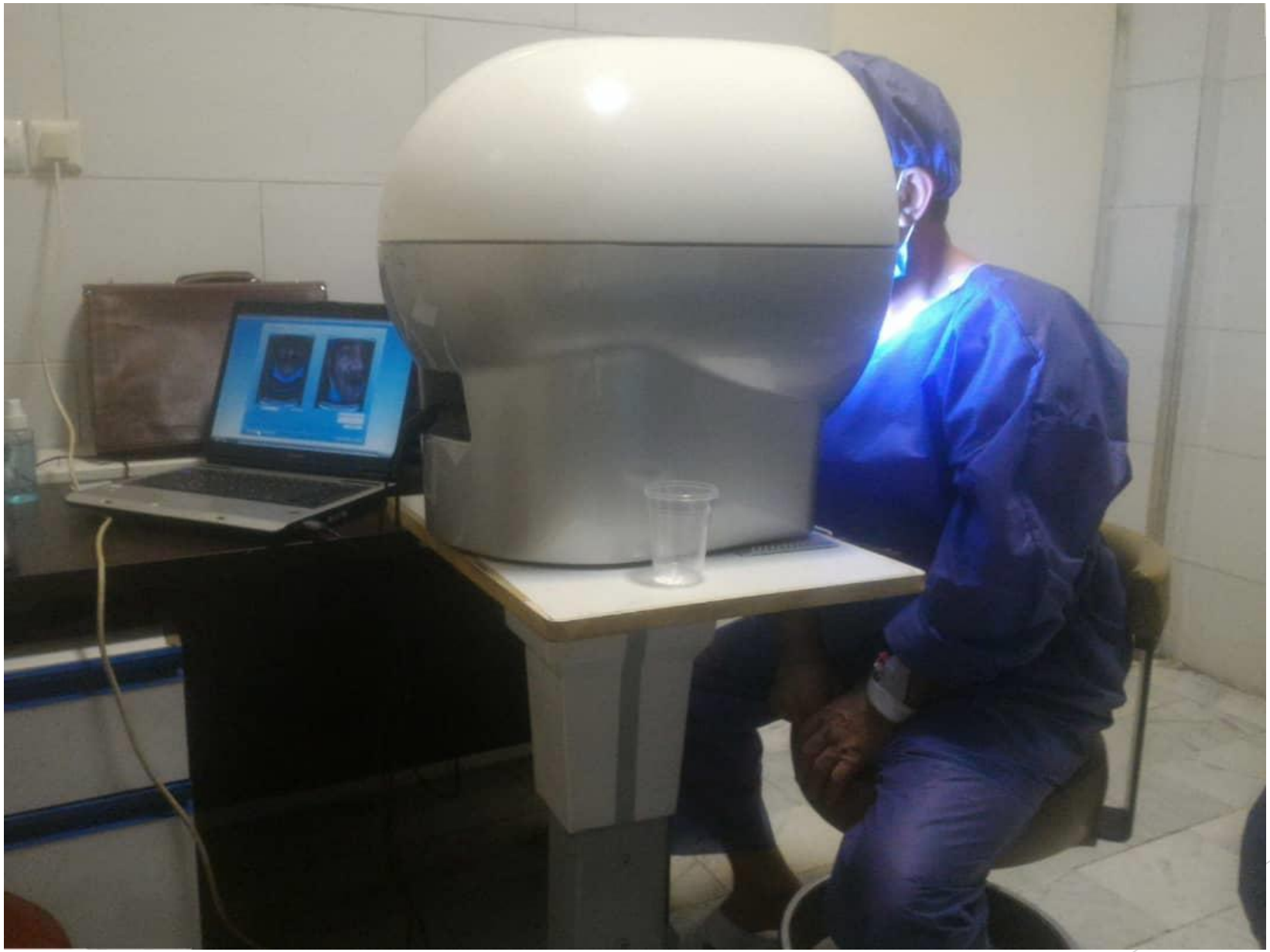
Exclusion criteria: *Patient non-cooperation*, *Unconscious or hemodynamically unstable patient*, *Cognition or behaviorally impairment*, *active cancer or active oral infection*, *oral cancer related symptoms in past 2 year*, *pregnancy or lactation*, *congenital heart disease*, *geographic tongue*

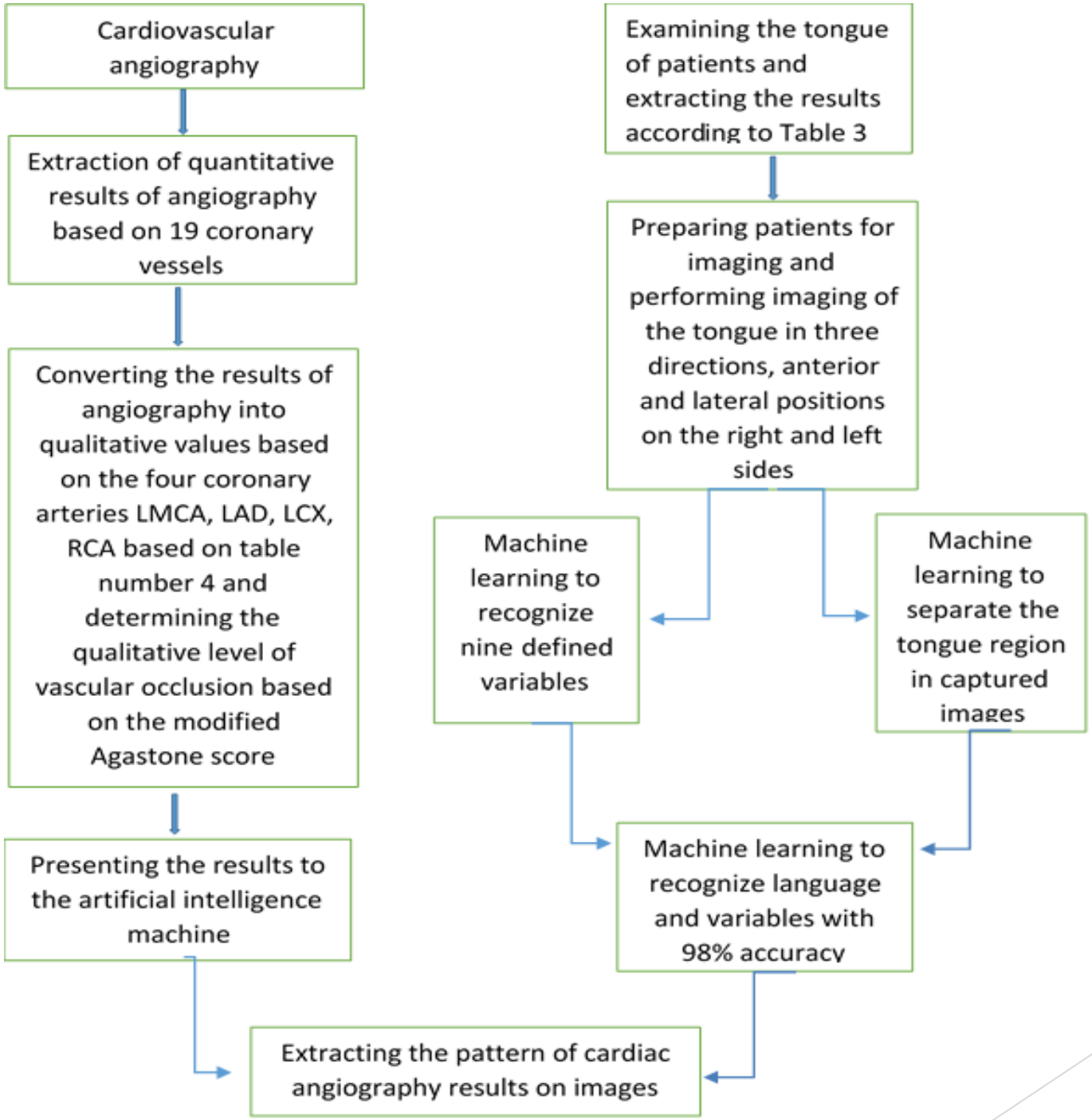
Sample size

Sampling will continue until the AI software recognizes the tongue images and their characteristics. However, our preliminary estimate is between“900 to 1200”.

Data collection

- Patients who meet the entry criteria will complete the consent form
- medical history and demographic information will be recorded in the relevant forms
- imaging procedure will take place in a room without windows or access to natural light
- will use the special device, which has 210 LEDs to illuminate the tongue evenly, and comes with a head and chin support for photography
- The photos of the tongue from the front, right, and left sides in the same direction will be taken
- To train the AI machine, in easily identifiable variables such as color, shape, and coating. We plan to use around 300 to 500 images for this purpose. Other variables like fissures, red spots, teeth marks, and moisture on the tongue, we will draw upon a database of over 5000 tongue images.




Cardiovascular angiography
Extraction of quantitative results of angiography based on 19 coronary vessels
Converting the results of angiography into qualitative values based on the four coronary arteries LMCA, LAD, LCX, RCA based on table number 4 and determining the qualitative level of vascular occlusion based on the modified Agastone score
Presenting the results to the artificial intelligence machine
Extracting the pattern of cardiac angiography results on images
Examining the tongue of patients and extracting the results according to Table 3
Preparing patients for imaging and performing imaging of the tongue in three directions, anterior and lateral positions on the right and left sides
Machine learning to recognize nine defined variables
Machine learning to separate the tongue region in captured images
Machine learning to recognize language and variables with 98% accuracy

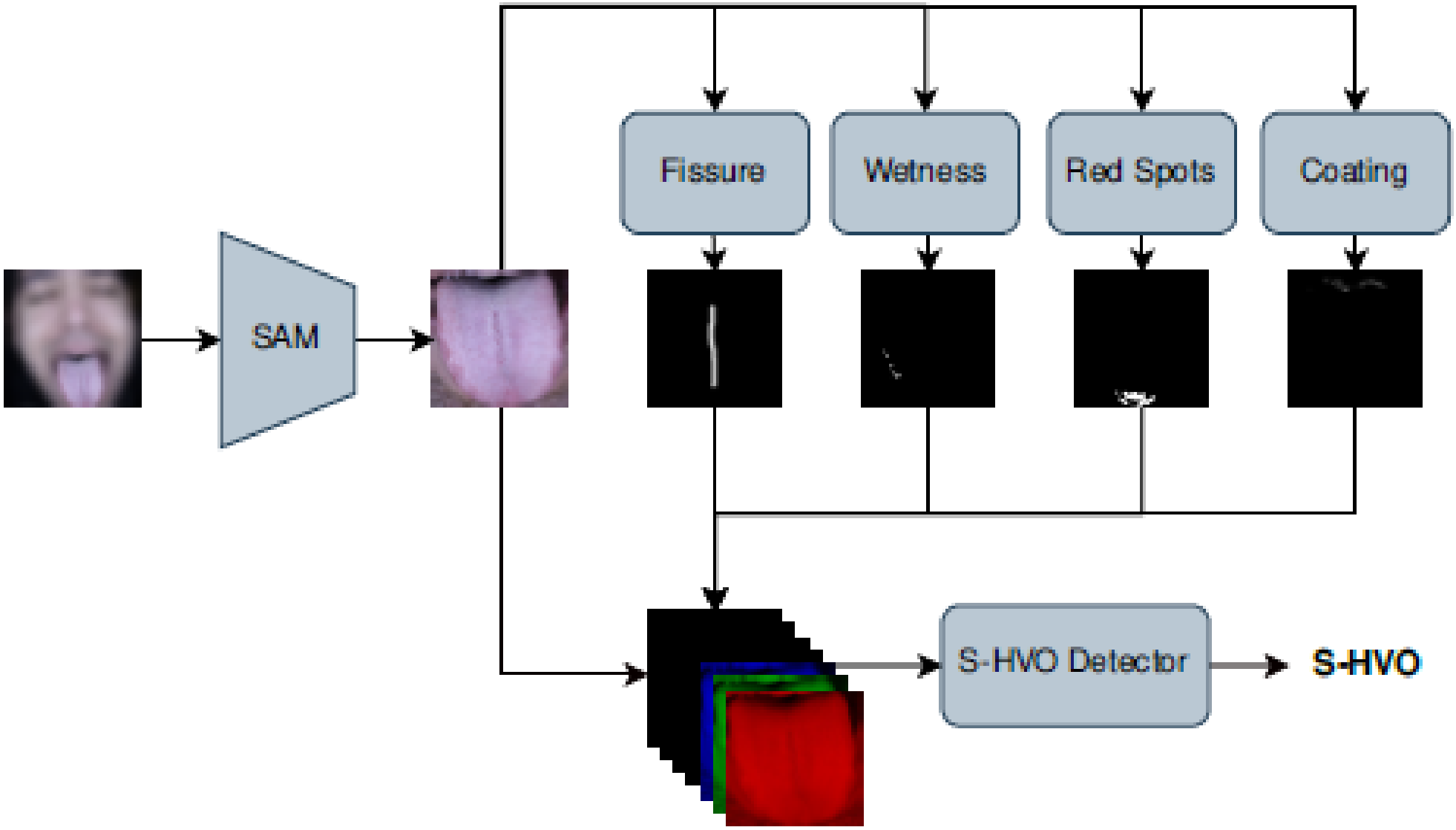


Figure 1. Overall pipeline of the proposed method. After extracting tongue region by SAM, different features are extracted by their corresponding models, then added to the tongue image and all together given to the S-HVO classifier to detect severe occlusion in coronary arteries.

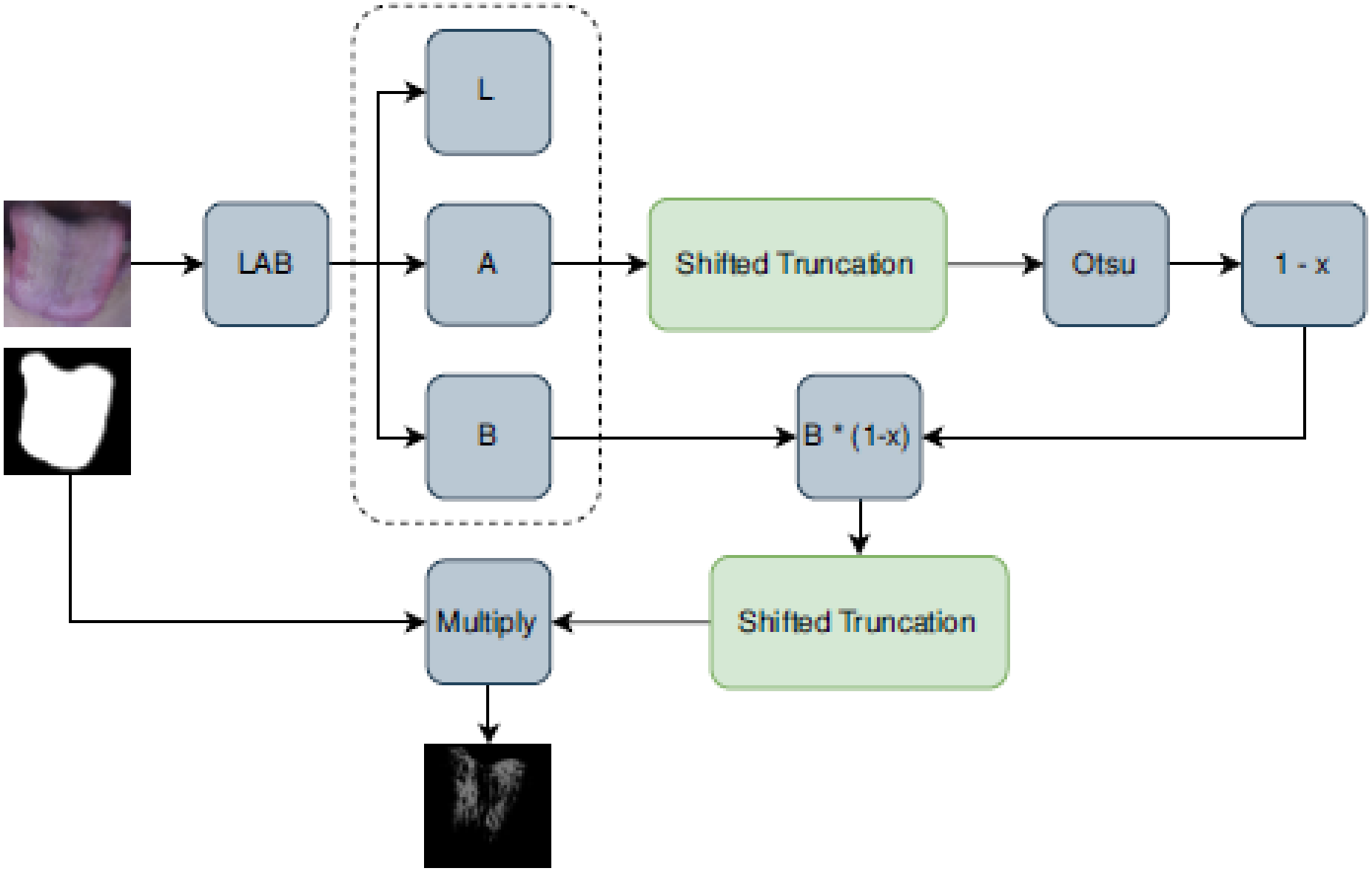


Figure 3. Procedure to extract coating from tongue image. Regions with low red color and high yellow color are considered as coating. The contrast from a normal tongue color indicates the intensity and thickness of the coating.

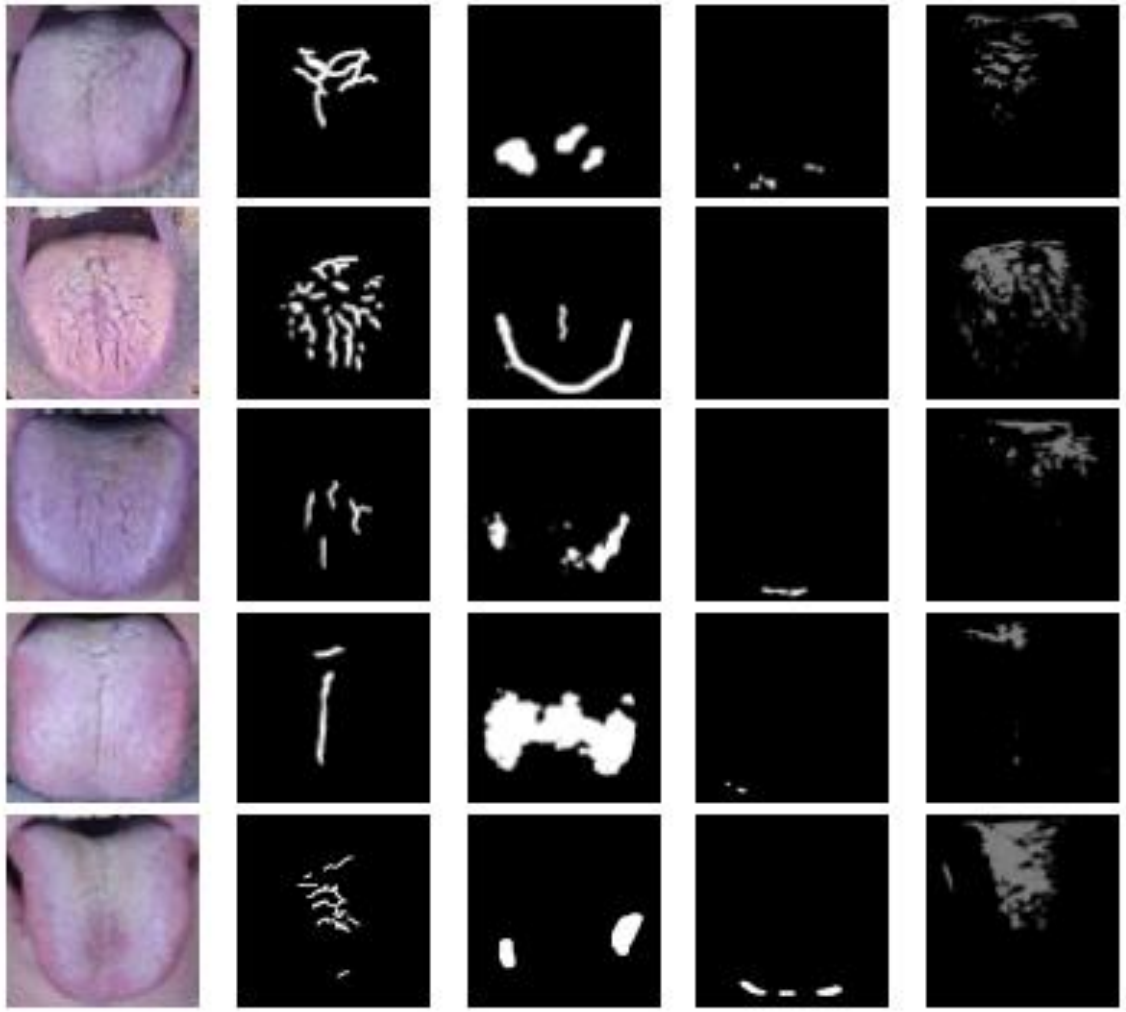


Figure 4. Visualization of tongue characteristics on four example images. In Each row, from left to right, 1. tongue image, 2. fissures, 3. wetness, 4. red spots, 5. coating are shown.

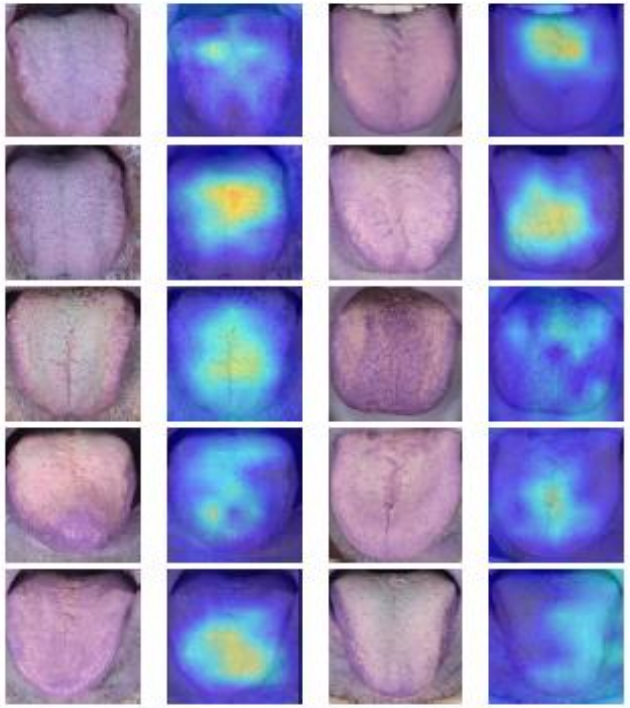


Figure 5. Grad-CAM results on our model for 10 samples of tongue image.

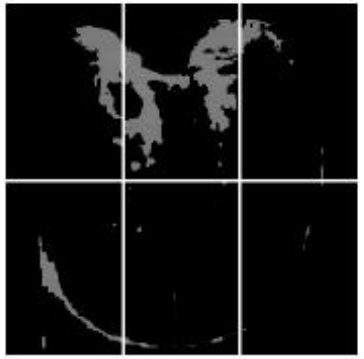


Figure 6. Tongue image regions illustrated on the coating mask. In order to extract numerical features for SVM, we average the binarized coating values over each region as a measure of its intensity. The same method is used for other features.

Table 1. S-HVO Classification Results

	Accuracy	Precision	Recall	F1 score
Raw image	45%	66%	45%	53%
SVM	62%	60%	88%	71%
Ours (image+features)	**71**%	**72**%	**97**%	**83**%

Table 2. Effect of the removal of each feature on the performance of our proposed model

	Accuracy	Precision	Recall	F1 score
Wetness removed	65%	70%	86%	77%
Fissure removed	62%	71%	77%	74%
Red Spots removed	68%	74%	83%	78%
Coating removed	56%	69%	69%	69%
Ours (image+features)	**71**%	**72**%	**97**%	**83**%

Table 3. Effect of the removal of each feature on the performance of SVM model

	Accuracy	Precision	Recall	F1 score
Wetness removed	59%	58%	89%	70%
Fissure removed	58%	58%	88%	70%
Red Spots removed	60%	59%	**89**%	**71**%
Coating removed	53%	54%	88%	67%
SVM	**62**%	**60**%	88%	**71**%

Table 4. Effect of the removal of each region on the performance of SVM model

	Accuracy	Precision	Recall	F1 score
Bottom left removed	60%	59%	88%	70%
Bottom center removed	60%	59%	86%	70%
Bottom right removed	60%	58%	**89**%	71%
Top left features removed	53%	54%	88%	67%
Top center features removed	54%	55%	86%	67%
Top right features removed	57%	57%	88%	69%
SVM	**62**%	**60**%	88%	**71**%

Discussion

- To aid in the quick diagnosis and treatment of CVD.
- could lead to the development of software that can be installed on cellphones and, by taking a picture of a patient's tongue, analyze the risk of CVD.
- This is a diagnostic assistance tool that, in conjunction with other diagnostic aids such as an electrocardiogram.
- This program is quite valuable, particularly in individuals who have non-specific cardiac symptoms yet are at risk of CAD. The findings of this study will enhance the physical and mental well-being of society and decrease treatment and rehabilitation expenses

Input *The images of patients tongue Cardiac angiographic results*

Process *Finding the possibility of blockage in coronary arteries by AI*

Out put *Improved detection of potential blockage in the coronary artery*

Out come *Reducing the incidence of mortality and physical and mental disabilities resulting from coronary artery blockage*

Impact *Enhancing community health and lowering treatment and rehabilitation expenses*


از توجه شما متشکرم