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Coronary Artery Disease Prediction: A Systematic Review

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Abstract: ***Coronary artery disease (CAD) continues to be the primary cause of mortality and chronic impairment in cardiovascular illnesses around the globe, hence coronary artery disease prediction is becoming more important in today's society. As we know, more individuals died as a result of late detection of cardiac disease, thus anticipating it in the early stages is critical. As there are more techniques to predict heart disease but, they are either time consuming or more expensive. So, our goal is to create a system that can predict the outcome fast, cheaply, and more precisely from our house, from our smart phone camera. We know that facial recognition plays a significant part in human-computer interaction, thus we want to integrate this approach with the medical profession in order to anticipate a condition that contributes significantly to the world population's mortality rate. The goal of this review paper is to compare these approaches to the current state-of-the-art and to discuss the challenges that must be addressed. It also includes recommendations for further study.***
Keywords: Coronary Artery Disease, Heart Disease, Face recognition, cardiac images, tomographic images

I. INTRODUCTION

A. Coronary Artery Disease

Coronary artery disease is most prevalent kind of heart disease, often known as coronary heart disease. So, when arteries of heart are unable to carry essential oxygen and nutrients to the heart, CAD occurs. This is frequently due to damaged, diseased, or blocked arteries, all of which can lead blood circulation to be disturbed. The most prevalent causes of CAD are injury and plaque build-up in these channels, known as coronary arteries. As the arteries narrow, there is less space for blood to flow. As a result, blood flow is reduced, making it more difficult for the body to feed the heart with the necessary oxygen and nutrients. Inadequate blood circulation may cause chest pain, trouble breathing, and other symptoms of heart disease. Plaque often builds up over time. In some people, a heart attack may be the first indication of CAD.

Coronary heart disease occurs whenever the primary blood arteries supplying the heart becomes inflamed or infected. Coronary artery disease is often caused by cholesterol-containing formations (plaques) in the blood vessels as well as hypertension.

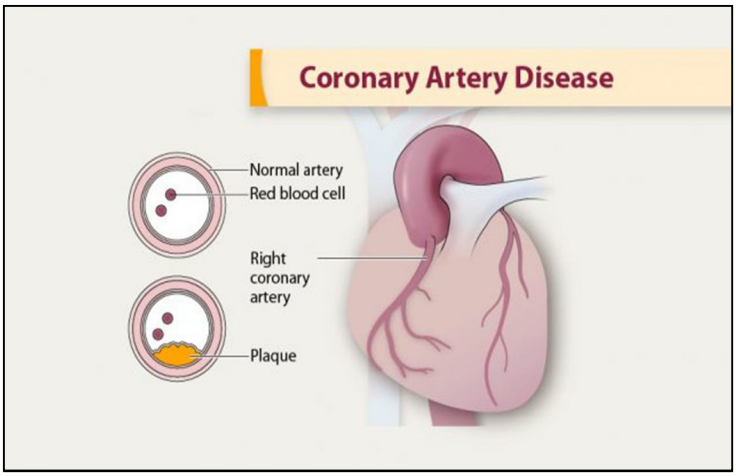


Fig.1. Coronary Artery Disease

The coronary arteries provide blood, oxygen, and nutrition to the body. Plaque build-up may block those arteries, limiting the heart's capacity to pump. Finally, the limited blood circulation may cause chest pain (angina), trouble breathing, or other signs of coronary heart disease. A complete occlusion might cause a cardiac condition.

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Since coronary heart disease frequently occurs beyond a long period of time, people don't always detect any issue unless they have a large occlusion or even a cardiac arrest. However, there are things patients may do to avoid & cure coronary artery disease. The sensible diet may have a significant impact.

B. Symptoms

As the coronary arteries shrinks, it can't give sufficient oxygen-rich blood back to the heart, particularly as it's working hard, like it does throughout activity. Initially, the poor circulation doesn't always create any discomfort. Nevertheless, when plaque accumulates in the blood vessels, people can experience numerous coronary artery disease indications and effects such as shortness of breath, pain spreading to arms, shoulders, jaw, neck or back, pressure, heaviness, or pain in the chest, weakness and fatigue, abnormal heart beat, excessive sweating.

Women are slightly likelier to experience less common heart attack symptoms, including neck or jaw discomfort. They may also experience additional symptoms of fatigue of breath, exhaustion, and anxiety.

C. Causes

Coronary heart disease is assumed to start when the core part of a coronary artery is damaged or injured, which may happen as early years of life. The injury might be affected by a multitude of sources, namely:

1) Having high cholesterol
2) Having diabetes
3) Smoking
4) High blood pressure
5) Not being active

An increase in clots (plaque) made up mostly of cholesterol and other cellulosic components occurs when the bottom plate of an artery is damaged. It's called atherosclerosis. Cracks or break in the top of the plaque cause platelets to gather in an effort to repair the damaged artery. A heart attack may occur if a knot obstructs an artery.

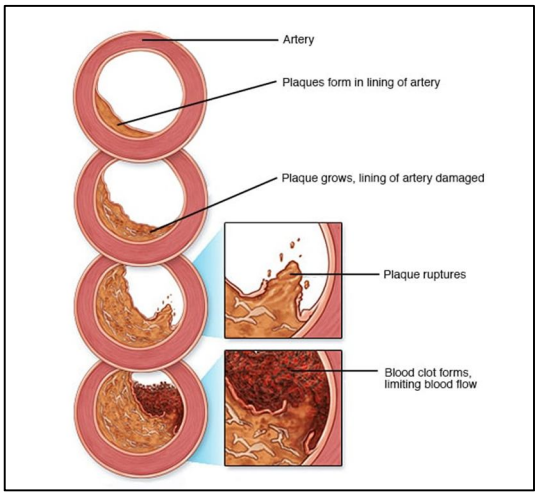


Fig.2. Development of atherosclerosis

D. Why is it important to work on coronary artery disease?

Because coronary arteries provide blood to the heart, any coronary artery malfunction or illness may have catastrophic consequences by decreasing the supply of blood and oxygen towards the heart tissue. This may result in a cardiac arrest &, in extreme cases, death. Angina, or chest pain, may occur when the heart does not get the oxygen it needs because of a lack of blood flow to the organ. Your heart's capacity to pump blood may be compromised, resulting in oxygen depletion throughout your body. It is possible that you may experience exhaustion or shortness of breath if you don't get enough oxygen to the tissues. When plaque ruptures and fully blocks an artery, it results in a heart attack.

Coronary artery disease (CAD), in particular, is on the increase in India. Deaths from CHD increased from 17% to 26% in 2001-2003 according to the Registrar General of India; by 2010-2013, these numbers had risen to 23% overall and 32% among adults.

Global Burden of Disease and the World Health Organization (WHO) have both shown an increase in years of life lost (YLLs) and disorder life years (DALYs) in India due to cardiovascular disease (CHD). The incidence of coronary heart disease (CHD) in India has grown significantly over the last 60 years, from 1% to 9% in urban areas and 1% to 4% in rural areas. Its prevalence is estimated to be 1% to 2% in rural areas and 2% to 4% in urban areas based on more stringent criteria (clinical Q waves). It's possible that India has a greater CHD incidence than previously thought. Key risk factors for coronary heart disease (CHD) in India include dyslipidaemias (smoking and obesity), hypertension (adiposity and psychological stress), unhealthy lifestyles and lack of physical exercise. Appropriate preventive approaches are required to combat this epidemic.

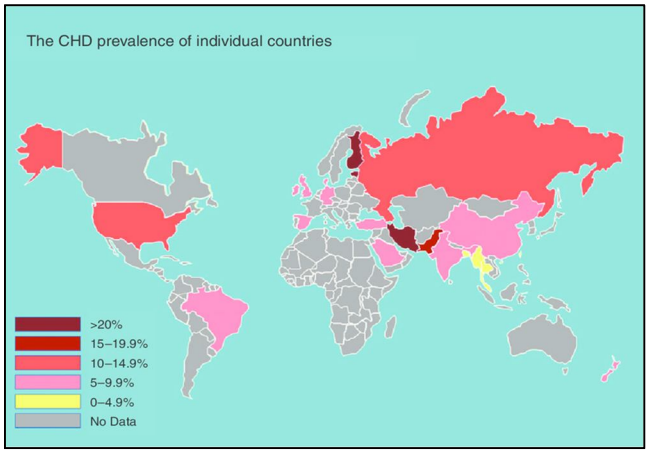


Fig.3. Global Status of CAD

E. Traditional Methods to Detect Coronary Artery Disease

Because coronary arteries provide blood to the heart, any coronary artery malfunction or illness may have catastrophic consequences by decreasing the supply of blood and oxygen towards the heart tissue. This may result in a cardiac arrest &, in extreme cases, death.

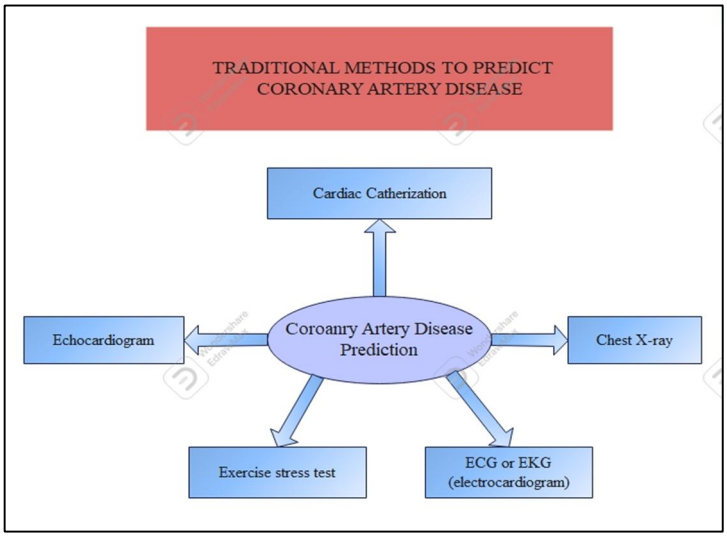


Fig.4. Traditional Methods

1) *ECG or EKG (electrocardiogram):* The electrical impulses in the heart are recorded by an electrocardiogram. It is a frequent and non-invasive test used to detect heart abnormalities and monitor cardiovascular health. An ecg, commonly known as an ECG or EKG, is often performed at a doctor's office, clinic, or maternity ward. ECG devices are used in operating theatres and paramedics. ECG monitoring is available in several personal gadgets, like wristwatch.
2) *Echocardiogram:* An echocardiography creates pictures of your heart using sound waves. This routine test lets the physician to watch your heart rhythm and blood flowing. An echocardiography may be used by the physician to diagnose heart problems.

3) *Exercise stress test:* An incremental exercise test is generally used to assist the physician in determining if the heart gets sufficient oxygen and sufficient blood circulation when it is most needed, including when you work out. An exercising stress test has also been used to measure your standard of health, particularly if you really are beginning a new fitness programme. This enables the physician to determine the amount of activity you can operate safely.
4) *Chest X-ray:* X-rays of the chest may confirm the existence of calcium inside the heart's arteries. Its presence might indicate the existence of lipids and other materials in the arteries, as well as harm to your aortic valve, coronary arteries, heart muscle, or even the protecting sac that protects the heart. Calcification lumps in the lungs are usually the result of an old, cured infection.
5) *Cardiac catheterization:* Cardiac catheterization is a treatment that involves guiding a thin, tube called (catheter) through such a blood artery towards the heart to detect or cure specific cardiovascular disease including such blocked arteries or heart problems. Cardiac catheterization provides clinicians with crucial data well about heart tissue, pericardium, and blood arteries.

F. Disadvantages of Traditional methods

Coronary artery disease (CAD) continues to be the major risk factor for mortality and persistent impairment in all parts of the globe. Previously, blood samples, electrocardiograms, CT scans, heart MRIs, and other diagnostic procedures have been used to diagnose cardiovascular disease. Conventional diagnostic approaches, on the contrary, are time intensive and/or intrusive. As a result, there's any need to suggest a non-invasive computing technology based on face scans that can objectively diagnose cardiac disease.

G. Technology Methods

1) *Coronary artery prediction using Cardiac images:* A Detection of cardiovascular disease is dependent on cardiac imaging (CVD). It has only been used in the visual and contextual context of particular heart architecture and function till now. However, new opportunities for the development of AI systems that directly assist doctors in the detection of CVDs are arising with the advantage of big data and ML.[4].

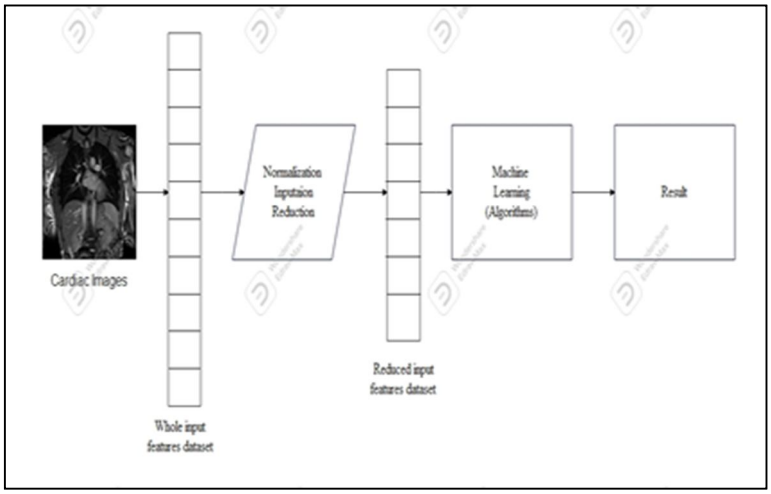


Fig.5. Workflow: Using Cardiac Images

2) *Coronary Artery disease prediction using Tomographic images:*Despite indications and medical risk factors, cardiac radiography is critical to the identification and risk classification of coronary heart disease by giving objective proof of myocardial ischaemia & description of cardiac plaques. CT coronary angiogram can identify high-resolution coronary plaque, evaluate the extent of practical stenosis, and describe plaque characteristics. However, the danger of coronary heart disease is indeed based on biological factors including such irritation, which would not be completely represented by stenosis grade, myocardial ischaemia, or coronary plaque characteristics. New cardiac CT methods may quantify cardiac irritation by scanning microvascular fat, which might be a significant step forward towards finding the "risk level" which plaques or cerebral ischemia imaging cannot identify. A much more detailed personalised method to quantifying and stratifying coronary artery disease risk that integrates clinical variables, plaque attributes, and microvascular infection offers a broader adaptive strategy to quantifying and stratifying cardiovascular disease risk, to prospective health coverage for preventative measures, diagnostic test, and treatment strategies.[5]

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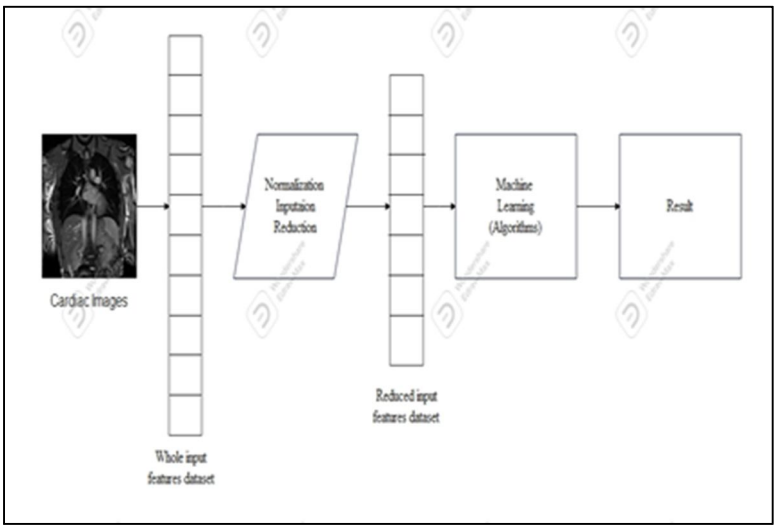


Fig.6. Workflow: Using Tomographic Images

3) *Coronary Artery disease prediction using facial photos:* Artificial intelligence evolved along with machine learning and deep learning algorithms, which helps to make predictions from facial features to detect various diseases. As we discussed various methods for predicting CAD, here is another method for detecting CAD or CHD in less time as well as in low price budget i.e., predict CAD from facial photos. With the help of facial photos from different angles [1], it helps to predict CAD in efficient manner. It is done by taking photos from four distinct perspectives (top, front, 60 degrees right and 60 degrees left). Not only from facial features, prediction also requires side angle which involves ear side to play a big role for making prediction more accurate, also from top angle which takes images of the scalp which also help to make prediction efficiently [3]. It takes facial features such as wrinkles, eyes, canthus, and nasal bridge, as well as the forehead [2]. With the help of different machine learning algorithms and deep learning concept we can efficiently predict the CAD in the early stage.

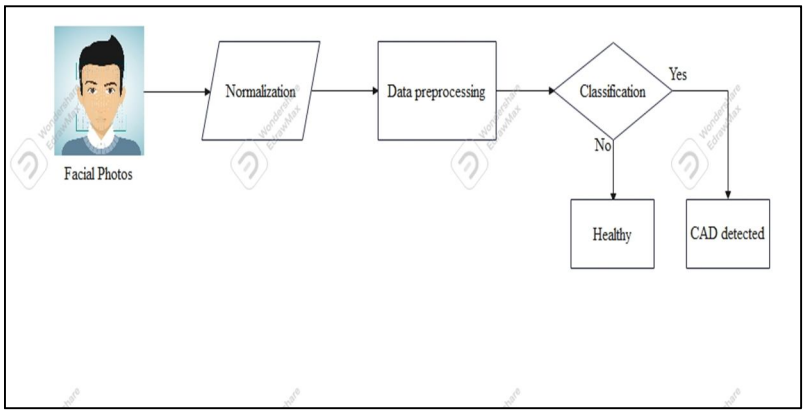


Fig.7. Workflow: Using Facial Photos

II. RESULT ANALYSIS

In this paper [1], the authors employed facial recordings to predict Coronary Artery Disease because they focused on face traits as well as changes in skin tones, which may be a major cause of CAD. They recorded 1200 videos of 500 samples, half of which were CAD positive and the other half were healthy. They have chosen two modules from which to calculate high accuracy for CAD prediction. PulseCAD and ImageCAD were two modules that assisted in predicting CAD from facial videos and calculated the maximum accuracy for prediction based on pulse-related skin colour change features. They were almost 90% accurate in classifying the samples.

In this paper [2], the authors provided information regarding predicting Coronary Artery Disease from facial pictures using several methodologies, such as a shot of a patient's face taken from four distinct perspectives (top, front, 60 degrees right and 60 degrees left). They examined data from 1013 Chinese patients.

They employed many methods and also suggested their own approach for CAD prediction. The results suggested a unique approach in which facial analysis using machine learning and deep learning might help in the identification of CAD for large population of Chinese people. This work lends support to the improvement of a deep learning-based device for estimating early prediction of CAD which will use probability small clines i.e., in OPD clinics or CAD screening in the group, which might assist in directing future diagnostic testing. They got accuracy 76% approximately.

In this paper [3], it gives a novel approach towards CHD prediction based on facial photos The random forest and decision tree models are used for prediction. The authors employed a variety of parameters to predict CHD, including a side view of the picture, which included the ears, eyes, canthus, and nasal bridge, as well as the forehead. They also use medical terminology to increase accuracy and make predictions more accurate. By employing extracted characteristics as input towards a model, there suggested technique obtains a 72.73 percent identification rate, and they may conclude that the faces of patients with CHD may vary from others. They collected information from 1528 patients.

In this paper [4], The authors provided us with comprehensive information regarding how they obtained datasets and predicted heart disease outcomes. They used face pictures to predict illness and also provided findings from several algorithms. They suggested their own algorithm, which proved to be the most accurate of the bunch. They primarily concentrated on neural networking, which is an essential aspect of the medical industry in terms of facial recognition. They collected information from 581 people with heart disease and 581 people who did not have heart disease. a new dataset with 581 heart disease patients samples and 581 H samples. The face photos are originally acquired using custom-built technology, out of which 4 facial key blocks are selected to represent a single sample. A facial colour scale with six-colour centroids is used to extract colour attributes for each face key block. They were around 88 percent accurate (87.71 percent).

In this paper [5], Cardiac pictures were employed by the authors to predict Cardio-Vascular disease. They collected cardiac images from around 100 age-matched controls and 300 patients with a history of myocardial infarction. Cardiac pictures are the results of Magnetic Resonance Imaging (MRI). These pictures are utilised to diagnose numerous cardiac issues, as such as the size and structure of the heart, as well as leaking heart valves. They developed a technique that allows us to determine how accurate each strategy would be if different Machine Learning Classification Algorithms were used. The accuracy of the MRI modality, as well as the SVM and DICTL algorithms, is around 96 percent; however, if just SVM is utilised, the accuracy drops to 86 percent.

In this paper [6], based on tomographic scans, the authors forecast Coronary Artery Disease. The database contains 553 patient labels, 343 of which are trained and 174 of which are tested, with a sample size of 36 for each patient. Tomographic pictures are used to provide detailed images of bones, blood arteries and internal organs, soft tissue. This aids in the prediction of a variety of heart-related issues. They give more accurate illness prediction by using machine learning and deep learning concepts. The inquiry indicated that the momentum strategy for forecasting coronary artery disease is a rid disease interaction since the physiological data as well as the crude data Computed Tomography is created in a few processes to provide an approximate result of 84 percent of the full cycle of analysing, recording, and forecasting.

In this paper [7], The writers provided us with information on predicting heart illness based on medical words. They spoke about several strategies for predicting cardiac disease. They used a dataset: UCI heart disease, which is an open dataset with 76 features, however only 14 were chosen for the study. Their dataset, on the other hand, contains data on patients and includes a total of 4,240 records and 15 characteristics for this research. They used many algorithms as Adaboost, extra trees, XGboost, gradient boosting, Nu SVM , SGDC, light gradient boosting Light-gbm and the stacking strategy in a classification step, yielding to score a accuracy of 95.83 percent.

In this paper [8], the Cleveland Heart Disease dataset is being explored for trying out purposes in this research. When the data set was constructed, there were 303 occurrences and 75 characteristics, but they only utilised 14 of them. In the system's architecture, Logistic Regression, K-Nearest Neighbour, Naïve Bayes Support vector machine, DT and machine learning classifiers such as Artificial Neural Network are used. To address the feature selection problem, 4 conventional feature selection methods, LASSO, MRMR, and MRMR, LLBFS as well as a novel feature selection algorithm, were given. The LOSSO cross-validation method is used withinside the system to determine the best hyper parameters. On features selected using the FCMIM FS approach, the classifier Logistic Regression MCC obtained 91.1 percent accuracy.

In this paper [9], the Prediction of Acromegaly is done using facial features, study suggest that facial changes are common in the patient also the changes are slow and patient are unable to notice it. They used the dataset consist of 124 patients in which 62 patients are diseased and 62 patients are healthy. 3-dimensional imaging techniques is used with 58 facial parameters were considered.

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A two-way analysis of variance (ANOVA) and a *post-hoc t*-tests were conducted to examine the variations of these parameters with disease status and gender, and using linear discriminant analysis (LDA) help to distinguished the characteristics of patients. The accuracy they got in female group is 92.86 percent and in male group is 75 percent.

In this paper[10], the study about an early disease prediction using facial emotional recognition is done. They discussed about stages of PD and in that facial expression and emotion plays very big role. The dataset they had used is Parkinson's Progression Markers Initiative (PPMI) standard dataset, in which total 188 Parkinson disease patients in which 87 are female and 107 male PD patients. They gave comparative study between CNN and VGG 16 (Visual Geometry Group) and got 96.5 percent accuracy.

In this paper [11], they suggest that Hypomimia and voice changes are the signs and classical motor disability in patients with Parkinson Disease. They used the dataset of 371 patients. In which 112 "on" phase and 74 "off" phase. They discussed 9 different machine learning classifier function. They used the assessment Movement Disorder Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) along with result as diagnostic value of 0.85 and the optimal diagnostic value as 0.90.

In this paper [12], they studied the different machine learning algorithms which help to give the idea about the different results. About the dataset, they took 70,000 patient records with 12 distinct features of the medical terms. The accuracy varies from 86 percent to 87 percent. But this study help us to understand how machine learning algorithm help to study the dataset. Different machine learning concepts were explained along with the results and confusion matrix. The highest accuracy they got is 87.28 percent.

In this paper [13], their study mainly focused on K-Nearest Neighbour (K-NN) and Random Forest with all the required machine learning concepts. They states that cardiovascular system of our body should remain fir for great health. They gave the great explanation about confusion matrix, different types of graphs for understanding about relationships between the attributes. The final accuracy for K-NN and Random Forest were 86.8 percent and 81.9 percent respectively.

In this paper [14], they merged two already available dataset to form big dataset. The two datasets are Cleveland Heart Disease dataset with 303 records and Statlog Heart Disease dataset with 270 records. Both the datasets having same type and number of attributes. They designed a model to detect and predict the heart disease, and they got the accuracy for SVM algorithm as 97.53 percent and sensitivity and specificity as 97.5 percent and 94.94 percent respectively. Along with that using Arduino for detection of body heartbeat, temperature, heartbeat, humidity.

III. IMPLEMENTATION IDEA

A. *Facial Features Which We Are Taking For The Prediction Of Coronary Artery Disease*

1) *Xanthelasma (Yellowish-orange, waxy growths on your skin):* A disorder characterized by the formation of tiny, soft, yellow papules loaded with cholesterol above the eyes. It may suggest that the person has a high risk of coronary artery disease, which may worsen over time.



Fig.8. Xanthelasma

2) *Arcus cornea (white, grey or blue opaque ring in the outer edges of the cornea):* Arcus senilis is another name for it. Which refers to the creation of a ring around the cornea, which is generally grey-black in colour. That ring-like shape is caused by lipid, fat, and cholesterol deposits, and it may increase with time.

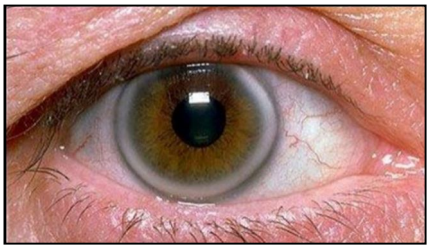


Fig.9. Arcus cornea

3) *Thinning or Grey Hair:* Coronary Artery Disease can be caused by hair thinning as well as greying. The disease's prognosis is also based on a patch of hair loss on the head.



Fig.10. Thin hairs

4) *Ear lobe crease:* The ear lobe crease (ELC) is a deep furrow that runs rearward from the tragus to the auricle. ELC is thought to be an indicator of coronary artery disease (CAD).



Fig.11. Ear lobe crease

5) *Wrinkles:* While aging is the most prevalent cause of wrinkles, smoking also contributes to wrinkles. Early wrinkling is also a cause of coronary artery disease.



Fig.12. Wrinkles

B. Related Work

The contrast in the characteristics of faces found in healthy and cardiac disease patients faces was analysed. It will make the forecast easier. It is beneficial to thoroughly examine the face images and characteristics. We extracted the person's facial features using cv2 and dlib, which will then be utilised for picture classification.

The extracted features are as follows:

1) *Eyes:*



Fig.13. Comparison of individual eye

The eyes will aid in the research of the disease by identifying the arcus cornea, which is a crucial characteristic in predicting the disease. An significant component of the Xanthelasma is also present where the nose and eyes connect. Also, wrinkles around the eyes aid in the discovery of other disease-related facts.

2) Both the Eyes with Eyebrows:



Fig.14. Comparison of both eyes

3) Face:

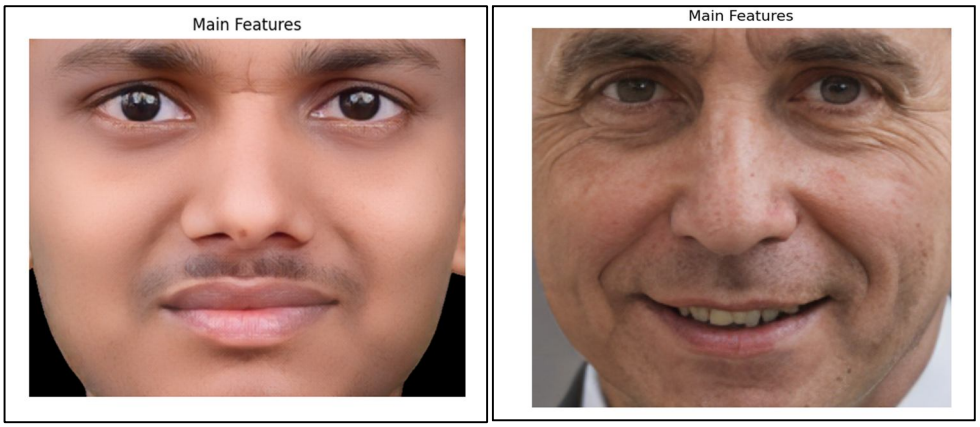


Fig.15. Comparison of face

IV. CHALLENGES

1) Traditional technologies were used for detecting the heart disease. We all know that medical tests take a long time and might be costly at times. As a result, there are obstacles in developing a solution that predicts CAD easily and quickly.
2) Another difficulty is to construct a system for prediction of CAD by substituting the medical reports with the facial images.
3) It is difficult to collect face images of patients for the establishment of a dataset. Also obtaining face photographs at proper angles is also a tough problem.
4) The researchers only examined for [2] Chinese patients. So, there are obstacles to establish a system based on different nationalities. Another problem is to compile a dataset of individuals from various nations who are performing research on both healthy and CAD patients.

V. FUTURE REASECRH DIRECTION

One of the important objectives of this review paper is to impart useful directions for future research. They are given below:

1) Create additional algorithms to improve forecast accuracy and to aid in the prediction of associated illnesses.
2) Different cultures (for example, Asians and Europeans) and age groups have different facial expressions and traits (children and adults). Such changes must be accommodated by CAD prediction systems.
3) Create a completely automated CAD prediction system that requires no human interaction.
4) A person with conditions such as facial weakness, facial paralysis, Bell's palsy, autistic disorder, sadness, or depressive disorders is unable to show facial emotions. A method or system for predicting CAD in such people should also be created.
5) The system should correctly anticipate the CAD with nil or minimal error rate.
6) In addition to CAD diagnosis, offer additional features such as heart disease prediction and CVD or CHD detection.
7) Design a system which will work online as well as offline.

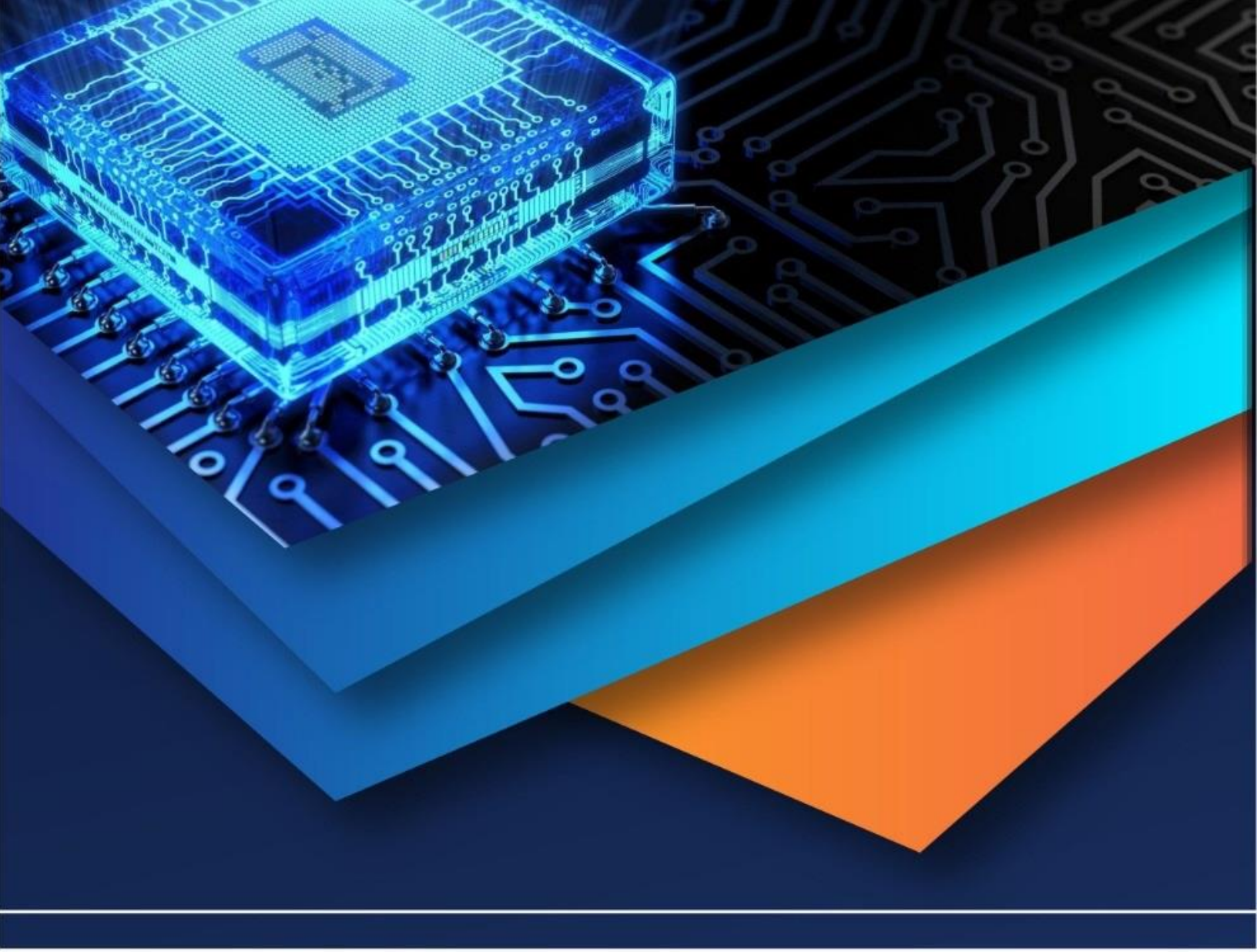
VI. CONCLUSION

This review study discusses the significance and usefulness of utilizing face pictures to predict heart disease. It discusses several methods for predicting heart illness, such as heart disease prediction using face photographs, heart disease prediction using tomographic images, heart disease prediction using cardiac diseases, and heart disease prediction using medical terminology. It also outlines the research that has been conducted in this area. It also includes recommendations for further study. It has been discovered that prediction using medical terminology provides more accuracy than other predicting methodologies, although accuracy using cardiac pictures and tomographic images is also greater. However, this requires time and money, since detecting heart disease from face pictures is an emerging and difficult subject. The scientific community should devote greater attention to this topic.

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