FAST PREDICTION OF KERATACONUS DETECTION USING SVM AND CORNEAL FEATURES

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ABSTRACT

Keratoconus is a disease were approximately one in 2,000 people globally suffer with keratoconus in one eye or both the eyes. It is commonly linked to a decline in visual acuity. In order to stop the disease's progression and eyesight loss, new instruments that can identify the condition early on are desperately needed, especially considering how common it is. This project aims to create and evaluate a machine learning system capable of early keratoconus detection. In order to identify keratoconus, a number of machine learning algorithms were used. The methods were then evaluated using actual medical data. 25 distinct machine learning models were implemented in Matlab, yielding accuracy ranging from 62% to 94.0%. A support vector machine (SVM) technique using a subset of the eight corneal parameters with the strongest discriminating power achieved the maximum accuracy level of 94%. The suggested model could help doctors identify keratoconus and assess corneal condition, which are difficult tasks to perform by subjective assessments, especially in the preclinical and early stages of the disease. The technique for evaluating the cornea and identifying early-stage keratoconus can be stand-alone-software or integrated into corneal imaging devices.

Keyword: - *SVM (Support Vector Machine), Keratoconus, prevalence, machine learning algorithms, Matlab, corneal, integrated, discriminating, preclinical, stand-alone-software*

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1. INTRODUCTION

A degenerative eye ailment called keratoconus results in the cornea becoming thinner and enlarging into the form of a cone, which distorts vision. It usually arises in youth or early adulthood and affects both eyes. Light sensitivity, astigmatism, and near-sightedness are all brought on by uneven corneal growth.

A condition called keratoconus damages the cornea and may be identified by a number of machine learning methods. The publication "Detecting Keratoconus by Using SVM and Decision Tree Classifiers with the Aid of Image Processing" uses SVM as one such approach. Multiple machine learning techniques are used in a different research titled "Detecting Keratoconus from Corneal Imaging Data using Machine Learning" to identify the condition early on. The work "A Hybrid Deep Learning Construct for Detecting Keratoconus from Corneal Maps" makes use of a hybrid deep learning construct. Based on corneal topographic maps, the algorithm's accuracy in detecting keratoconus is evaluated. Subclinical keratoconus is diagnosed using machine learning techniques in a different publication titled "Diagnosis of Subclinical Keratoconus Based on Machine Learning Techniques". Last but not least, a study named "Preventing Keratoconus through Eye Rubbing Activity Detection: A Machine Learning Approach" extracts keratoconus eye characteristics by analysing corneal topography using machine learning. The algorithm's ability to identify keratoconus is evaluated for accuracy.

This article provides literature reviews of studies on keratoconus that impair vision, as well as the conditions, causes, symptoms, and remedies. It also explores the SVM algorithm and talks about some of the studies and papers that have been written about it.

2. SYMPTOMS OF KERATOCONUS

2.1 Blurry Vision

Progressive blurriness in vision is a common symptom of keratoconus, particularly at night. The transparent, dome-shaped area in front of your eye progressively thins and expands outward to form a cone. Blurred vision and potential light and glare sensitivity are caused by a cone-shaped cornea.

2.2 Increased Sensitivity to Light

Photophobia, or light sensitivity, is common among those with keratoconus due to the irregular shape of the cornea. Heightened susceptibility to glare and bright light, which can make driving at night problematic.

2.3 Frequent Changes in Prescription

Patients may notice the need for frequent changes in their eyeglass or contact lens prescriptions as the condition progresses. Age, eye illness, shifting symptoms, or visual issues can all lead to a prescription modification. Both adults and children may see significant changes in their prescriptions for glasses and lenses.

3. CAUSES OF KERATOCONUS

3.1 Genetic Predisposition

Genetic factors may contribute to the development of keratoconus, according to available data. A family history of the illness increases a person's chance of getting it. Usually, it begins in your teenage years. However, it may appear sooner in infancy or not at all until you are thirty. Though less frequently, it can also impact those over 40.

3.2 Corneal Overexposure

The cornea may deteriorate as a result of excessive rubbing and persistent irritation, which might raise the risk of keratoconus. The cornea can be damaged over time by vigorously rubbing your eyes. If you already have keratoconus, it may potentially accelerate its progression.

3.3 Inflammation

The cornea's tissue can be harmed by inflammation brought on by conditions including atopic eye disease, asthma attacks, or allergies.

3.4 Certain disorders

According to studies, retinitis pigmentosa, Ehlers-Danlos syndrome, Down syndrome, and osteogenesis imperfecta are among the systemic disorders associated with keratoconus.

4. LEARNING

4.1 Current algorithm used

Diagnosis: Your eye doctor will do an eye exam, go over your medical and family history, and make the diagnosis of keratoconus. To learn more about the shape of your cornea, more tests could be performed. Exams used to identify keratoconus include:

Eye refraction: This exam evaluates your eyes using specialized equipment. You could be required to gaze through a phoropter, which is a device with wheels that hold various lenses. This tool assists in determining which combination results in the clearest eyesight. To examine the eyes, certain medical professionals may utilize a retinoscope, a portable device.

***Slit-lamp examination**:* This test entails shining a vertical light beam onto the surface of the eye and examining it with a low-powered microscope. The ophthalmologist assesses the form of your cornea and searches for further possible issues within the eye.

Keratometry: This test measures the reflection of a circle of light focused on the cornea. This establishes the fundamental form of the cornea. corneal mapping via computer. Specific photometric examinations, such corneal topography and corneal tomography, capture pictures in order to produce an intricate form map of the cornea.

Corneal tomography: Mainly used to can measure the thickness of the cornea. This type of testing can often detect early signs of keratoconus before the disease is visible by slit-lamp examination.

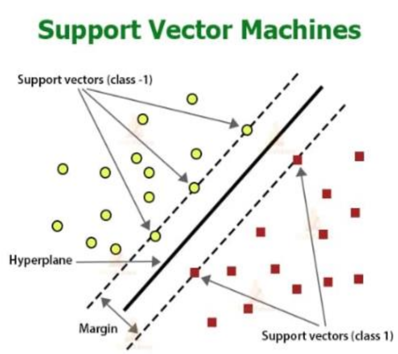
4.1 Modified algorithm used

SVM (Support Vector Machine)

SVM is an effective supervised method that performs best on complicated but smaller datasets. Although Support Vector Machines, often known as SVMs, are useful for classification as well as regression applications, their performance is typically greatest in the former.

When compared to the Naïve Bayes method, VM Classifiers predict more quickly and with excellent accuracy. As a result of using a portion of training points during the decision-making stage, they also consume less memory. When there is a distinct margin of separation and high dimensional space, SVM performs effectively.

Assuming that your eye functions similarly to a window, our goal is to preserve its integrity. This window occasionally becomes somewhat distorted or rough, which is known as Keratoconus and makes it difficult to see well. "Support Vector Machine," or SVM for short, functions much like an enhanced visual detector. It aids in our comprehension of this uneven structure and aids in determining the best course of action for correction. Imagine if we had a device that could capture an image of your eye and use lines to identify any bumps. SVM helps us draw those lines really well. It finds the best way to fix the bumps in your eye by making sure the lines are just right. So, SVM is like a helper for doctors, making sure they can understand and fix the bumps in your eye to keep your vision clear and sharp, like looking through a perfect window.



-Linear SVM

-Linear SVM

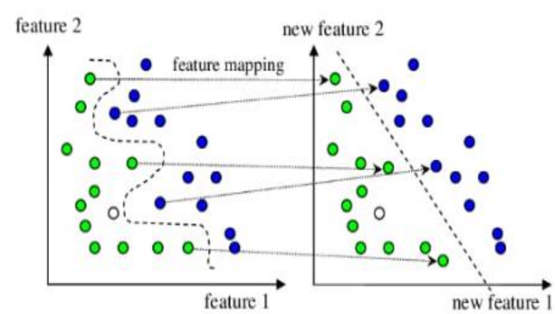


Chart - 1: SVM (Support Vector Machine).

Chart - 2: SVM (Support Vector Machine) Linear SVM

5. OVERVIEW OF THE TRAINING OF THE SYSTEM

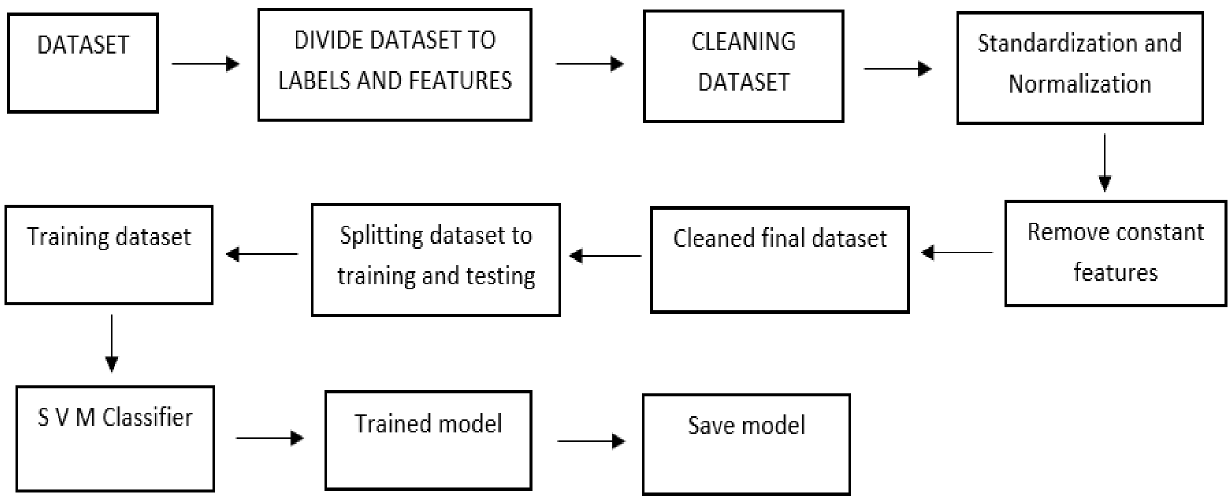


Chart - 3: Training the Model

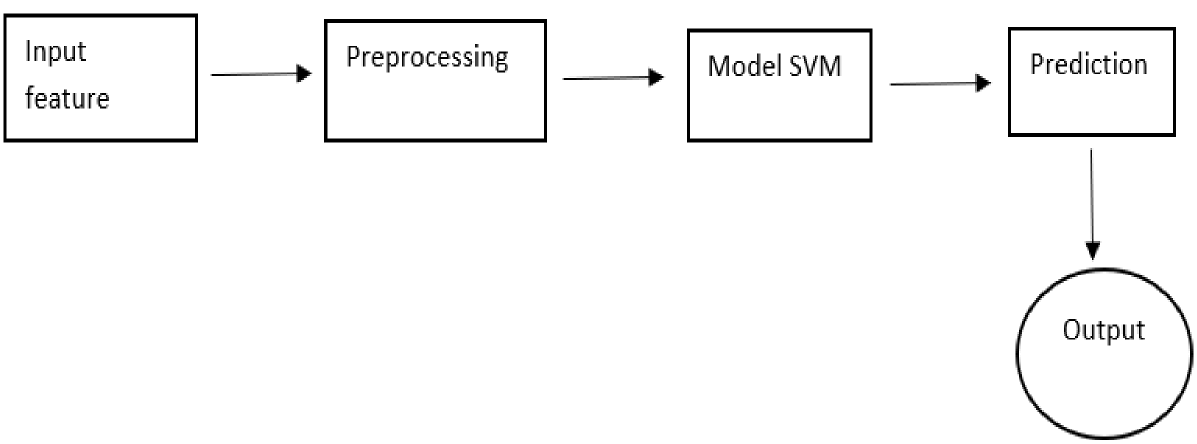


Chart - 4: Testing the Model

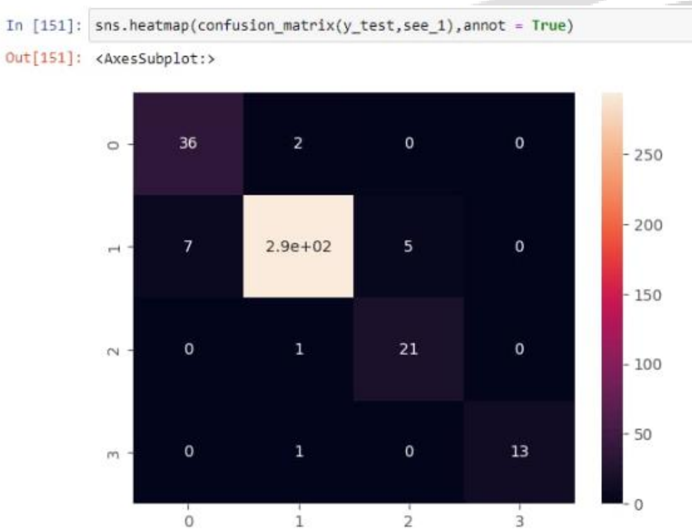
6. ACCURACY OF THE PROPOSED MODEL

6.1 Current accuracy

The accuracy of the paper is below 85% because the method used now for the keratoconus is manual detection which requires more time and the result. It almost takes about 3-4 weeks for the result to be reached to the doctor. To increase the speed of the response and the SVM algorithm is used.

6.2 Expected accuracy of the paper

The accuracy of the paper is expected to rise above 94% because the use of the SVM algorithm makes the result acquire quickly. The 144 features of the eye will be compared to show the dye contains which conditional state of the eye and what type of treatment should be done. Using the SVM algorithm in keratoconus helps in achieve the result as fast as possible.



Summary:

Algorithm	Accuracy	Recall	Precision
Optimized kNN	0.952	0.891	0.922
Decision Tree	0.933	0.861	0.847
Random Forest	0.958	0.917	0.914
linear SVM	0.946	0.913	0.941
kernel SVM	0.946	0.837	0.913
Logistic Regression	0.946	0.859	0.923

Accuracy: Tells us how many times the model was correct overall

Recall: Tells us how many times the model predicted a specific category correctly

Precision: Tells us how good the model's ability to predict a certain category

Chart - 5: Accuracy represented by Heat map

Chart - 6: Accuracy compared with other algorithms

7. IDENTIFYING KERATOCONUS USING SVM CLASSIFIER

The four states of the eyes that have been identified include Normal eye, Mild keratoconus state, Suspected keratoconus state, and Keratoconus impacted eyes. These categories are used to identify or discover the keratoconus problem that is now present. After that, the dataset is processed so that the characteristics may be matched and recognized within the given dataset by converting the picture features from the eyes into numerical values to assure consistency. Every numerical value is normalized to fall between 0 and 3 for the class. The Support Vector Machine (SVM) model has 144 characteristics per eye and a class of 4. Using the fit technique, the pre-processed features are sent into the SVM for training. Next, a different test set was used to assess the trained model.

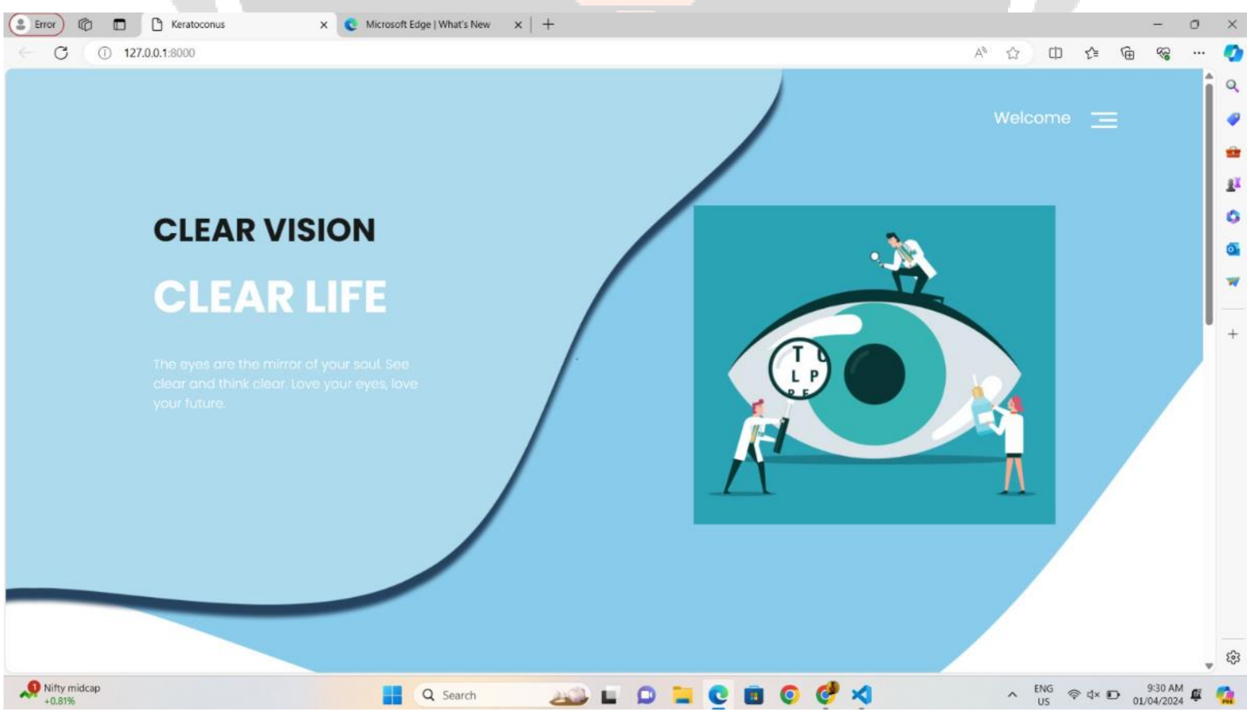
Building a SVM for Keratoconus eye detection is an iterative process that involves experimentation and optimization. In this process, during this procedure, we develop a training model that can correctly categorize the characteristics associated with various keratoconus states.

```
print(confusion_matrix(y_test,y_predictSVM))
print('Accuracy rbf SVM {0:.3f}'.format(accuracy_score(y_test,y_predictSVM)))
print('Precision rbf SVM {0:.3f}'.format(precision_score(y_test,y_predictSVM, average='macro')))
print('Recall rbf SVM {0:.3f}'.format(recall_score(y_test,y_predictSVM, average='macro')))

[[ 34   4   0   0]
 [  4 297   5   0]
 [  0   1  21   0]
 [  0   1   0  13]]
Accuracy rbf SVM 0.961
Precision rbf SVM 0.921
Recall rbf SVM 0.937

In [157]: print(classification_report(y_test,y_predictSVM))

              precision    recall  f1-score   support

           0       0.89      0.89      0.89        38
           1       0.98      0.97      0.98       306
           2       0.81      0.95      0.88        22
           3       1.00      0.93      0.96        14

    accuracy                           0.96       380
   macro avg       0.92      0.94      0.93       380
weighted avg       0.96      0.96      0.96       380
```

Chart - 7: 4 classes in SVM algorithm and their accuracy

8. RESULTING SYSTEM

The following is the welcome page of the Keratoconus State Detection System.



After logging in, the user can book appointments with a given number of eye specialists where the eyes is to be tested and the system to predict the Keratoconus state of the eye whether normal, mild, keratoconus or suspected. Upon submitting the 144 values collected from the test is matched with the inbuild dataset to figure out the eye disease after clicking the check button, the prediction will be displayed on the screen.

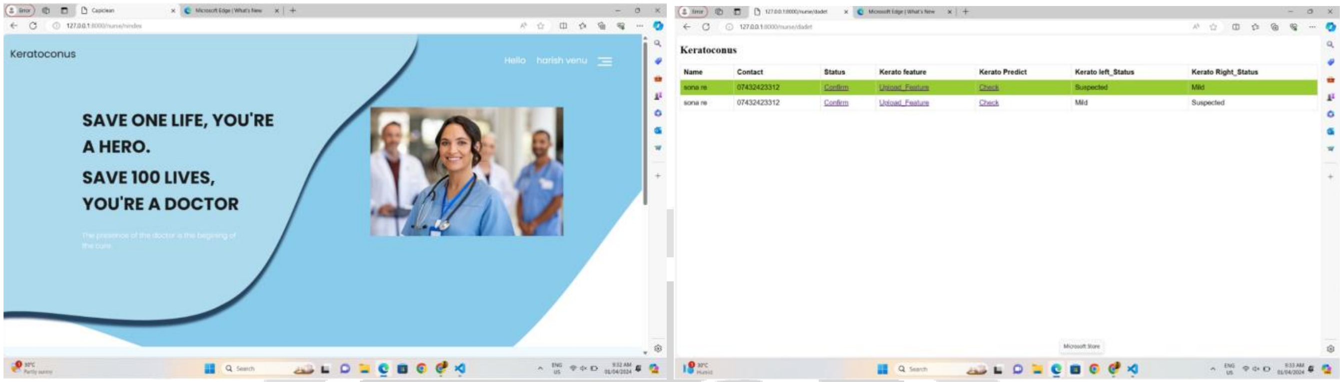


Chart-5: Page where the eye specialists enter the details

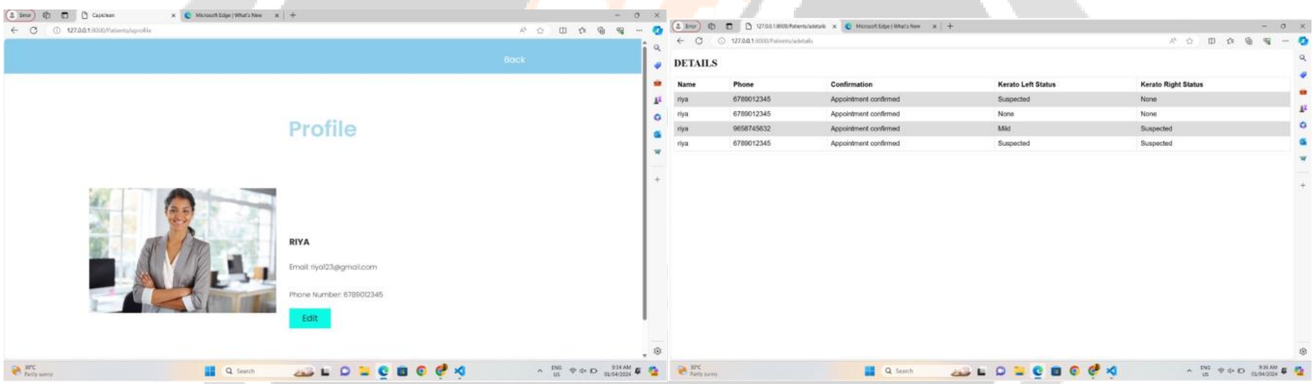


Chart 6: Prediction page for Keratoconus state of the eye

9. CONCLUSIONS

Support Vector Machine (SVM) is a kind of smart technology used in the context of Keratoconus that aids medical professionals in examining and comprehending the form of your cornea, the transparent front portion of your eye. Imagine that the SVM algorithm is a competent sculptor, and the cornea is a piece of clay. It attempts to determine the most effective method of reshaping the cornea to its typical, smooth curve by analyzing measurements and data from your eye. If you could picture yourself traveling on a rough road, SVM would be like a machine that helps to make the road smoother so you can see more clearly. It assists medical professionals in choosing the best course of action when it comes to correcting the irregular shape of your cornea through surgery or contact lens wear. Thus, surface keratoconus SVM is a useful technique that surgeons utilize to improve visual acuity by smoothing out the cornea, similar to repairing a rough road.

It assists physicians in deciding whether to correct your cornea's uneven shape with surgery or contact lenses in order to improve your vision. As a result, SVM in Keratoconus is a useful technique that surgeons employ to improve vision by smoothing out the cornea, much like a rough road.

The results are received as quickly as possible because the SVM database is used to create 144 values from the values that the machine of one eye captures. These values are then compared to determine the condition of the eyes. This facilitates the doctor's prompt implementation of remedial actions.

10. REFERENCES

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