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A CORONA RECOGNITION METHOD BASED ON VISIBLE LIGHT COLOUR ANDMACHINE LEARNING

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Abstract: Can we detect electric discharge states in gases based on the information on visual images? The document deals with a new kind of method where we build severaldetection models for different states of corona discharge by applying four kinds of machine learning algorithms to extract color, brightness, and shape information characteristics of visible images taken by a digital camera. Every model is then tested on a new set of images to measure its performance. The four different machine learningalgorithms are Support Vector Machine (SVM), K-Nearest Neighbor regression (KNN), Single Layer Perceptron (SLP), and Decision Tree (DT) algorithms.

In the existing system the traditional research of the discharge image was conducted from a qualitative point of view, such as morphology description, strong or weak light intensity, etc. However, only a few studies focused on quantitative evaluation can be found. With the development of computer techniques, the digital image processing methods have been applied extensively to study discharge characteristics, such as breakdown paths, discharge area, etc., especially in ultraviolet (UV), which can help tackle complex problems by using statistical techniques or the fractal theory. Although the images obtained by a high-speed camera (nanosecond timescale) can provide some details of a single discharge, the essence of gas discharge remains random under the same macroscopic physical conditions.

The proposed system proposes a method where we build several detection models of different states of corona discharge by applying machine learning algorithms to extract the color, brightness, and shape characteristics of visual images. In the secondpart, the experimental set of corona discharge is introduced. In the third part, the idea of three primary color- [red, green, and blue (RGB)] gray level histogram (RGB-GLH) of visual images will be introduced and the specific process of applying machine- learning algorithms to analyze the characteristic information of visual images will be discussed. In the fourth part, the prediction results of our model are reported and compared.

Introduction

Electric discharge is widespread in nature and is commonly used in the operation of industrial equipment. In an effort to understand the properties of electricaldischarge, researchers have investigated several physical quantities of discharge, including the voltage, current, optical spectrum, ultrahigh-frequency electromagnetic waves, number of discharges, phase angles (for ac discharge), etc.

However, such research works have been carried out without considering the relevant optical characteristics of discharge images even though the initial studies werebased on the image, such as that of the original meaning of corona. As a matter of fact, optical measurements are better suited than electromagnetic

measurements for the purpose of determining discharge geometries. If the optical characteristics of the discharge image can be incorporated in the diagnosis, the reliability of traditional recognition methods may be increased.

In the past, the traditional research of the discharge image was conducted from a qualitative point of view, such as morphology description, strong or weak light intensity, etc. However, only a few studies focused on quantitative evaluation can be found. With the development of computer techniques, the digital image processing methods have been applied extensively to study discharge characteristics, such as breakdown paths, discharge area, etc., especially in ultraviolet (UV), which can help tackle complex problems by using statistical techniques or the fractal theory.

Although the images obtained by a high-speed camera (nanosecond time scale) can provide some details of a single discharge, the essence of gas discharge remains random under the same macroscopic physical conditions. On the other hand, the discharge used in some industrial applications is a collection of a large number of micro discharges. Therefore, a statistical evaluation of discharge images covering a large number of stochastic processes on a long-time scale is still of great significance, compared with the research methods of high-speed cameras.

The colour information produced by optical radiation has not been widely used in the study of discharge images. In the year 2000, Russell and Jones proposed theuse of chromatic attributes to directly monitor the stability of plasma states. However, the studies were then limited only to the use of optical-electrical detection techniques, which can only be applied to a relatively large area for achieving a general understanding.

In the year 2009, Koppisetty et al. attempted to establish a correlation of colour information of the visual images with the progress of partial-vacuum breakdown. In the year 2016, Serrano et al. used colour information to monitor arc welding. Developments in nonthermal plasmas have stagnated. We conducted research on the colour difference in corona and surface discharge and filed for patents on using colour information to detect the discharge state.

In the year 2017, Prasad and Reddy introduced a method for extracting colour information from discharge images, which was then converted to brightness metrics tostudy the relationship with discharge power, which is an important progress. To summarize, utilizing colour information in the study of spatial distribution of nonthermal plasma discharge is an emerging area of research, due to the recent development of high-resolution digital cameras.

Research in AI/Machine Learning has made great progress in recent years. These techniques have demonstrated a great practical value in solving high-dimensionalnonlinear problems and have been widely used in high-voltage fields. For example, in the past, there has been research on applying support vector machine (SVM) and neural networks to recognize patterns of insulator conditions, PRPD, ultrahigh frequency for pattern recognition, and fusion plasmas.

Besides SVM, we have also explored using K-nearest neighbour regression (KNN), single layer perceptron (SLP), and decision tree (DT) for analysis. These algorithms are widely used for regression tasks that would require supervised learning. Here, we will not go into details of the algorithms, and for a detailed description of themachine learning algorithm, one can refer to many literatures available. This proposesa method

where we build several detection models of different states of corona discharge by applying machine learning algorithms to extract the colour, brightness, and shape characteristics of visual images.

Input and Output Design

The input design is the link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system.

The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and keeping the process simple. The input is designed in such a way so that it provides security and ease of usewith retaining the privacy.

The input design serves as a crucial bridge between the information system and its users, ensuring that data can be efficiently and accurately captured for processing. This process involves developing specifications and procedures for data preparation, which are necessary to transform transaction data into a usable form. Thereare various methods through which this can be achieved, including inspecting the computer to read data from written or printed documents, or having individuals directly inputting data into the system through manual entry.

A key focus of input design is to streamline the input process, aiming to control the amount of input required while minimizing errors and avoiding unnecessary delays or extra steps. By simplifying the data entry process, input design helps improve efficiency and user productivity, enabling users to perform their tasks more effectively.

Furthermore, input design places a strong emphasis on security and privacy. Measures are implemented to ensure that sensitive data is protected and that unauthorized access is prevented. This may involve incorporating authentication mechanisms, encryption protocols, and access controls to safeguard the integrity and confidentiality of the data being inputted into the system.

Additionally, input design aims to enhance the user experience by providing ease of use and intuitive interfaces. User-friendly input forms, validation checks, and error messages help guide users through the data entry process, reducing the likelihood of mistakes and enhancing user satisfaction. By prioritizing usability and accessibility,input design ensures that users can interact with the system comfortably and efficiently,regardless of their level of technical expertise.

Input design plays a crucial role in ensuring that data can be accurately captured and processed within an information system. By focusing on efficiency, accuracy, security, and usability, input design helps optimize the data entry process, facilitating smooth operations and enhancing the overall effectiveness of the system.
Input Design considered the following things:

- What data should be given as input?
- How the data should be arranged or coded?

- The dialog to guide the operating personnel in providing input.
- Methods for preparing input validations and steps to follow when error occur.

Output Design

A quality output is one, which meets the requirements of the end user andpresents the information clearly. In any system results of processing are communicatedto the users and to other system through outputs. In output design it is determined howthe information is to be displaced for immediate need and also the hard copy output. Itis the most important and direct source information to the user. Efficient and intelligentoutput design improves the system's relationship to help user decision-making.

Quality output in a system is paramount, as it directly impacts user satisfaction and decision-making processes. A quality output is one that not only meets the requirements of the end user but also presents information clearly and effectively. In any information system, the results of processing are communicated to users and other systems through outputs. Therefore, output design plays a crucial role in determining how information is displayed for immediate use and in hard copy format.

Output design involves considering the needs and preferences of end users toensure that information is presented in a way that is accessible, understandable, and actionable. This includes determining the format, layout, and organization of output documents or displays to facilitate easy comprehension and interpretation. Clear and concise presentation of information helps users quickly grasp key insights and make informed decisions based on the data provided.

Efficient and intelligent output design goes beyond simply presenting data—it aims to enhance the system's relationship with users by empowering them to make better decisions. By organizing and formatting information in a logical and intuitive manner, output design supports user decision-making processes and enables users to extract valuable insights from the data. This may involve incorporating visual aids, suchas charts, graphs, or tables, to facilitate data analysis and interpretation.

Moreover, output design considers the immediate needs of users as well as thelong-term requirements of the organization. It ensures that output formats are adaptableand scalable to accommodate evolving needs and changing circumstances. This flexibility allows the system to remain responsive to user feedback and evolving business requirements, ensuring that output remains relevant and valuable over time.

Additionally, output design encompasses considerations for both digital and hard copy outputs. While digital outputs may be optimized for presentation on computerscreens or mobile devices, hard copy outputs may require formatting for printing or distribution. Output design ensures that both digital and hard copy outputs are consistent in terms of content, branding, and usability, providing a seamless user experience across different channels.

Effective output design is essential for delivering quality information to usersand supporting decision-making processes within an information system. By presentinginformation clearly, efficiently, and intelligently, output design enhances the system's usability, usefulness, and overall value to users and stakeholders.

Sample Test Cases

Table No:1 Sample Test Cases

S.no	Test Case	xceptedResult	Result	arks (IFfails)
1.	User Register	If User registration successfully.	Pass	If already user exists thenit fails.
2.	User Login	If User name and password is correct then it will getting valid page.	Pass	Un Register Users will notlog in.
3.	t Data Preprocess	ge has toupload	Pass	Corona Discharge Image must be select
4.	H Gray Level Histogram	Image Gray level Histogram will generate	Pass	mage GLH willcreate based on Python library
5.	RGB Color Recognitions	Image RGB Score and generated on graph	Pass	Each image RGB Colors based on image
6.	Image Brightness Calculated	Per block and per black pixels calculated	Pass	Image pixelblock will calculate
7.	lease RMSE Calculated	Means RMSE first we need tofind RMSE	Pass	Rise Score calculated basedon this MeanRmase calculated
8.	Models Executed	For out four algorithms has executed and calculated 3 features	Pass	Models executedand predicted the results
9.	Admin login	Admin can loginwith his login credential. I success he gethis home page	Pass	Invalid login details will notallow here
10.	Admin canactivate the register users	Admin canactivate the register user id	Pass	If user id notfound then it won't login.

Result and it's Discussion

Result

Home page
The user First enter into Home Page with the link provided.

Fig 1 Home Page

User Register page
The User can register the first. While registering he required a valid user email andmobile for further communications.

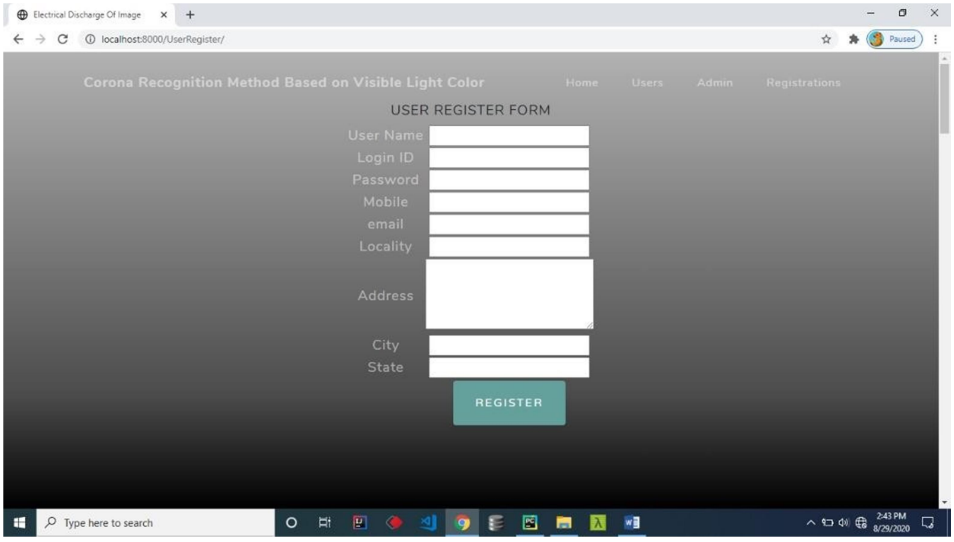

Fig 2 User Register page

User Login page
Once the user register then admin can activate the customer. Once admin activated thecustomer then user can login into our system.

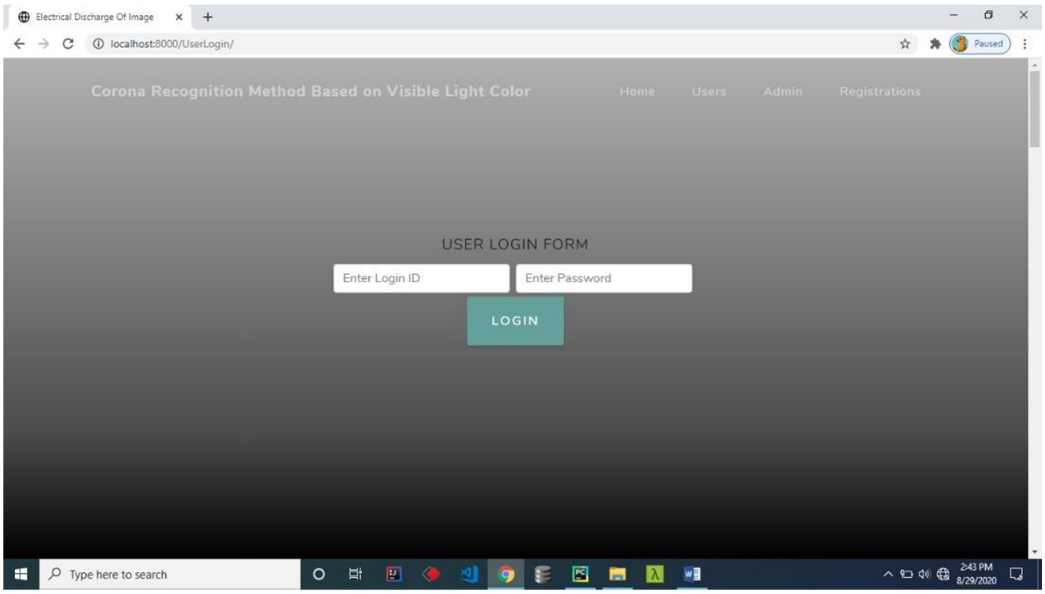

Fig 3 User Login Page

Image Upload page
User can upload corona discharge images by browser. in the server side we need toexecute two times

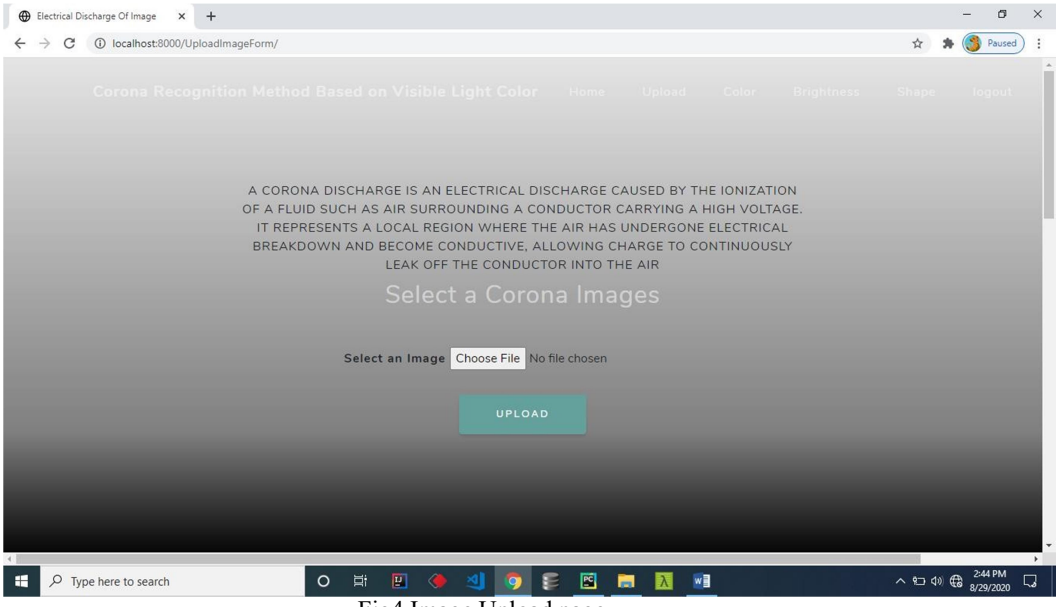

Fig4 Image Upload page

Input Image
The user can test the colour features as input for all images and can find theMeanRmse, same we can test Shape and brightness features.

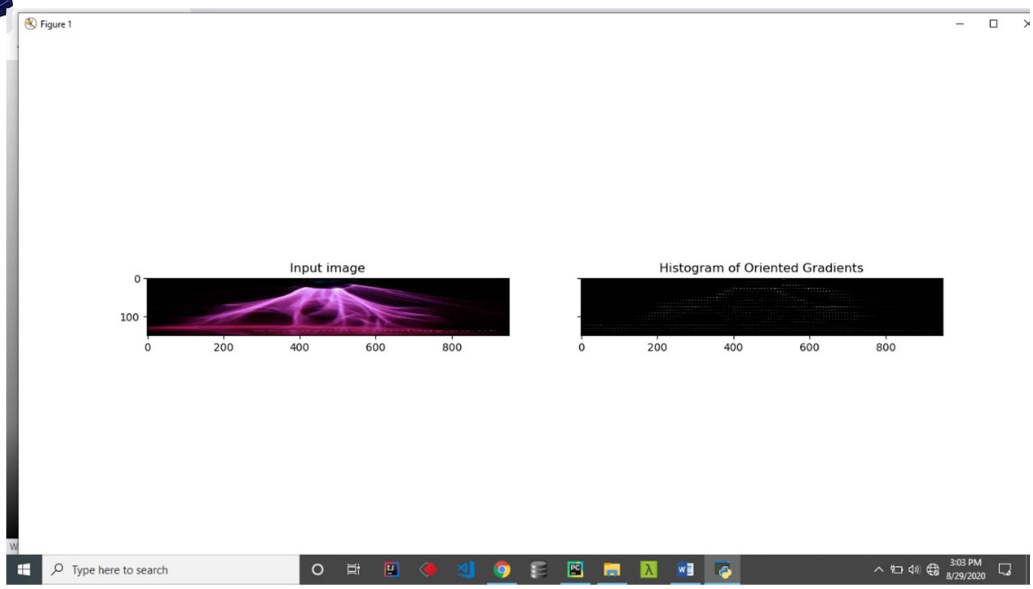

Fig 5 Input Image

Admin login page
Admin can login with his credentials. Once he login he can activate the users. Theactivated user only login in our applications.

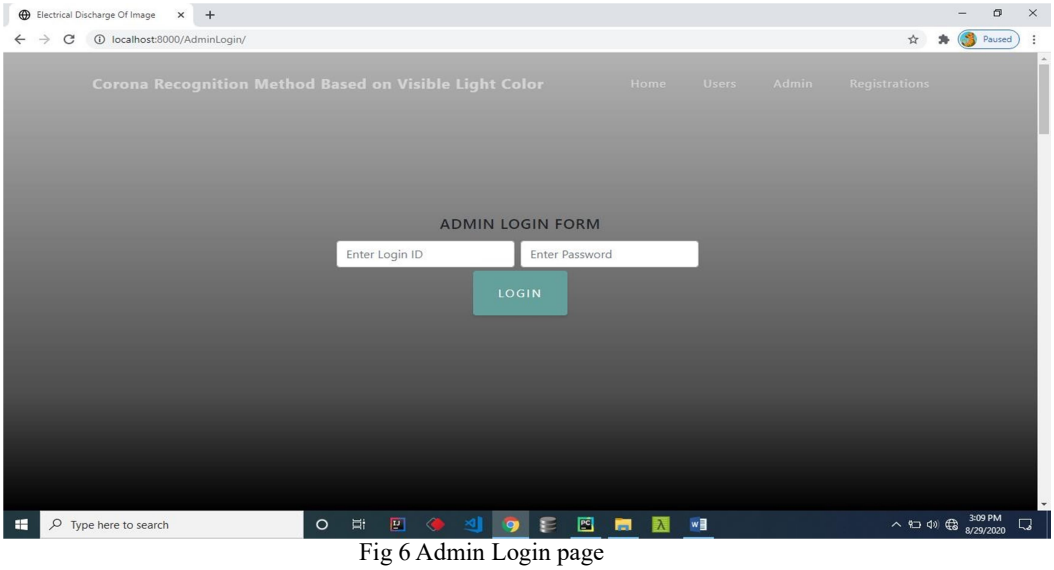

Fig 6 Admin Login page

Activating Register Users
The admin can view the all-user uploaded images. By clicking any image he can get the Graph of RGB values, Histograms graph. The image resining and converted into Gray scale also displayed to the admin side.

Fig.7 Activating Register Users

Colour Features

The graph are grayscale, rgb, glh values are curved in the graph. The user can test thecolour features as input for all images and can find the MeanRmse, same we can test Shape and brightness features.

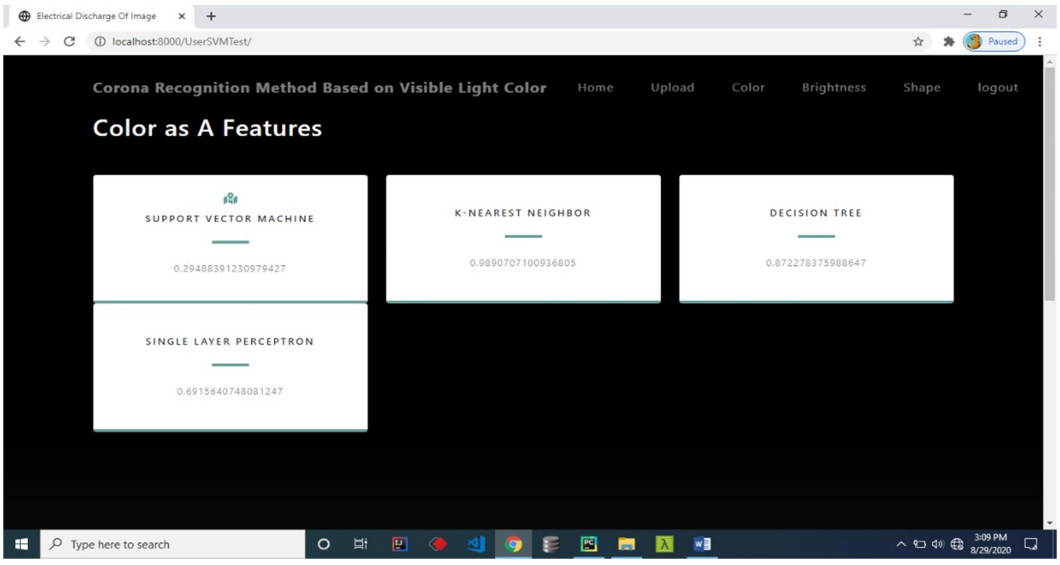

Fig 8 Colour Feature

Brightness Features

The graph are grayscale, rgb, glh values are curved in the graph. The user can test thebrightness features as input for all images and can find the MeanRmse, same we can test Shape and brightness features.

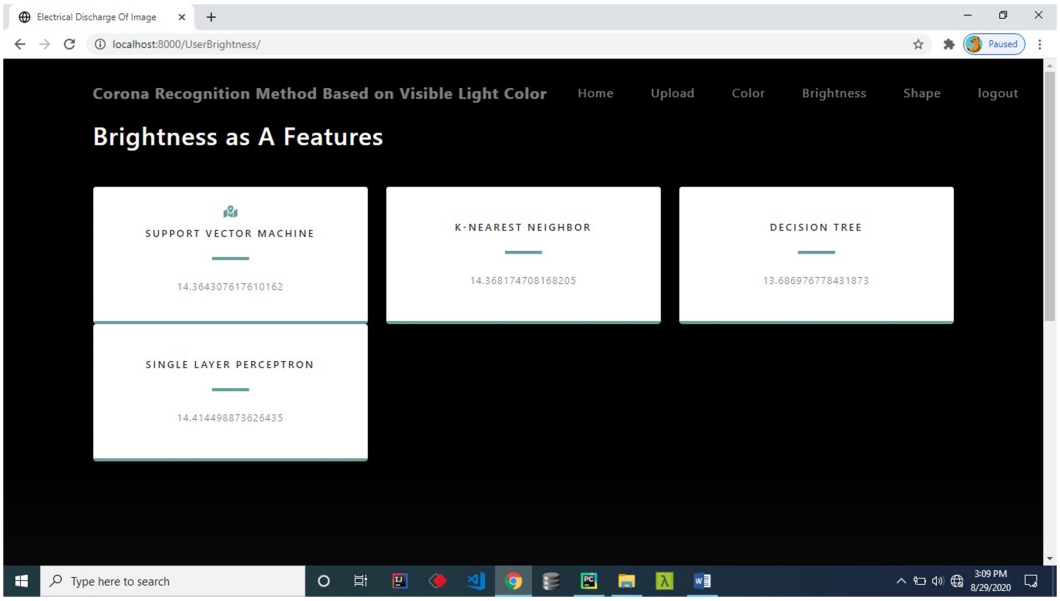

Fig 9 Brightness Feature

Results Table

Fig 10 Results Table

Conclusion and Future Work

The prediction shows that the colour features perform the best among all the three characteristics information and the KNN algorithm performs the best among all four algorithms. The model shows consistently good performance with different cameras and camera settings as well. Discharge produces radiation of UV,

visible, andnear infrared wavelengths. Past studies focused mostly on the UV spectrum, yet the measurement of the light spectrum demonstrates that radiation intensity of the visible spectrum can be high as well.

Objects that can produce radiation of visible spectrum is affected by radiation across all spectra. Because of this, even though our RGB-GLH method uses informationonly from the visible spectrum, it is still able to encompass discharge status-related information across spectra, thus enabling us to build a more successful model. The RGBcolour information characteristics method can also be applied to other discharge typesother than corona.

Future Work

Corona discharge only forms when the electric field (potential gradient) at the surface of the conductor exceeds a critical value, the dielectric strength or disruptive potential gradient of the fluid. In air at atmospheric pressure, it is roughly 30 kilovolts per centimetre, but this decreases with pressure, so corona is more of a problem at highaltitudes. A corona discharge is an electrical discharge possible because of the ionization of air surrounding a conductor that is electrically charged. The corona treatment is frequently used for polypropylene, PVC, PET, polyethylene, metallized surfaces, paper, and paperboard stock. Electric cables, automotive components, 3D parts, medical devices, pipes & tubes, board & foam, domestic appliances, extruded profiles are some components that are processed with corona.

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