Mobile Light Flicker Analyzer

Project Plan

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BACKGROUND

Climate change is one of the main points of concern at the moment across the world, and individuals are trying to help in whichever way they can. Switching from traditional light bulbs to LED bulbs sounds insignificant but the cumulative results create a significant impact. According to the U.S. Environmental Protection Agency Reports, about 9 billion pounds of greenhouse gases can be prevented from being released into the atmosphere if only one light bulb in American homes are replaced by the Energy-Star rated light bulb [1].

These new LED bulbs have a drawback - flickering of light. Light flicker refers to the quick and repeated changes in the brightness of light over time due to the change in voltage supply [2]. It is not a unique drawback, but it is quite predominant in LED bulbs as they fluctuate between less than 10% to 100% dimness, whereas fluorescent lights fluctuate between 35% and above [2]. These continuous flickering of light might seem trivial at the first glance, and for someone without any special condition, a minor exposure might go unnoticed. But for someone who experiences visual hypersensitivity, such as in cases of Autism Spectrum, even that minor flicker can create obstacles in everyday life [3]. Common people when exposed to a continuous duration of light flicker also experience various ill-effects such as headaches, migraines, blurred vision, fatigue and eyestrain [3]. This lowers the overall productivity of an individual in a working environment. In certain special situations, where operators' quick responses are essential for the safety of that person and others present there, excessive flickering might cause the fast-rotating elements present in an operator’s field of vision to appear to be moving slowly or even stopped [4]. This might prove to be fatal in certain cases. In the field of broadcasting, flicker greatly impacts the lighting required for digital image capture [4].

Currently, a complex system is required to test this light flicker, which results in overlooking of this aspect by some companies and moreover, it’s not possible for the consumer to test it at their end. At the moment, a temperature regulated, isolated test enclosure is required so that no stray light can interfere with the results. Instruments such as photodetector, signal amplifier and digital oscilloscope are presently needed to test the light flicker [5]. The unavailability of such instruments leads to consumers buying lights which can prove harmful for themselves in the long run.

Due to these harmful implications of this light flicker, few governments have started regulating the amount of permissible light flicker. Few startups are trying to find different ways to quantify this light flicker in a simpler manner for the end consumers. We also wish to serve the end consumers and be a preliminary quality check for LED bulb manufacturers. By providing a simple mobile user interface and with the help of machine learning, we wish to make it easier for the end user to check for light flicker levels before making a purchase and ensuring their well-being and safety.
OBJECTIVE

The project aims to develop a mobile application to check light flicker and compare different light bulbs for both consumer needs and industrial purposes. This friendly, handy means of comparing light bulbs for health concerns will allow consumers to know the health hazardous parameters of a light emitting source with the help of a photo or a video taken with their mobile camera and will serve as a preliminary checking for industrial purposes.

In a world dominated by Fluorescent Lamps(CFLs) and Light Emitting Diodes(LEDs) as major light emitting sources, the health concerns of the consumers have also increased and remains undetected due to lack of handy devices that are accessible to each and every consumer. We aim to create such a mobile application that uses machine learning techniques to classify flicker images of the bulbs into different flicker related parameters to give a better analysis to the consumer of the light emitting source’s efficiency.

We will create a database with labelled data from different light bulbs images and videos, captured through mobile cameras and rolling shutters cameras and apply machine learning techniques on the images captured by the consumer from his or her camera to give a detailed analysis on the harmful effects of light bulbs, mainly containing percent flicker, order of flicker index and order of flicker frequency.

The end product of the project aims to deliver a mobile application that when presented with a picture or a video of the light emitting source produces a result showing the safety level of the source.
METHODOLOGY

The different tasks involved in the creation of the Mobile Light Flicker Analyzer have been discussed below.

3.1 CREATING DATABASE

Our first task is to create a database for our machine learning model that can be used to train the model and increase its accuracy over time. We will take pictures and videos of different light bulbs (both CFCs and LEDs) with mobile cameras and rolling shutter cameras and after processing the images and the videos with noise filter we will label them into several categories from good to bad (a range of values from 1 to 5, 5 being the best to use) depending on their flicker parameters, namely, percent flicker, order of flicker index and order of flicker frequency.[6] The flicker parameters will be calculated based on pixel analysis and black and white line column analysis of the images taken.[6] These parameters will help to determine the class that a particular image will belong to.

3.2 TRAINING MACHINE LEARNING MODEL

After our database has been created, we will train our machine learning model on that database by dividing our dataset into training set, validation set and test set datasets. Since we use labelled data, we plan to use machine learning models based under supervised learning and under classification models under multiclass learning.

A few machine learning algorithms are compared below:

Comparing Support Vector Machine (SVM) and Logistic Regression for multi-class classification we can say that while logistic regression gives a probabilistic approach to the solution, SVM can be used for more discrete results and the latter might be in our favour as SVM in general works better with unstructured data like images with less overfitting chances [7]. Given our training dataset to be large enough in the range of thousands of samples, we can first use logistic regression to see if our data is linearly separable and if it fails then we can try SVM with a gaussian kernel [8].

On the other hand, Artificial Neural Network (ANN) seems to be a positive choice for our model. Comparing it with SVM, ANN is much faster in terms of prediction time while SVM is much faster in terms of the training time [9]. As there is no restriction of training time in our case and faster prediction time will be really advantageous for our mobile application, ANN can be really helpful. Also, as and when consumers use the app new data adds to our database and ANN will self-improve over time. Besides this, we can also constrain the size of networks and the number of
layers unlike that in SVM with non-linear kernels but at the same time doing so might make the model easier to learn rather than train and thus overfitting risks come up.

A very good multiclass classification problem machine learning model could be Convolution Neural Network(CNN) which works very well especially for images especially as a feature extractor in the images although it has a high computational cost and a slower processing time with the need of huge dataset[10]. Since CNN can be affected by images taken from different angles and different lighting, we will process our database in black and white and take our images from the front of the light emitting source. Random forest, a possible multi-class classification model, although much easier to train with a robust model in the end, is not considered as it works best with tabular data.

A possible solution can also be to classify our multi-class classification problem into one-vs-one or one-vs-rest categories[11]. The one-vs-one classification splits a multi-class classification problem into one binary classification problem per class while a one-vs-rest splits a multi-class classification problem into one binary classification problem per each pair of classes and then Perceptron, Linear Regression or SVM with linear kernel models can be easily applied to each of the classes.[11]

We aim to follow the aforementioned approaches and with time make adjustments to our model depending on our dataset and accuracy results.

Once our model has been trained and tested with our datasets we are ready to implement it into our mobile application that can give us the desired results.

3.3 FLICKER ANALYZER

The images captured from a consumer's phone are now processed by our trained machine learning model to compute metrics estimations of percent flicker, the order of flicker index, and order of flicker frequency and the new image by the consumer is added to our database for further improvement and better learning of our model. If the consumer records a video of the light emitting source then the video is processed in the application by taking out frames, smoothing the frames and then submitted to the model.

3.4. MOBILE APPLICATION

Finally, we have a mobile application that embodies the machine learning algorithm to give the consumer result and analysis on the safety parameters of the light-emitting source when presented with an image or a video.
TIMELINE

4.1 September 2020

I. Research on light flicker and its implications on humans and technology.
II. Market analysis and review of published papers on light flicker from various light emitting sources.
III. Creation of detailed project plan to outline project background, objectives, methodology, schedule and milestones.
IV. Website development to display key information about the project
V. Phase 1 Deliverables due 4th October 2020.

4.2 October 2020 to December 2020

I. Collection of data for creating our own database.
II. Processing and labelling collected data to make it suitable for our machine learning model.
III. Research on existing machine learning models and techniques on light flicker analyzer methodologies.
IV. Testing different machine learning models on our database to identify the most accurate algorithm.
V. Creating version 1 of our mobile application.

4.3 January 2021

I. Testing and implementation of our machine learning algorithm integrated with the mobile application.
II. Creating an Interim Report that explains implementation, development scope and current progress.
III. Creating an initial presentation for presenting the current progress and tested phases.
IV. First Presentation between 11th to 15th January 2021.
V. Phase 2 Deliverables due 24th January 2021.
4.4 February 2021 to April 2021

I. Improving machine learning model and UI/UX of our mobile application.
II. Creating a final report to thoroughly explain the goals achieved, problems solved, constraints, and future scope.
III. The final pitch to showcase the use of our mobile application and the integrated machine learning algorithm.
IV. Phase 3 Deliverables due 18th April 2021.
V. Final Presentation between 19th to 23rd April 2021.

4.5 May 2021 to June 2021

I. Project Competition on 4th May 2021.
II. Project Exhibition for selected projects on 2nd June 2021.
REFERENCES


