A Web Application for Social Distancing Monitoring and Data Analysis

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Abstract **— The ongoing COVID-19 coronavirus outbreak has become a serious concern causing a global disaster with its deadly spreading. Due to the inadequacy of effective remedial agents and the shortage of vaccinations against the virus, the population is endangered, and continually the vulnerability increases. In the current situation, social distancing is an adequate precaution to tackle the spread of the pandemic virus. The risks of spreading this virus can be minimized by avoiding physical contact among people. In this paper, we propose a web-based system that could help administrators of a public place in monitoring social distancing. Administrators can register themselves on our platform, add their cameras to our platform and get a detailed analysis of social distancing for all the cameras installed on their premises on a dashboard. We used a hybrid Computer Vision and YOLOv4-based Deep Neural Network (DNN) model called DeepSocial for automated people detection in the crowd in indoor and outdoor environments using common CCTV security cameras. An alert is sent to the registered camera admins in case if the social distancing is severely violated. Additionally, we developed a plugin tool, which can be added to the website of an organization if the organization has registered on our system. The plug-in tool displays real-time social distancing data of organization premises and gives an idea of the safety of the premises to the probable visitors.**

Keywords --- social distancing, COVID-19, human detection and tracking, distance estimation, deep convolutional neural networks, crowd monitoring, web application, IP camera

I. INTRODUCTION

The novel generation of the coronavirus disease (COVID-19) was reported in late December of 2019 in Wuhan, China. Within a few months, this virus came forward as the worldwide epidemic outburst in May 2020. The World Health Organisation (WHO) declared the situation as a pandemic [7]. The statistics by worldometers.info on 23rd April 2021 confirm 145 million infected people and a scary number of 3,091,203 deaths in 200 countries [6]. With the growing trend of patients, there is still no effective treatment available for the virus. While every scientist, healthcare organisations, and researchers are continuously working to produce relevant and most effective medications for the deadly virus, no substantial success has been reported and hence there is no certain treatments or recommendation have been discovered to prevent or cure this disease. Therefore, taking precautions plays an important role to reduce the spread of infection. These crucial situations have forced worldwide communities to look for various alternative ways to reduce the extent of the COVID19 virus.

Social distancing refers to safeguard actions to prevent the rapid expansion of the disease, by minimizing the vicinity of human physical contacts in covered or crowded public places such as schools, colleges, offices, workplaces, gyms etc to stop the widespread of the infection risk. The virus spreads when an infected person sneezes, coughs or talks, the droplets from their nose or mouth disperse through the air and affect nearby individuals. The droplets can also enter into the lungs through the respiratory system, where it starts killing lung cells. According to the prescribed norms by the WHO, the minimum distance between individuals must be at least 6 feet (1.8 meters) to maintain adequate social distancing among the people [8]. According to a report by Health Ministry published in May 2021, a COVID-19 infected person who is not following any social distancing measure can spread the virus to as many as 406 people in 30 days.[9]

If social distancing is implemented at the initial stages, it can perform a significant role in overcoming the spread of the virus and prohibiting the pandemic disease's peak. During the ongoing COVID-19 pandemic situation, various governments have implemented several social distancing measures such as travel restrictions about interstate travelling, closing public places and much more. It can be noticeable that social distancing can decrease the number of infected persons and reduce the burden on the healthcare sector. It also lowers the fatality rates by ensuring that the number of infected cases does not exceed the public healthcare sector capability. In such circumstances, technologies play a vital role in promoting social distancing standards. For example, wireless positioning systems can be effective to help people maintain a safe distance by measuring the distances among individuals and warning them when they come or are too close to each other. Besides these other technologies such as Artificial Intelligence technologies can be applied to facilitate social distancing. The majority of governments and national health authorities have set the 2-m physical distancing as a mandatory safety measure in shopping centers, schools and other covered areas. [10]

The major contribution of this research can be highlighted as follows:

• This study aims to support the reduction of the coronavirus spread and its economic prices by providing an AI-based solution that might help the administrators of a public place by mechanically monitoring and detecting violations of social distancing among people.

• The system is based on DeepSocial[4] model for detection, tracking, and distance estimation among people. We analyze the data generated by the system and present a platform which could be helpful for the administrators of a public place and ease their work of social distancing monitoring by presenting the video outputs and data in a visualised and lucid form.

• The developed system can be used for monitoring social distancing at various public places such as Airports, Hospitals, Retail shops, metro stations. Further analysis of the data obtained from the system gives additional insights to the administrators regarding the safety and crowd control of the place.

• A dashboard which displays three different video outputs, various statistics and visualisation of the data generated after processing of video input.

• An alert system to notify the registered admins of the camera about the violation of social distancing in the camera observed region so that they can take appropriate action on time.

• A plug-in tool that can be added to the website of a registered organization or public place. The plug-in tool displays the real-time data generated by the system which is fetched from the server using API. The data is useful for people who want to visit a public place. Such people can get

the idea of the safety of the place by checking the data on the website. This can help them in making an informed decision if they want to visit the place at that time or later.

II. Literature Survey

In this section, we provide a brief literature review. In Consideration of ongoing coronavirus pandemic, many countries have used technology-based solutions, to inhibit the spread of the disease. For example, some of the developed countries, use GPS data to monitor the movements of infected or suspected individuals to find any possible exposure among the healthy people.

The utilization of Artificial Intelligence, Computer Vision, and Machine Learning, can help to discover the correlation of high-level features. For example, it may enable us to understand and predict pedestrian behaviours in traffic scenes, sports activities, medical imaging, or anomaly detection, by analysing spatio-temporal visual information and statistical data analysis of the images sequences.

Recent advances in Computer Vision, Deep Learning, and pattern recognition, as the sub-categories of the AI, enable the computers to understand and interpret the visual data from digital images or videos. It also allows computers to identify and classify different types of objects. Such capabilities can play an important role in empowering, encouraging, and performing social distancing surveillance and measurements as well. People detection in image sequences is one of the most important sub-branches in the field of object detection and computer vision. Although many research works have been done in human detection and human action recognition

In the study by Wen Yaomin, the author have used the GMM model to extract the foreground of the frame, which restrains the environmental interference in the scenic spot and obtain the stable foreground image.

Cluster feature points based on density centre, which can exclude the abnormal points produced by background changes.

Then according to study, established model between the number of scenes and the feature points, uses the SVR algorithm to predict the number of people. [1]

According to the Study by Dr. S. Syed Ameer Abbas, Authors have developed a system using Raspberry Pi 3 board which consists of this ARMv8 CPU. This will help to detect the human heads and provide a count of individual in that area. Initially a cascade classifier is trained for head detection with the samples collected from the site. Haar features are used to train the cascade classifier through OpenCV. The tracking is done by the optical flow concept.

The direction of movement of a person is determined by comparing the pixel values in each frame. And in this way each person is tracked individually. [2]

Narinder Singh Punn [3] proposed a deep learning-based framework, it is applicable for the object detection and tracking models to help in maintaining the social distancing remedy for dealing with the rapid growth of COVID-19 patients. In order to keep the equilibrium between the speed and accuracy, YOLO v3 together with the Deepsort are used as object detection and tracking approaches while surrounding each detected object with the bounding boxes. [3] The generated bounding boxes aid in searching the clusters or groups of people satisfying the closeness property computed with the help of pairwise vectorized approach. The number of violations is confirmed by computing the number of groups formed and violation index term computed as the ratio of the number of people to the number of groups.
They propose an efficient real-time deep learning-based framework to automate the process of monitoring the social distancing via object detection and tracking approaches.

In another study by Mahdi Rezaei, Authors have addressed a three-stage model including people detection, tracking, inter-distance estimation as a total solution for social distancing monitoring and zone-based infection risk analysis.

The input video sequences are collected by a CCTV Camera and passes them to the Deep Neural Network model called DeepSocial. The output of the model would be the detected people on the site with their unique localization bounding boxes. The objective is to develop a robust human (people) detection model, which should be capable of dealing with different types of challenges such as variations in clothes, at far and close distances, postures, under different lighting conditions and with/without occlusion.[4] They have used the Simple Online and Real-time (SORT) tracking technique as a framework for the Kalman filter along with the Hungarian optimization technique to track the people.

Predicting the position using Kalman filters is an effective way to keep localizing the human in case of occlusion. Tracking and ID assignment are used for analyzing the level of social distancing violations and high-risk zones of the scene.

If we project a 3-D world scene into a 2-D perspective image plane then it leads to unrealistic pixel distances between the objects. This is called the perspective effect, in which we can not find the uniform distribution of distances in the entire image.

We need to apply a calibrated IPM transition to eliminate the perspective effect. The video frame is changed from perspective space to inverse perspective space i.e a bird's eye view(BEV) is created.

After the IPM transition, the location of each person is in the homogeneous space of BEV with a linear distance representation. Then the distance between objects is found using the Euclidean distance formula.

After studying various Object detection techniques, we found the DeepSocial model to be the most appropriate for Object detection, so we have used it in our system.

III. System Overview

Our proposed work is to develop a system for which could help in the administration of social distancing in the crowd in indoor and outdoor environments using IP cameras It is a system that could help the administrators of a public place by automatically monitoring and detecting violations of social distancing among individuals. The system is deployed in form of a web application which let user create their account on the web application, add IP cameras to their profile and monitor the CCTV with additional information generated by our system. Three types of video feeds are generated by the system which is displayed on the camera dashboard. The first feed consists of a video that marks the humans in the video with bounding boxes, the second feed shows the people following social distancing in green circles and the people violating social distancing in red circles. The third feed contains the crowd map of the input feed identifying different risk zones. Additionally, the real-time data generated by the system is analyzed and stored in the

MongoDB cloud database which is fetched and visualized on the dashboard. The system regularly checks each registered camera if social distancing is violated. In case there is a violation then an alert is sent to the mobile number registered with the camera in form of SMS. The data stored in the database can also be fetched using API and displayed with our Plug-in tool on the website of the user or organization which is helpful for the visitors of the organization in giving them real-time data to decide if the premises of the organization are safe to visit currently or not.

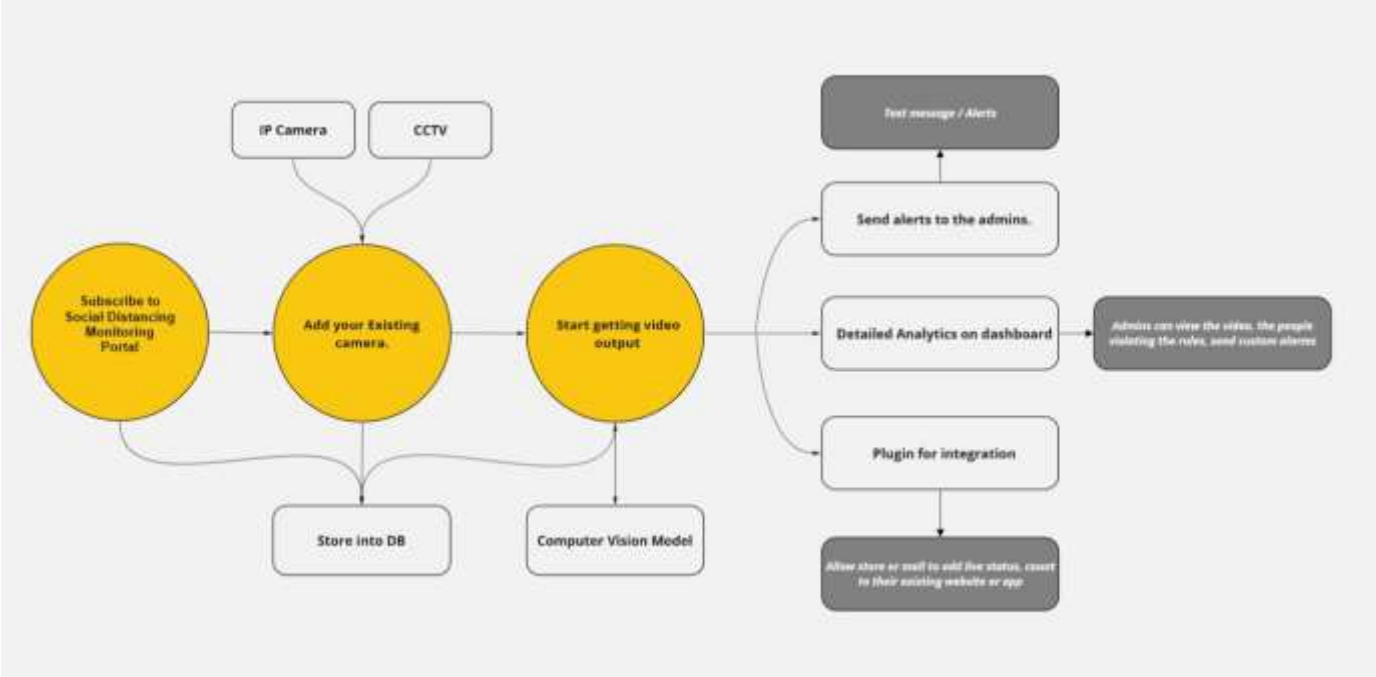

Fig 1 – System Architecture of Social Distancing Monitoring System

The system is divided into four modules which include web portal, server, video analyzer and plugin as a total solution for social distancing monitoring.

A. Web portal

Web Portal is the part of the system which is visible to the end-user. The user visits the web portal, create an account, add a camera and view the results generated by the system. The website is user friendly and easy to use. The requests created by the user is sent to the server and the server validates the request and sent the response to the web portal Following functionalities are available on the web portal.

1) Create Account: The new user needs to register on the portal before using the system. The user can create a new account using an email address and a password.

2) Add camera: The new user has to add information about a camera like IP address, username, password and a camera name. This information is required to connect the camera to the server and perform various operations on it.

3) Edit Camera: If the user entered some wrong details, then the connection to the camera will not be successful hence the user will require to change the camera details.

4) Remove camera: If the user no longer wants to use a particular camera, then they can remove it.

5) View Dashboard: Various outputs generated by the system are visible to the user on the dashboard.

B. Server Module:

The requests sent by the user are received by the server and then the required action is taken by the server to serve the request. It is the responsibility of the server to connect the Web portal and Video Analyzer module. User interacts with the web portal and sends various request to the server like create a new account, edit account info, add a camera, remove a camera, edit a camera and view the dashboard. The server accepts these requests, validate them and then serve them to the client as required. It is the responsibility of the server to connect the Web portal and Video Analyzer module. The server receives the data from the video Analyzer module and then send it to the web portal.

The server is also responsible to store the data related to users, camera and the data generated after processing on the mongo DB cloud. The server checks regularly after a specific interval of time for any social distancing violations. If there are violations then an alert is sent to the t mobile number which is associated with the corresponding camera in which the violation takes place.

The server is also responsible to serve any API requests from the plug-in tool which is linked on the user's website.

C. Video Analyzer:

The Video Analyzer module is responsible for creating a connection with the IP camera input, detect a human in the video frame, estimate the distance between them and identify the social distancing violations. When a user adds a camera to the portal, a Video Analyzer Class object is created on the server and all the analysis takes place in Video Analyzer Class. The input camera is connected to the server and each frame from the input camera is put in an input buffer queue. Then each frame from the input buffer queue is analyzed by the DNN model. A bird's-eye view is created of the frame. Then humans are extracted from the frame. Distance between the humans detected is identified and if the person violates the social distancing norms, then they are marked. Three video outputs are generated by this module. The first output is the video feed which marks the people in the video inside bounding boxes, second video feed marks the people which are not following social distancing norms, the third video output generates a crowd map that identifies the risk zones present in the video frame. The data like the number of people in the frame and the number of people violating social distancing is also calculated. Each output is sent to the server and then the server sends the output to the user dashboard.

Each video frame from the camera is fed to a deep learning model and the relevant information and results are obtained after performing various steps as shown in figure 2.

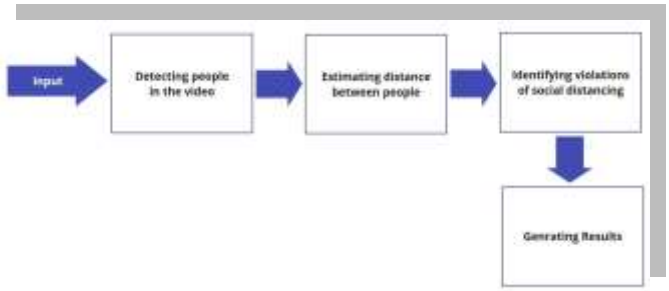

Fig 2 –Steps of Video Analyzer Module

The steps involved are as follows:

1) Detecting people in the video:

The deep learning model that we have used to detect humans in video frames is called DeepSocial. DeepSocial is a hybrid Computer Vision and YOLOv4-based Deep Neural Network (DNN) model for automated people detection in the crowd. (See Fig 3)

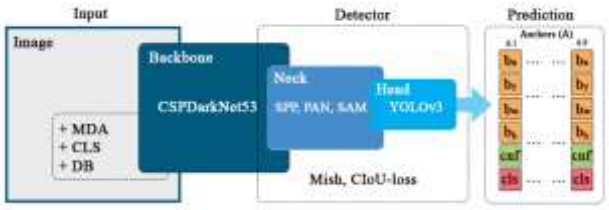

Fig 3 – Network Structure of Deep Social Model

2) Estimating distancing between people:

A bird eye view of the image frame is created and then the distance is estimated between all the people detected in the video. [11]

Any two people Pi, Pj with the Euclidean distance of smaller than r (i.e., the set restriction) in the bird's eye view space were considered as contributors in social distancing violation.

If the co-ordinates of Pi and Pj are (xi, yi) and (xj, yj) respectively. Then distance between Pi and Pj is

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

3) Identifying social distancing violations:

Let r be the safe distance between people

If D >= r then

Pi and Pj are not violating social distancing

If D < r then

Pi and Pj are violating social distancing.

D. Plugin Tool:

The data generated by Social Distancing Monitoring System can be displayed on the website of an organization if the organization have registered itself on the web portal. A unique UID is assigned to each user when their account is registered on the web portal. This UID is used to fetch the data related to the account which is generated by the System after video processing of the CCTV feed. The plug-in tool can be added to the website of the registered organization. The plug-in tool calls the API with UID as a parameter and receives real-time updates related to the registered UID in the system. The steps required to add a plugin tool to the website are displayed on the web portal under the plug-in tab for user convenience.

Fig 4 – Module Diagram

IV. RESULTS

The web portal has various features which enable a user to register themselves, log-in, add one or more cameras, edit camera details. The main dashboard displays the stream from all the cameras along with the results generated by the system after processing the input from all cameras added by the user to their profile. These are the same results that are fetched by the API and are displayed on the website of the registered user. The various results generated by the system on the main dashboard (refer Fig 7) are:

1) No of people currently in the area: This is the sum of people visible in all cameras

2) No of people violating social distancing in the are: This is the sum of all people visible in all cameras who are violating social distancing

3) Average No of people present on-premises in a day: This is the average no of people visible in all cameras in a day

4) percentage violations currently in premises: This the percentage of violations currently taking place considering all cameras added by the user.

User can view the specific camera results by clicking the desired camera stream from the main dashboard. Various results are displayed on the camera dashboard page which includes three different feeds, various statistics and visualizations. The first feed consists of the people detected in the input video feed and is marked by bounding boxes, the second feed shows the people following social distancing in green circles and the people violating social distancing in red circles and the third feed contains the crowd map of input feed which identify different risk zones. The regions in the third feed which are more crowded are comparatively redder than those which are less crowded.

The various statistics generated (see Fig 8) are:

1) people in the area: this is the number of people who are currently visible in the camera frame
2) people violating rules: this is the number of people violating the social distancing
3) Average people in 24 Hr.: this is the average number of people visible on camera in the last 24 hours
4) Average violations in 24 Hr.: this is the average number of people observed violating social distancing in the last 24 hours

Visualization of data helps in better analysis, identifying patterns, grasping the trends so we have visualized the data that we have saved in our database using the following graphs (see Fig 12):

1) No of people and violators in last 24 hr.: This graph is a line graph of no of people and no of violators which are made from all the data points saved in our database in last 24 hours. Line graphs are very useful to understand how the crowd varies overall in a day.

2) Average no of people and violators in the last 8 days: This graph is a bar graph which shows no of people and no of violations in the last 8 days including today.

This is helpful for administrators to understand the variation of the crowd in a week and plan the schedule or timing of any activity during different days in a way such that the number of social distancing violations can be reduced.

The other important feature of our system alerts. Whenever people are continuously violating social distancing then an alert in form of SMS (refer to Fig 10) is sent to the mobile which is saved in the database along with the camera details while adding the camera to the user profile.

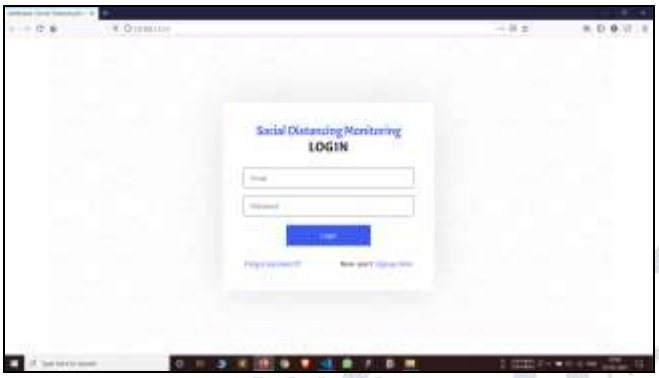

Fig 5 – Login Page

Fig 6 – Sign Up Page

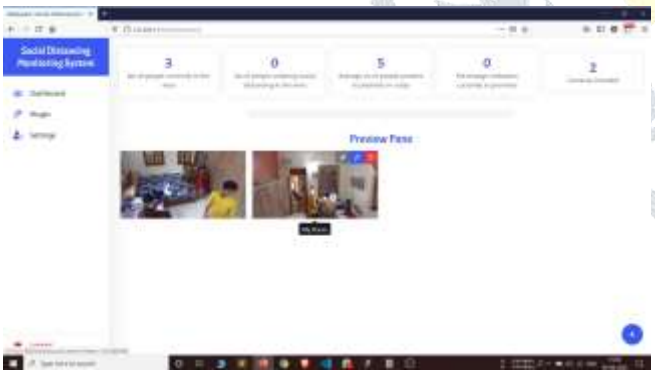
Fig 7 – Main Dashboard

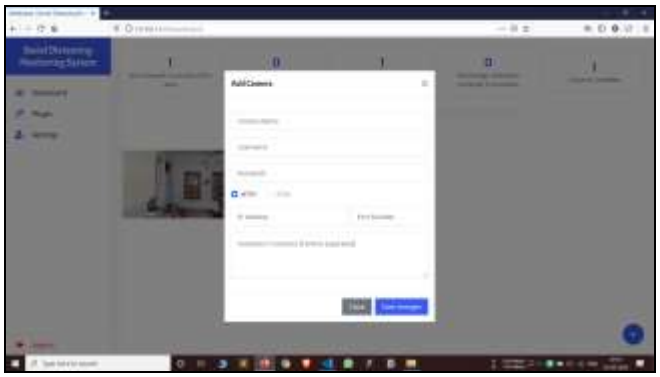
Fig 8 – Add Camera to the Dashboard


Fig 9 – People Detection on Camera Page

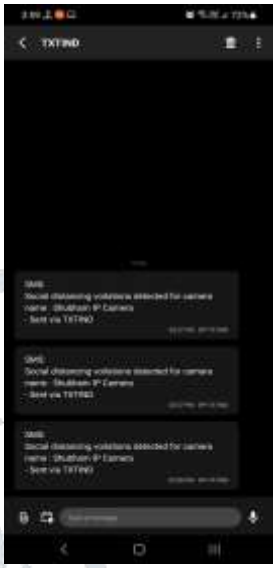

Fig 11 – Alert sent to register mobile number on social distancing violations

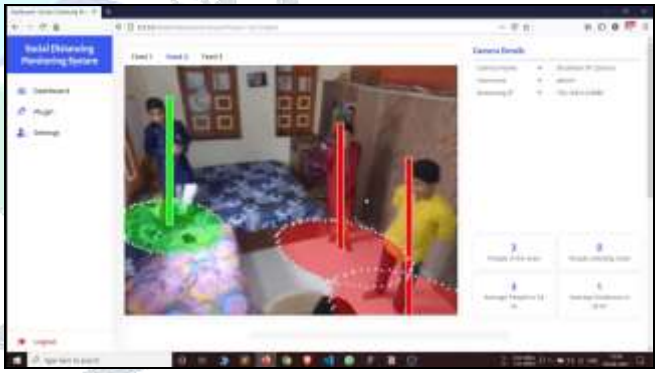
Fig 10 – Social Distancing Monitoring on Camera Page

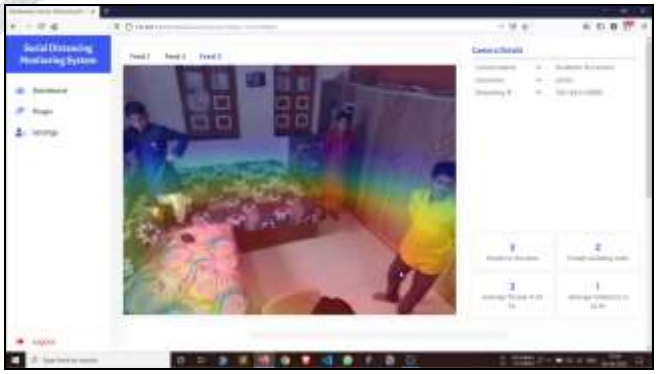
Fig 12 – Crowd Map generated on Camera Page

Fig 13 – Visualizations on Camera Page

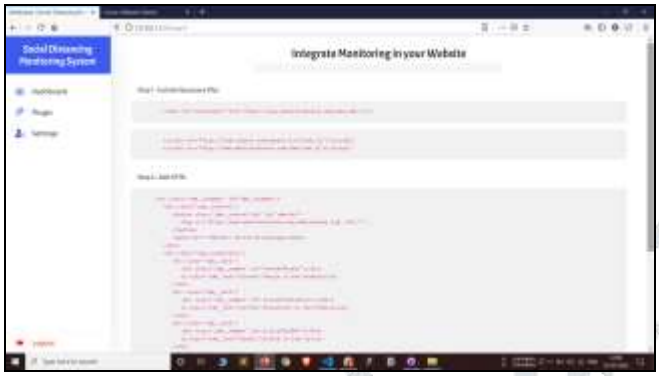

Fig 14 – API Integration Page

V. CONCLUSION

The working of the social distancing monitoring system is satisfactory in the real-time scenario. The user can register themselves on the portal and add cameras to the system. Once the connection is established between the camera and the server, the processing of video frames starts. The system can accurately detect social distancing violation and identify the risk zones. If there are continuous violations then an alert is sent to the admins whose mobile number is registered in the system related to a particular camera. The data after analysis is displayed on the dashboard and visualizations are generated which helps the admins to understand the data easily. Our plugin tool can be added to the website of the user which fetches real-time updates from the server on the website using API.

In the overall development of the project, we learnt advanced techniques to detect humans, estimate the distance between them and verify if social distancing is practiced or not and use the data for visualization. Apart from learning this project gives accurate results which are practically usable.

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