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The Development of an Improvised Crowd Analysis Model

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Abstract: The goal of this project is to create a deep learning-based visual crowd counting system. The objective of this project is to build a functioning system that can analyze pictures and determine the number of individuals present within these images. It will also demonstrate its approximate density map, a graph comparing the expected count to the actual count, and information on its accuracy in terms of Mean Absolute Error (MAE). To routinely supervise audiences, researchers recently moved to computer vision. This research analysis proposed the implementation of a Deep learning algorithm CNN for which the aim was to detect the crowd and estimate increased influx of people which has been successfully achieved by employing deep learning technique. We have used the shanghai tech dataset part B for our research purpose. CNN model detected the crowd and estimated the density with an absolute error of 21. In 312 we obtained a validation mean absolute error of 21.3, which means on average, the model will estimate 21 persons in excess or deficit.

I. INTRODUCTION

The human population has been expanding at an astronomical rate in recent years, which has indirectly increased the prevalence of crowding. The purpose of gathering has a significant impact on a wide variety of assets and crowded behaviors. The examination of crowdmovements and behaviors has aroused a lot of scholarly interest in public service, security, and safety, as well as computer vision. Because human faces vary in color, stance, emotion, location, orientation, and illumination, the task of distinguishing a face in a crowd is difficult. A jam-packed situation causes enormous hordes of bewilderment, finishing in pushing, mass frenzy, rushes, or crowd pulverizes, and a deficiency of control. Weighty downpours killed22 individuals and harmed hundreds more in the early evening between Mumbai, Parel, and Elphinstone Road in 2017, while 27 walkers were killed in Andhra Pradesh state of India in 2015 as displayed in Fig. 1, 32 individuals kicked the bucket in a rush on the banks of the Godavari waterway in 2015. what's more, 26 others were harmed during the Stampedeoccurred on the event of Diwali at Gandhi Maiden 2014.

To keep away from these misfortunes, the programmed location of dire and startling conditions in enormous groups is fundamental. Accordingly, it will certainly support the execution of crisis gauges just as suitable security and wellbeing measures. Group location is quite possibly the most troublesome errand in visual reconnaissance frameworks. This innovation might be utilized to identify and tally individuals, just as screen swarm levels and convey alerts when there is an enormous group.

Figure 1. A crowd image example- Bank of Godavari, Datia District
[Source: https://sputniknews.com/society/201507141024595193/]

The goal of a crowded headcount is to determine the number of persons present in congested areas. There are a few uses for crowd detection, such as

1) *Safety Control:* Video surveillance cameras in places like games arenas, shopping centers, and air terminals have affirmed swarm checking for conduct examination, clog investigation, and irregularity location.
2) *Disaster Management:* Music exhibitions and political shows, for instance, are dependent upon disasters like charges. For early conclusion of overpopulation, it isimportant to utilize.
3) *Public Areas:* Many public scenes, like shopping centers, stations, air terminals, and different spots where human wellbeing might be impacted, may have a high group level.
4) *Visual Surveillance:* Because public spaces, for example, jungle gyms and huge fields are so packed, this sort of innovation might miss an individual among the group. The Visual Surveillance framework assists with decreasing disappointment rates by identifying and informing abnormalities.

A crowd is formed when a massive amount of people meets together and they principally agree on a common goal. This gathering may be noisy, laid-back, cheerful, and, interestingly, may initiate with unbelievable displays of negativity. The crowd is mainly referred to as the average number of people present in a particular place. A place is said to be crowded if the population of an area becomes much more than the capacity of that place. Thus, a crowd potentially result in a broad range of incidents. Excessive overpopulation sometimes results in individuals losing control & tear down the surroundings. People typically enjoy the benefits of this type of gathering to engage in brutal behavior like insulting ladies. Therefore, it is crucial to determine the number of people in a gathering in order to assure everyone's safe. To assess any crowd, it is necessary to estimate the density of the crowd. If the safe limit of the crowd is crossed, the warning signs can be easily given to avoid certain mishaps. This can lead to maintain the infrastructure and management of the area. The counting of people can help us to classify the area as crowded or non-crowded and if the place is crowded, the place can be monitored.

There is numerous population identification comment section that relate with the population detecting and analysis process, which include:

a) Man, identification as well as tracking
b) Object detection and analysis

Among the above two sections, the detection of humans is a difficult process as it is influenced by various possible appearances due to expressed pose, outfits, illumination, and the surroundings but these limitations can improve the performance of detection task if we have its prior knowledge.

Human detection can be used in a variety of situations, like: -

- Identifying and spotting individuals in crowded places.
- Human recognition as well as tracing
- Categorization of gender
- The individual being spotted via foot
- Fall protection with the aged
- Discovery of abnormal events

Crowd control is assessed by intellectuals, theorists, as well as surveyors, however information technology engineers are mostly interested in detection, smart environments, as well as abstract conditions. The present method of keeping an eye on mobs involves security systems that are individually operated by very far human employees. Since there are often more cops watching visual information than there are clips, of that kind monitoring models are important worthless for detecting and preventing in actual environments.

A. Approaches To Crowd Detection

As illustrated in Fig. 2, the Crowd Detection System includes Embedding Information, Methods, Aspects, as well as Outcome. There are three approaches for crowd detection. These approaches are detection based, regression based and density based.

B. Approaches On The Basis Of Detection

The recognition model attempts to sort out the number of people there are by recognizing a solitary individual and their areas at the same time. Jones and Snow et al. portrayed a spatiotemporal data based filtering window walker identifier. [17].

Supreme contrast, Haar- like channels. To catch moving items, three sorts of channels are utilized: the Haar channel, the moved distinction channel, and the moved contrast channel. The Adaboost learning calculation was utilized to prepare eight distinct passerby finders for eight unique movements. Moreover, utilizing both development and appearance information, this procedure is utilized to create and endeavor to mastermind the moving person. In a hierarchical division situation, Leibe et al. [19] recommended a strategy for recognizing walkers in clogged regions that utilizes a calculation that joins nearby and worldwide information. Their trials showed that they are dependant on the framework, and people on foot can be distinguished in any event, when there is a ton of cross-over. Lin et al. [20] proposed a recognition approach for swarmed assessments dependent on wavelet layouts and vision-based advances. The Haar Wavelet Transform (HWT) was used to determine the component's determination of head shape. Any vector support devices (SVM) was used to arrange a featured district as having or not having a head. In complex situations where the head was not apparent, this strategy was restricted, and it end up being a computationally requesting arrangement continuously applications [21]. For distinguishing and searching for swarmed individuals, Zhao and Nevatia [22] proposed a 3D human shape model. The solution they offer is based on separating the foreground blobs to determine the top of the head. For the identification and tracking of people, a Posteriori problem was developed. There is an occlusion problem in the Using the Markov-Chain Monte Carlo method that prevents the combined likelihood of different people (MCMC).

C. Items And Administrations Related Upon Regression

Local picture patches are utilized in the relapse based way to deal with get include planning for tallying purposes. A portion of the qualities used to encode low-level data are forefront, highlights, edge components, surface, and inclination highlights. Nearby Binary Pattern (LBP), Practices In order Clustering (HOG), and Gray Level Co-event Matrices (GLCM) are instances of approaches to further develop results by catching neighborhood and worldwide scene highlights. Subsequent to removing nearby and worldwide information, distinctive relapse calculations, like straight relapse, edge relapse, and neural networks [15], are utilized to figure out how to plan for swarm tallying purposes. Idrees et al. [22] found that nobody element or identification technique is adequately dependable to precisely evaluate the presence of the great thickness issue, hence they offered Fourier examination, head recognition, SIFT interest point, or alternate approaches to separate elements.

D. Arrangements Focused Solely Upon Intensity

A thickness-based procedure is utilized to attempt a straight planning between nearby way includes and related thing thickness maps. It ought to be referenced, nonetheless, that dominating direct planning is troublesome. Pham et al. [23] proposed learning a non-direct planning between neighborhood fix elements and thickness maps. Backwoods of Chance Voting for thickness of a few objective options is finished utilizing relapse from various picture patches

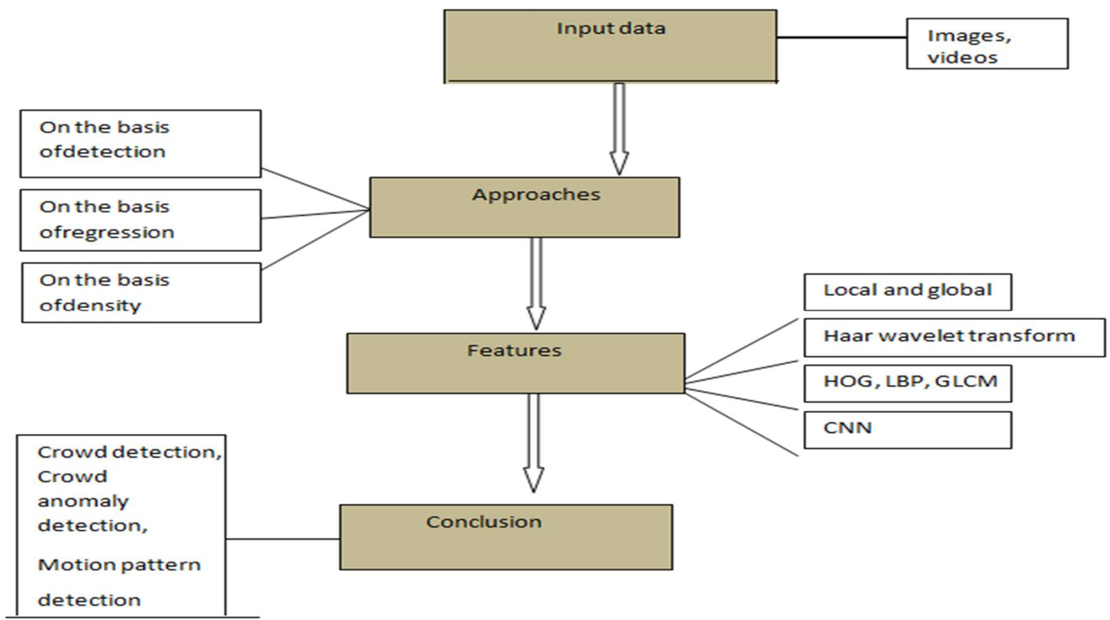

Figure 2. General structure of crowd detection system
Fig 1: soil

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II. RESEARCH OBJECTIVES

The proposed work is to achieve a set of research objectives which are listed below:

1) To study the already existing crowd detection techniques by conducting a systematicstudy.
2) To design a crowd detection tool to filter outperformance and efficiency.
3) To assess the effectiveness of the designed approach by comparing the results withthe existing methodologies and interpreting them to draw appropriate conclusions.

A. *Research Methodology*

To solve any problem, a systematic approach must be followed efficiently to reach the desired solution. The research methodology that might be executed in this work is presented in Figure 4.

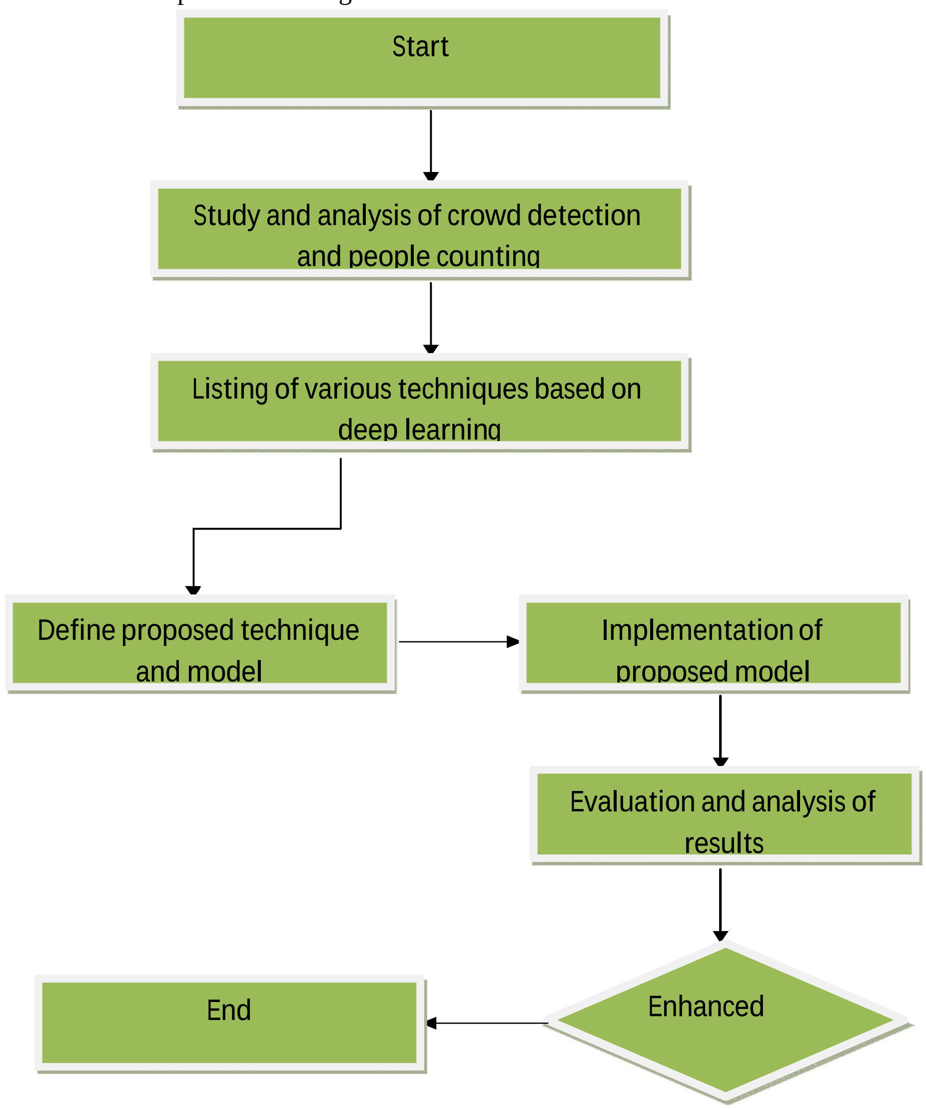

Fig. 4. Research methodology

To understand the extent of work done in this field, a comprehensive literature survey has been done for better understanding the concepts related to the problem. A detailed review of literature about the research problem has been done by going through various books, papers, journals etc. and framework or model will be proposed.

The next phase would be the implementation of these models on hardware or software-based system and then experiments might be executed to calculate the efficiency of the model. The hardware and the software required would be identified for effective implementation. Then the results obtained will be compared and analyzed for validation.

III. SUMMARY

This chapter starts with a brief introduction to crowd detection. An overview of the research gaps and challenges is presented followed by the problem formulation. The research objectives are also mentioned along with the research methodology to carry out the research work. The diagrammatic flow of the research work is also presented in the chapter. The next chapter (chapter 4) presents the proposed models for human tracking and crowding recognition.

IV. RESULTS AND DISCUSSION

The dataset that we use for training the model is Shanghai Tech Part B. We have implemented our model in python using the Pytorch Lightening library. We will discuss each of our code blocks here. We will begin by making all the necessary imports.

A. Simulation Step

```
import pandas as pd
import numpy as np
import scipy
import scipy.io
import cv2
from matplotlib import pyplot as plt
from scipy.ndimage import gaussian_filter
import torch
import torch.nn as nn
from torch.utils.data import DataLoader, Dataset
from PIL import Image
from pytorch_lightning import LightningModule, Trainer
from pytorch_lightning import seed_everything
import os
```

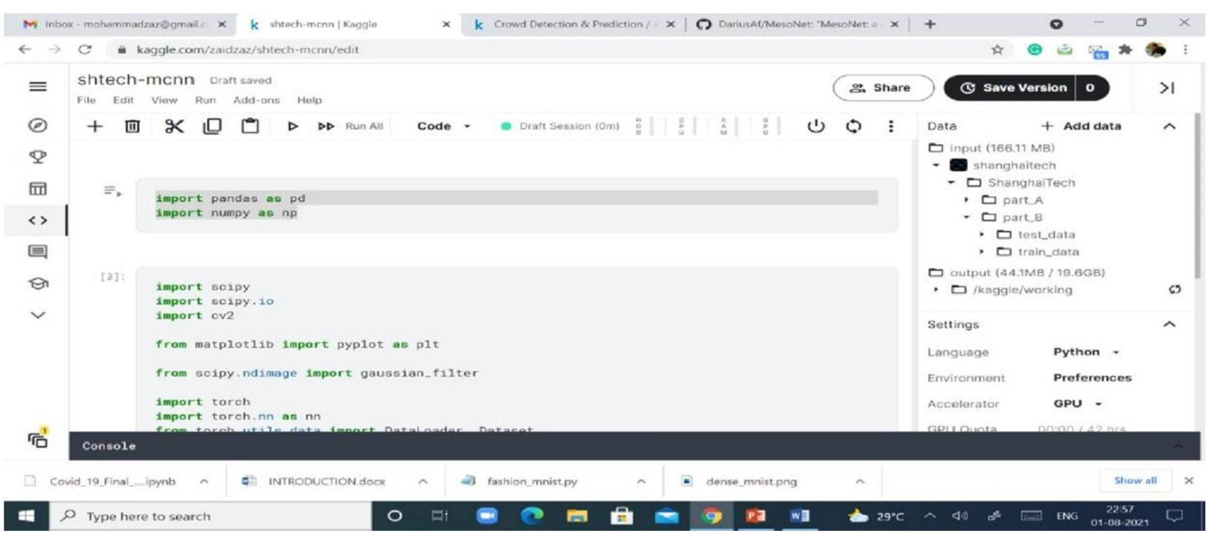

Figure 7. Screenshot of Jupyter environment

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B. Data Visualization

After making the necessary imports, we define a function to display our images. Once, wehave defined this function, we call it for some of the images in the dataset.

im = cv2.imread('../input/shanghaitech/ShanghaiTech/part_B/train_data/images/IMG_1.jpg', cv2.IMREAD_COLOR)
show(im)
def show(im):
After making the necessary imports, we define a function to display our images.
def show(im):
plt.figure(figsize=(10, 10))

Figure 8. Screenshot of the loaded dataset image

Once, we have visualized one of our data points, we proceed to prepare our data. We use thetrain test split module of Scikit learn for this purpose.

```
from sklearn.model_selection import train_test_split

train = [p.path for p in
os.scandir('../input/shanghaitech/ShanghaiTech/part_B/train_data/images/')]
valid_full = [p.path for p in
os.scandir('../input/shanghaitech/ShanghaiTech/part_B/test_data/images/')]

## use a small subset for validation
_, valid = train_test_split(valid_full, test_size=64, random_state=42)

len(train), len(valid)
```

This will give us the number of instances used for training and testing.

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V. DATA PRE-PROCESSING

Once we have split the data into training and testing sets, we proceed to perform some data augmentation. Data augmentation routines are found in the pytorch lighting. The most important augmentation routines that we will use are Horizontal flip and Random Brightness contrast. Once these routines are called, we will define a class to implement them. The next step after data augmentation is to apply Gaussian filters to head annotations for density estimation. All of this is implemented in the following lines of code.

```
im_size = 512
aug_train = A.Compose([
    A.RandomCrop(im_size, im_size),
    A.HorizontalFlip(p=0.5),
    A.RandomBrightnessContrast(), A.Normalize((0.5), (0.5)),
], keypoint_params=A.KeypointParams(format='xy', angle_in_degrees=False))

aug_val = A.Compose([
    A.Resize(768, 1024),
   A.Normalize((0.5), (0.5)),
], keypoint_params=A.KeypointParams(format='xy', angle_in_degrees=False))

class  MyDataset(Dataset):
  def___init (self, files, aug):
  self.files = files
 self.aug = aug

def_____len_(self):
   return len(self.files)

ps = m['image_info'][0][0][0][0][0]
rst = self.aug(image=im, keypoints=ps) im = rst['image']
ps = rst['keypoints']
dm = np.zeros((im.shape[0], im.shape[1]), dtype=np.float32) for x, y in ps:
x = int(x) y = int(y)
dm[y, x] = 1
sigma = 4
dm = gaussian_filter(dm, sigma=sigma, truncate=4*sigma)

dm = cv2.resize(dm, (im.shape[1] // 4, im.shape[0] // 4), interpolation=cv2.INTER_LINEAR) dm *= 1
im = torch.from_numpy(im) dm = torch.from_numpy(dm)

return it, dm
```

We now display some of our data instances after data augmentation.

```
ds = MyDataset(train, aug_train) im, dm = ds[0]
plt.imshow(im, cmap='gray')
```

Subsequently, we display the Gaussian filters.

```
plt.imshow(dm)
```

These steps conclude our data visualization and preparation.

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<matplotlib.image.AxesImage at 0x7fa5c1bc0450>

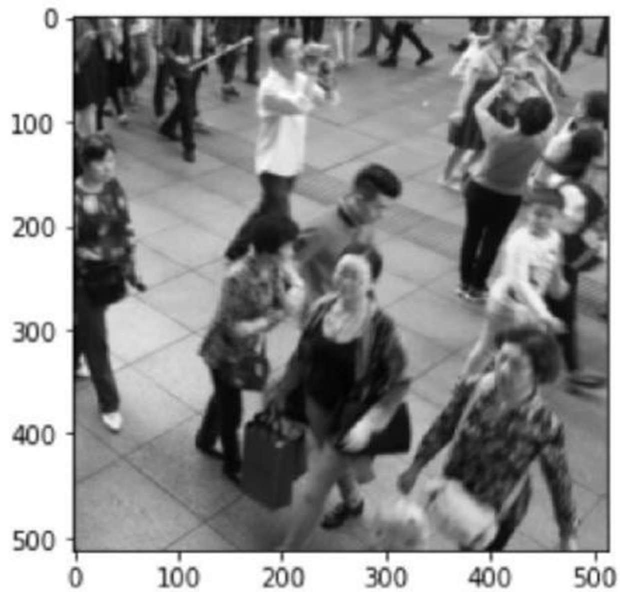
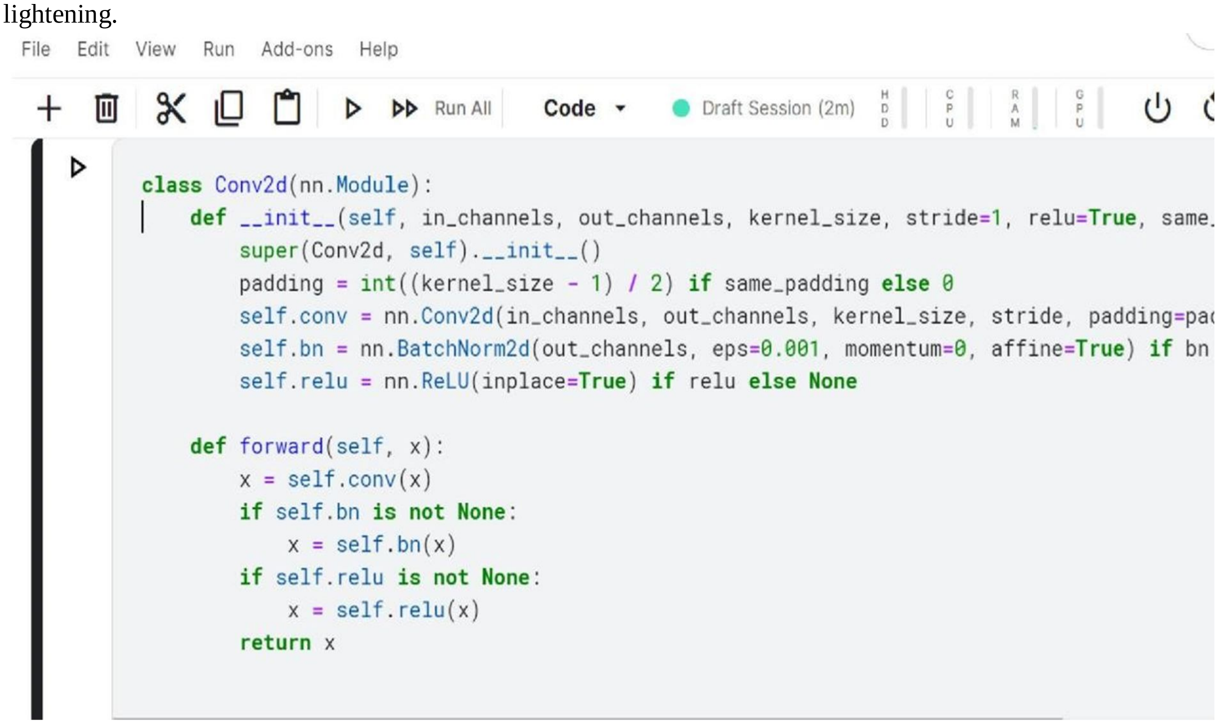


Figure 9 screenshot of pre-processed image

VI. PREDICTION MODEL

The next step is that of designing building and training CNN, We will design some helper functions which will be called for convenience throughout the model building process. The following class and function define a CNN model and a forward pass in PyTorch lightening.




```
class Conv2d(nn.Module):
    def __init__(self, in_channels, out_channels, kernel_size, stride=1, relu=True, same_
        super(Conv2d, self).__init__()
        padding = int((kernel_size - 1) / 2) if same_padding else 0
        self.conv = nn.Conv2d(in_channels, out_channels, kernel_size, stride, padding=pad
        self.bn = nn.BatchNorm2d(out_channels, eps=0.001, momentum=0, affine=True) if bn
        self.relu = nn.ReLU(inplace=True) if relu else None

    def forward(self, x):
        x = self.conv(x)
        if self.bn is not None:
            x = self.bn(x)
        if self.relu is not None:
            x = self.relu(x)
        return x
```

Figure 10. Screenshot of imported CNN model

In the following class and function, we build our CNN model by making calls to thepreviously defined function and class.
class MCNN(LightningModule):
'''

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```
Multi-column CNN '''
def    init (self, lr, batch_size, max_steps, bn=False):
super(MCNN, self).  init  ()
self.lr = lr self.save_hyperparameters()
self.use = 0
x = self.fuse(x) elif self.use == 1:
x = self.out1(x1) elif self.use == 2:
x = self.out2(x2) elif self.use == 3:
x = self.out3(x3) return x.squeeze(1)
```

Now having defined our model, we proceed to train the model. For training, we define the following helper functions and subsequently call them.

```
gt_sum = torch.round(y.sum(dim=(1,2))).int() acc =
(pred_sum == gt_sum).float().mean()
mae = torch.abs(pred_sum –
gt_sum).float().mean()
self.log('train_loss', loss)
self.log('train_acc', acc)
self.log('train_mae', mae)
return loss
def validation_step(self, batch, batch_idx):
with torch.no_grad():
self.eval() x, y = batch

pred = self(x)
loss = self.crit(pred, y)
pred_sum = torch.round(pred.sum(dim=(1,2))).int()
 gt_sum = torch.round(y.sum(dim=(1,2))).int()
acc = (pred_sum == gt_sum).float().mean()

scheduler = {
'scheduler':torch.optim.lr_scheduler.OneCycleLR(optimizer,max_lr=self.lr, total_steps=self.hparams.max_steps,
pct_start=0.1, cycle_momentum=False),
'interval': 'step', 'frequency': 1
}
return [optimizer], [scheduler]
```

A. Density Map Generation

We now pass our training parameters, begin training and generate the density map.

```
batch_size = 32
epochs = 300
max_steps = epochs * len(train) // batch_size
trainer=Trainer(gpus=1,max_steps=max_steps,precision=16,benchmark=True,callbacks=[checkpoint_cb,
LearningRateMonitor()])
        lr = 3e-4
```

After this, we proceed to display the results on the testing dataset. Note that we can use any crowdimages here.

```
ds = MyDataset(valid, aug_val) d = ds[50][0]
plt.imshow(d, cmap='gray')

plt.imshow(model(d.unsqueeze(0)).detach()[0])
model(d.unsqueeze(0)).detach()[0].sum()
```

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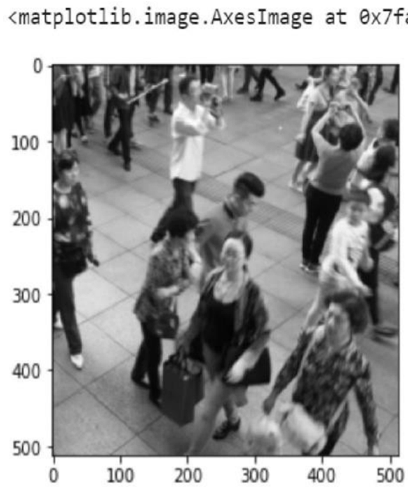
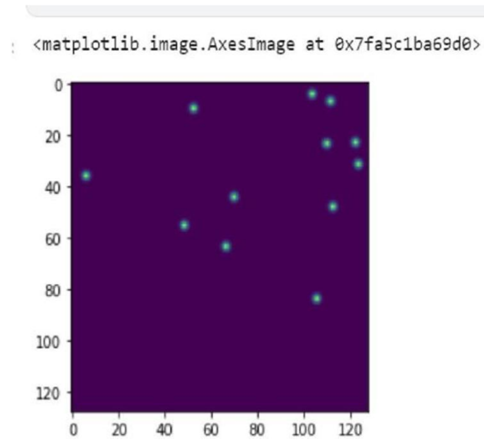
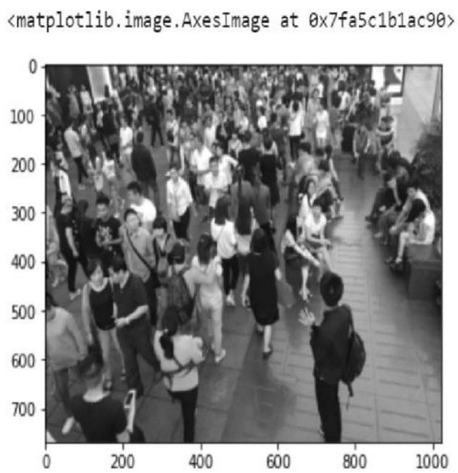
This will display the density map of images. These images are shown below.



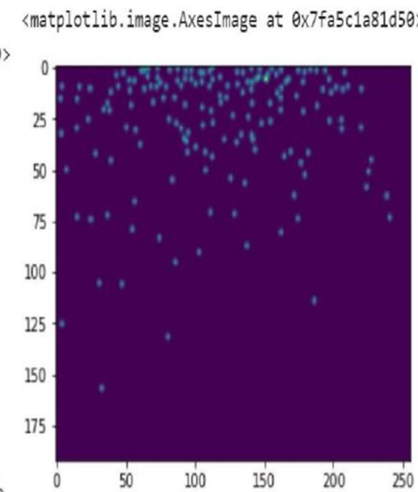
15(a)



15(b)



11(c)



11(d)

Figures 11(a, b, c and d) show the processed images and corresponding density maps.

VII. CONCLUSION

A. This research analysis proposed the implementation of a Deep learning algorithm CNN for which the aim was to detect the crowd and estimate increased influx of people which has been successfully achieved by employing deep learning technique.
B. For this study, a dataset was downloaded from the GITHUB website, which has a variety of datasets. This website also has the ShanghaiTech dataset.
C. This dataset from ShanghaiTech has 1198 photos with 330,165 labeled heads. There are two aspects to this: part A and part B.
D. Part A is made up of 482 photographs chosen at random from the internet, while Part B is made up of images taken from surveillance on Shanghai's streets and consists of 716 images.
E. We have used the shanghai tech dataset part B for our research purpose.
F. The result acquired in this technical report is promising. CNN model detected the crowd and estimated the density with an absolute error of 21.

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