CRIMINAL IDENTIFICATION FROM VIDEO SCENE USING CONDITIONAL GENERATIVE ADVERSARIAL NETWORK

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APPROVAL

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We hereby declare that, this paper has been done by us under the supervision of **Md. Reduanul Haque, Senior Lecturer, Department of Computer Science & Engineering** & co-supervision of **Ohidujjaman, Senior Lecturer, Department of Computer Science & Engineering** Daffodil International University. The work embodied in this paper has not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Criminal identification from a blurry image is a challenging task from a video scene. Many criminals are unidentified due to blur degradation or additional noise in videos. This paper introduces a novel approach of identifying the perpetrators using conditional Generative Adversarial Network. This network figures out how to distinguish the criminals, yet additionally, it learns a loss function for training the model. In this method, our model evaluates from a self-created dataset where the video frames are blurred or unclear. This work demonstrates how to detect criminals from the blurred dataset using cGAN. The conditional model of GAN makes the generator stronger to produce clear images from unclear data after a specific number of iterations. Then, the trained stable discriminator able to distinguish the real criminal. The proposed method performs significantly in an efficient way to identify the criminal which might be a revolutionary approach for the welfare of the society.

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CHAPTER 1
Introduction

In our society, crime has been increasing widely day by day in different ways such as snatching [1], fighting, stealing, and so on. In many countries, the problem is enhancing alarmingly. These sorts of criminal activities have been happening frequently in populous cities of underdeveloped countries. Not only undeveloped countries but also the luxury cities of many developed countries have vouched for these kinds of violence. Street fighting, snatching from moving vehicles like motorbike or bicycle often occurs in the midtown of glamorous cities [2]. There are a lot of paradigms of the street fighting where people die after involving outrages [3].

In forensic science for criminal identification, images and videos play a significant preamble in identifying criminals. In most cases, video surveillance like CCTV cameras have been mainly used in the domain of forensic identification. Moreover, it has also been easier to capture digital photos by the on spot eyewitnesses. The law enforcement personnel uses footage for tracking, identify and arrest criminals.

However, it is difficult to identify the criminal at times; for producing blurred images due to motion capture, low resolution, slow shutter speed or something else in digital devices. Furthermore, when a crime occurs at night, the night vision CCTV footage produces unclear or hazy images that are barely identifiable. In that case, it is not unrecognizable that a criminal is committing a crime, but the face of the criminal is not identifiable due to vague images. Furthermore, detecting perpetrators get tough even in daylight by video surveillance. For instance, Britain Metropolitan police revealed that fewer than one crime is disposed of among 1000 CCTV cameras in the capital due to insufficient quality of images [4].

Many image processing algorithms that were previously used to detect perpetrators. But detecting the criminal face from an unclear image is not a conventional concept. The motive of this paper is to identify criminals from low quality or blurred images.

In this paper, we are going to introduce a conditional Generative adversarial network [5] which will be used to deblur or clear the images from unclear image datasets. Our model analyzes the blur or unclear image data and identifies the criminal from the blurred

images. In this work, we will use our defined dataset where the GAN model takes the manual input as condition from our dataset instead of only taking random input. The main idea is that we feed the abnormal or unclear image data to the generator of GAN. Then we use both data produced by the generator & normal images of the criminals is used to train the discriminator as it can identify the criminal. Detecting criminals from blur images will help police personnel. This work is especially useful for law enforcement who sometimes faces trouble to identify the criminal from unclear, hazy, noisy or blurred images and surveillance videos.

The subsequent steps of this paper is organized as follows: Section 2 briefly demonstrates the literature review, section 3 provides the background methodology, section 4 introduces our proposed method of criminal identification using the generative adversarial network, section 5 represents the experiment result of our work and finally, section 6 draws the conclusion of our research.

CHAPTER 2

Literature Review

Forensic science investigates relationship between perpetrator and environment. A lot of work has been done in the field of criminology using Deep Neural Network. Many information has been discovered for being done a lot of work in that field.

Saikia et al. (2017) introduces R-CNN based object detection using VGG-16 and RPN architecture to identify criminals [6]. The strategy detects the belongings of the object instances that can be used in the field of video surveillance, internet videos for crime evidence in face detection and recognition. Moreover, the technique could be used in cybercrime for internet videos to identify criminals' face detection and recognition. The authors demonstrate 74.33% accuracy which can play a significant impact in the field of crime evidence analysis. Nevertheless, the approach cannot be always suitable for perpetrator identification. The alternative strategy could be applied for more accuracy.

Nurhudatiana et al. (2015) propose a paper where skin marks are used to identify criminals using color images of skin and identifying the patterns of veins via inferred technology [7]. Criminals such as rioters, rapists, gunmen involved in crime wearing masks at times. Hence it is impossible to detect their faces. The authors present a methodology where criminals can be identified detecting criminal signs in the body of criminals. But the partially visible body sign would be challenging for this strategy.

Tayal et al. (2014) examine a criminal detection and criminal identification (CDCI) model using data mining for Indian crime data [8]. In India, the crime rate in the capital New Delhi is 33.45%. Besides, the rate in Kolkata and Mumbai is 23.31%, 19.56% subsequently. Many people died and wounded chronologically by terrorists, gunmen in many incidents. These types of criminal occurrences make scary in the society of India. K-means clustering has been applied to detect criminals. Moreover, the identification & prediction have done by the KNN classification algorithm. This novel approach might be suitable for criminal detection and identification as well as using this data, other approaches might be applicable.

Sikandar et al. shows detection of crime in ATM using surveillance camera where instant video analysis method has been used [9]. Prabakaran et al. show techniques about

detecting crime using data mining and machine learning [10]. Benjamin et al. show by using data mining techniques in crime prediction and analysis [11].

Stalidis et al. (2018) present a deep learning architecture based crime prediction and classification which is based on spatiotemporal data [12]. This paper focuses on likely place and time instead of identifying victims or perpetrators directly. Forecasting of the violence place and time is a challenging task. The authors examine the previous data for the prediction and classification using DL architecture. This work can be an evolutionary effort for law enforcement to deploy patrols in the right place. In case, the deployment of cops in the wrong place, the whole time and deployment will be in vain.

Eltameen et al. (2018) have presented a paper for predicting criminal activities using big data techniques [13]. In many countries, cops, or law enforcement use criminal predicting tools which are helping tremendously to predict the perpetrators. The author of this paper shows soft computing and big data techniques for the recognition of criminal activities. The crime data has been clustered using a firefly algorithm based on the fuzzy cognitive map which help to foresee the wrongdoing movement related highlights in compelling way. Then the predictive process has been carried out by the enhanced associative neural network model. This model selects the optimized feature and after that the authors also analyze the performance.

A paper of crime analysis by Kim et al. (2018) using machine learning has been proposed. Machine learning is such kind of technology by which machine learns and gains the ability to make decisions like human beings without the interference of any person [14]. The authors illustrate the prediction of crime using machine learning. They have created a predictive model to predict crime efficiently through machine learning using KNN(K-nearest neighborhood) & boosted decision tree algorithm. The authors illustrate how many crimes committed per hour in every day of a week, crimes committed per day & per month, average crimes per month. The approach of this work must help to make an idea about the crime happenings in a day, week, month and the type of crime.

CHAPTER 3

Background Study

In this section, we would identify criminal which is based on a Conditional generative adversarial network. In the beginning, we will describe the unconditioned generative adversarial net(GAN) and then, we represent the architecture of the conditional adversarial net(cGAN) for criminal identification.

3.1 Introduction

Artificial Neural Network is a computing system which pattern is modeled following the working procedure of neuron of human brain. Artificial neural network is a part of deep learning or machine learning that analyzes something following the procedure of human brain neurons.

3.2 Principle of Artificial Neural Network

An artificial neural system has a huge number of processors that works parallelly. The processors are arranges in layers. The first layer of ANN takes the raw input. Then the subsequent layers take the input from the previous layer and the last layer interprets the final output. The ANN layer can be categorized into three basic layers: 1. Input layer 2. Hidden layer 3. Fully connected layer. Each node is profoundly interconnected to each other of previous and the afterward layers. The way in to the viability of neural network systems is that they are amazingly versatile and learn quickly. Every node weights the significance of the information it gets from the nodes before it. The information sources that contribute the most towards the correct output are given the most noteworthy weight.

3.3 Classification of Artificial Neural Network

There are different types of neural network such as:

1. Feedforward Neural Network – Artificial Neuron
2. Radial Basis Function Neural Network
3. Multilayer Perceptron

4. Recurrent Neural Network
5. Modular Neural Network
6. Sequence-To-Sequence Models
7. Convolutional Neural Network (CNN)

3.3.1 Feedforward Neural Network - Artificial Neuron

Artificial neural network has many variances and among all, one of the easiest one is the feedforward neural network. In this type of neural network, data reaches the output node via passing through the different input nodes. In another saying, data passes through just a single direction from the beginning tier onwards until it arrives at the output node. This process is also recognized as a front propagated wave that is commonly acquired through a function of classifying activation. In this type of neural network, data passes through only in a single direction which is rare in other types of complex neural network and so no backpropagation is needed. This neural network may have either only one layer or hidden layers. Calculations like the sum of the products and weights values are required especially for the inputs in a feedforward neural network. After this, output is fed by the result. A single layer feedforward neural network example is given afterwards.

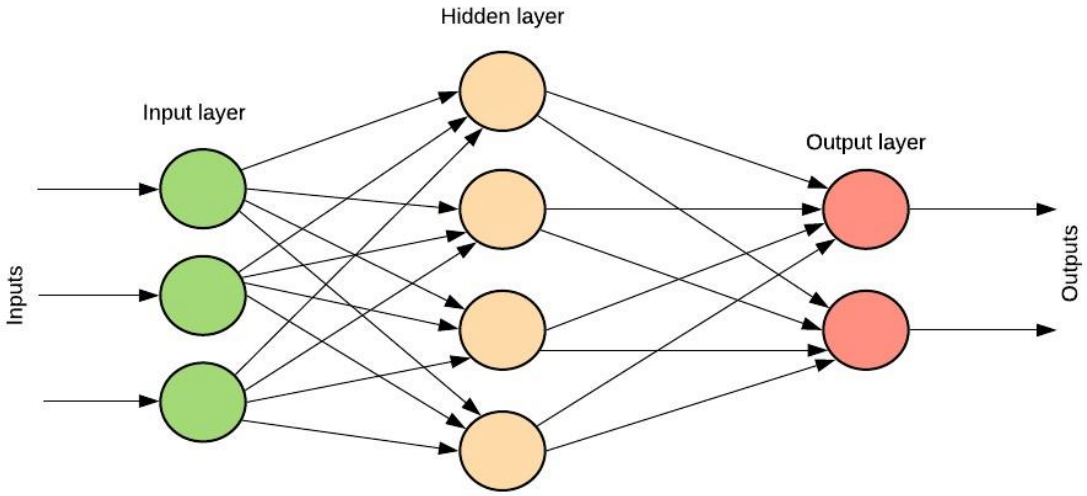


Figure 1: Feedforward Neural Network

Technologies like computer vision and recognition of face are the applications of this neural network. The reason behind it is, in these applications the target classes are difficult to classify. The data which contains a lot of noise are dealt by equipping a

simple feedforward neural network. Maintaining feedforward neural networks are also simply relative.

3.3.2. Radial Basis Function Neural Network

Among all other neural networks, intervention of any point similar to the centre, gains consideration for the radial basis function. Two layers have been identified till now in this neural network. The properties are assembled in the inner layer with the radial basis function. At the time of calculation of the same output in the afterward time-step, the output of these properties is taken. A figure which illustrates a radial basis function neural network is given below.

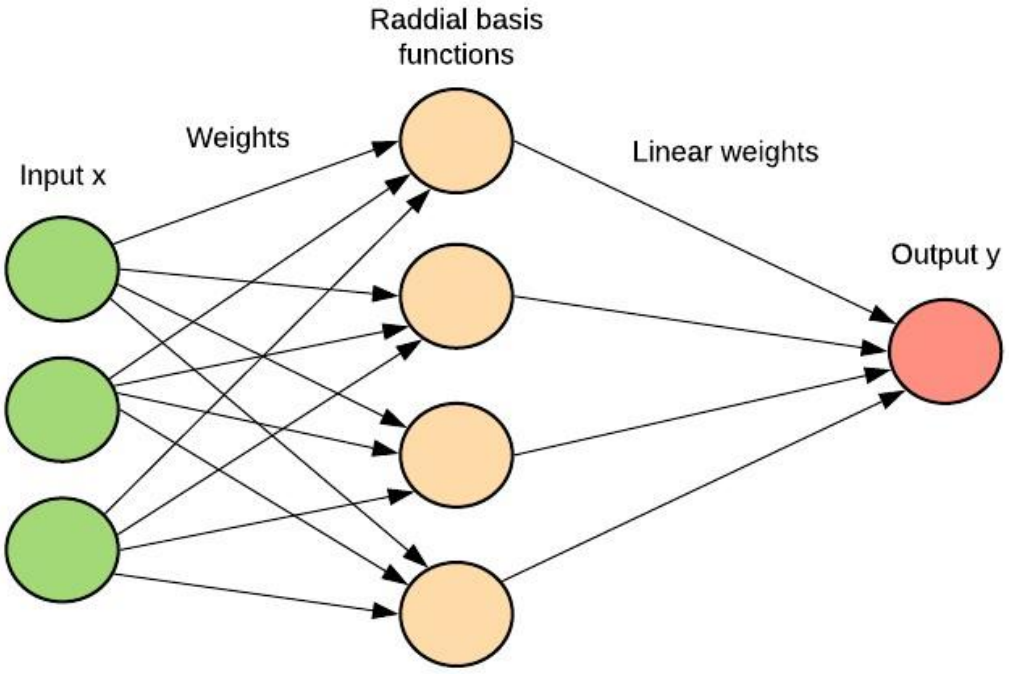


Figure 2: Radial Basis Function Neural Network

In power recovery systems, this network is applied comprehensively. This power system has turned larger and become over complex in modern years. Chances of blackout rise by this. To restore power in the least probable time, this neural network is used in the power recovery systems.

3.3.3 Multilayer Perceptron

Three or more layers, a multilayer perceptron can contain. The data which are unable to detach linearly uses this network to classify the data. This type of network is fully connected artificial neural network. The reason behind this is all nodes are connected with each other and to the next layer. A nonlinear activation function (predominantly hyperbolic tangent or logistic function) is used by this neural network. A figure is given below to understand how a multilayer perceptron looks like.

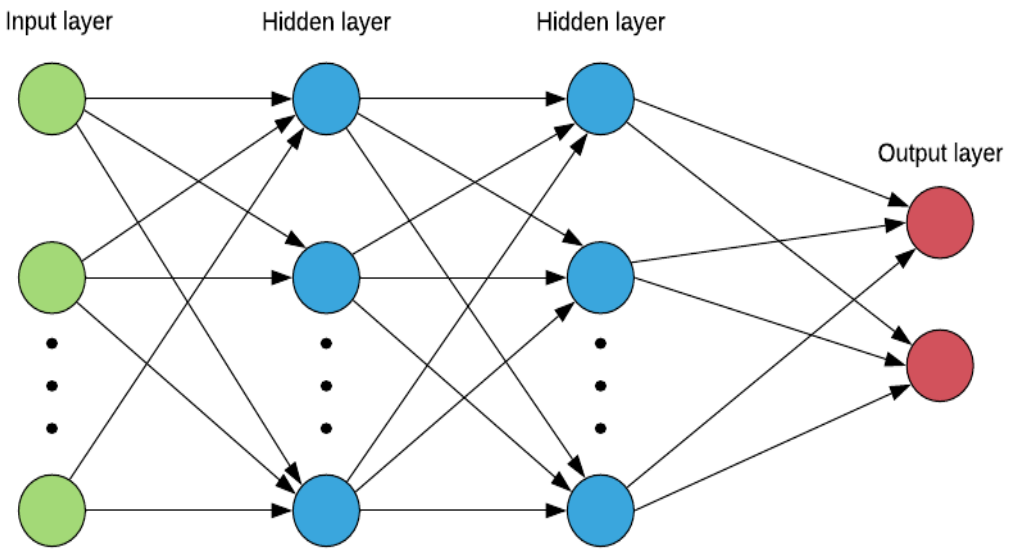


Figure 3: Multilayer Perceptron

The application of such type of neural network is in speech recognition and machine translation technologies.

3.3.4 Recurrent Neural Network

Among all type of artificial neural network, Recurrent Neural Network generates output of a specific layer and saves the output to be fed back to the input. Thus, the prediction of the outcome of the layer becomes easy. Like feedforward network, the beginning layer is built in the same way. Calculation like the sum of the products and weights values with features. The recurrent neural network process begins in the following layers. Every time-step afterwards, each node will contain some fact that it had in the prior time-step. In another saying, every node works as a memory in the time of computing and doing

activities. This neural network normally starts with the front propagation, but contains the fact it might need to utilize afterwards. If the prophecy is not accurate, the system learns itself and during the backpropagation works on making the accurate prophecy. In text-to-speech transformation recurrent neural network is very useful technology. A figure is given below to understand how a recurrent neural network looks like.

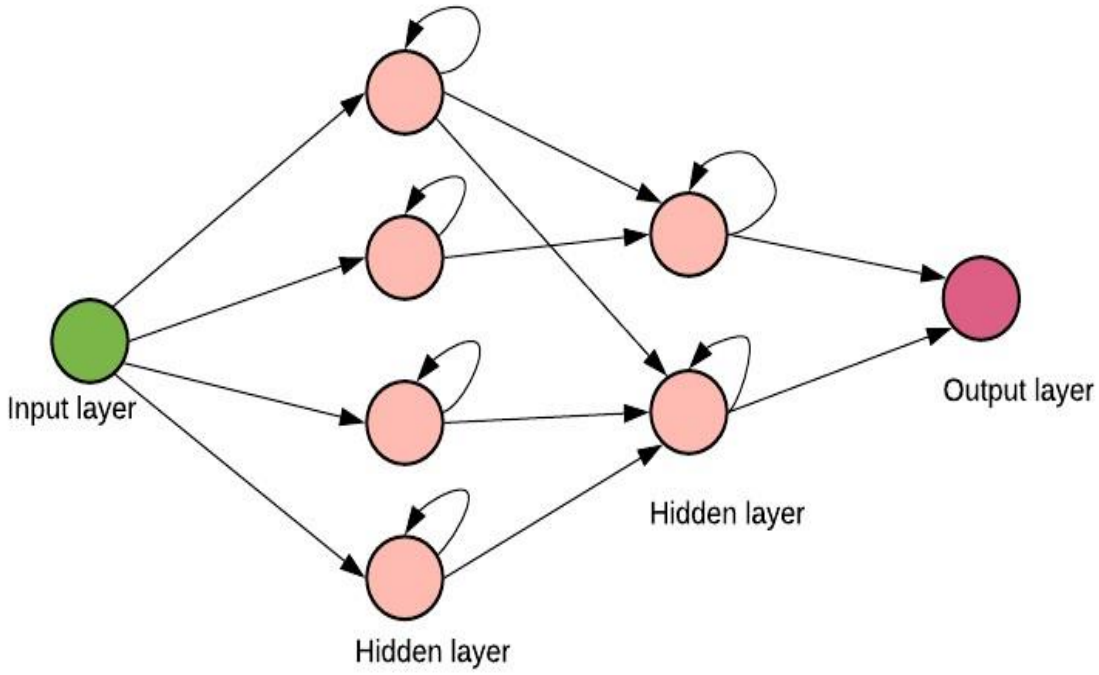


Figure 4: Recurrent Neural Network

3.3.5 Modular Neural Network

To perform sub-tasks, a neural network named Modular Neural Network has many varieties of networks which works freely. When the calculation process happens then the individual networks do not actually communicate with or signal to one another. The individual networks work freely on attaining the output result. In this process, many large and computationally complex components splits significantly quicker into autonomous components. And so, the speed of calculation goes up just because the networks do not communicate or interact with one another. A figure is given below to understand how a modular neural network looks like.

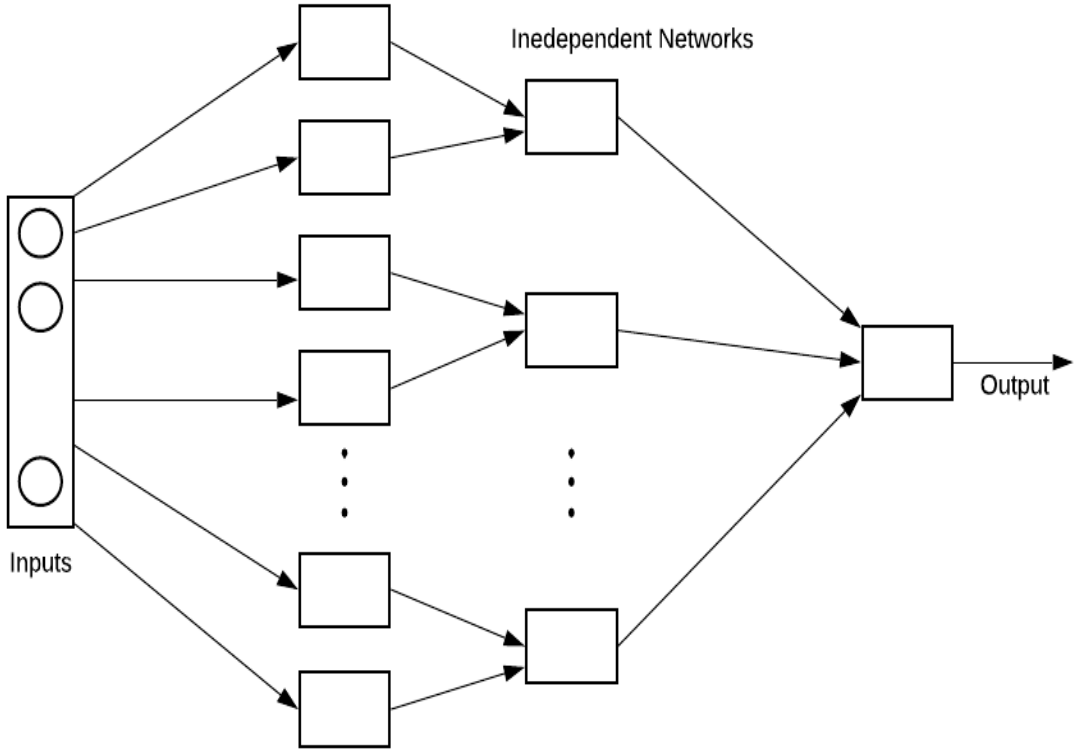


Figure 5: Modular Neural Network

3.3.6 Sequence-To-Sequence Models

There is a neural network named sequence to sequence model which forms by recurrent neural networks. The two recurrent neural networks are needed to make a sequence to sequence model. The input is processed by the encoder and the output is processed by a decoder. Either exact or various parameters can be used by both encoder and decoder. Sequence to sequence model can only be used in such cases where input data length and output data length is different from one another. Question answering systems, chatbots, and machine translation are mainly the application of sequence to sequence model.

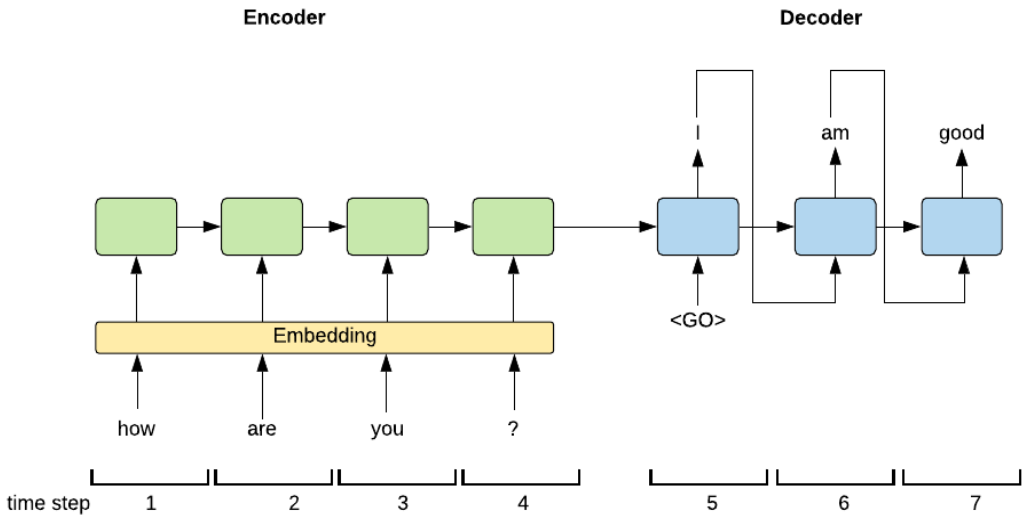


Figure 6: Sequence-To-Sequence Models

3.3.7 Convolutional Neural Network

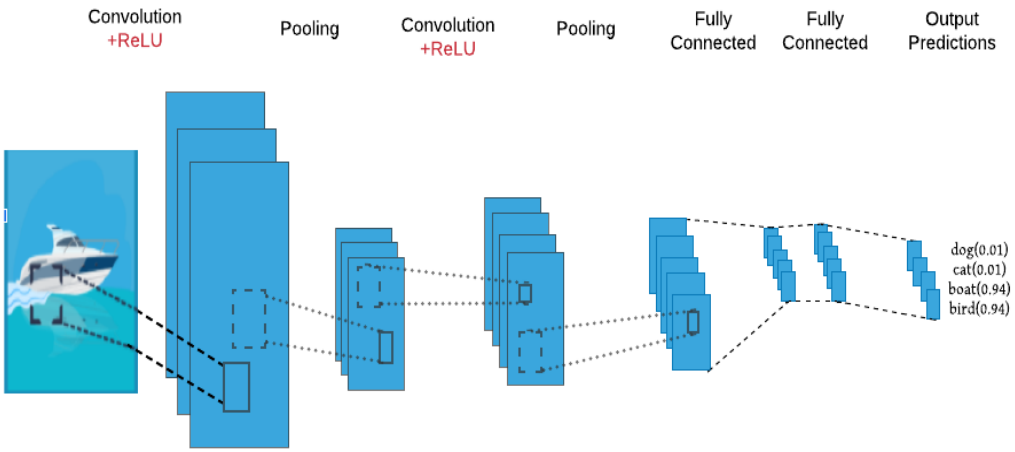


Figure 7: Convolutional Neural Network

Convolutional neural network is one type of classification algorithm which enables a machine to classify something like human beings. The convolutional neural network is built inspired by the pattern of the human brain neurons. In the domain of computer vision, the convolutional neural network plays an important role. This deep learning

algorithm has been highly used in the field of computer vision like image processing and analyzing, video recognition, recommendation system and so on.

This classification algorithm has been used in the generative adversarial network both in the generator and the discriminator to generate and classify between real and fake.

The convolutional neural network consists of five layers:

i. Input layer
ii. Convolutional layer
iii. Activation layer
iv. Pooling layer
v. Fully connected layer

1. **Input layer:** Input layer takes an image as input with a height, width and a channel. In this work, 256 X 256 image has been used and the RGB color channel is used as a channel. RGB comprises red, green and blue color planes. The job of the ConvNet is to decrease the images into a form which is simpler to process, without losing a single feature which is basic for getting a decent prediction
2. **Convolutional layer:** Convolutional layer convolves an image with a kernel to get an nXn convolved feature. For instance: An image dimension is 256X256X1 where the height is 256 and width is, 256 and number of channels.

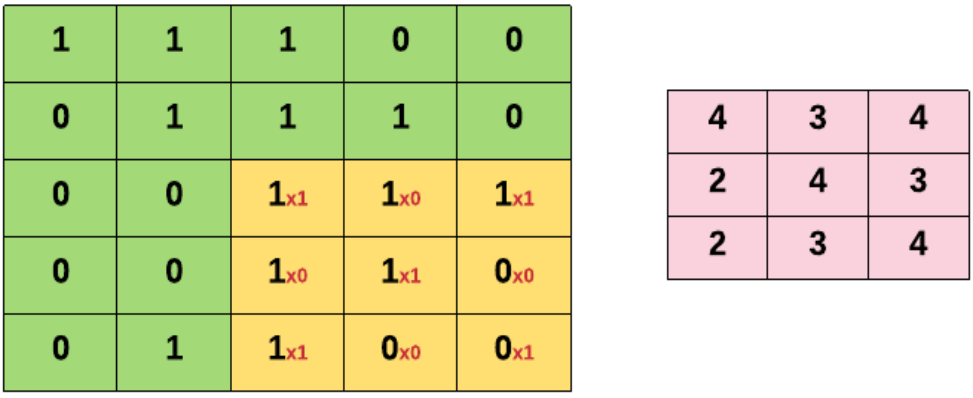


Figure 8: Convolutional layer

The image illustrates the convolutional feature. There is an image matrix of 256X256. The convolutional feature will be carried out by a kernel, K or a filter in the image matrix. In the above demonstration, the filter is:

1 0 1

0 1 0

1 0 1

Here, the stride length value is 1; following this value, the kernel moves all around the image matrix for generating the convolved matrix. For stride 1, the filter shifts total 9 times in the image to get the convolved feature. Matrix multiplication has been carried out between the kernel, K and the portion, P of the image in every traversal. The kernel moves from the top right of the image, then it moves right following by the same stride value 1. After completion of shifting from right to left, then it hops down. The whole image will be shifting over through this process until the full image matrix is traversed.

For the multiple channels of an image like RGB, BGR, the kernel will have the same depth as like as the input image. The matrix multiplication will be taken place for each channel and the final output will be carried out by the combined summation of the multiple channels.

Typically, the first convolutional layer is liable for extracting low-level features, for example, edges, shading, slope direction, and so forth. However, including the additional layers, the structure adopts the high-level features. The purpose of the convolutional operation is to extract high-level features. The convolutional layer is not limited to only one layer. Sometimes, we put an additional layer for getting better features.

The valid padding or the same padding can be applied on this occasion. Say, an input image, dimension is 5X5X1 in our work. By adding an additional layer, the dimension will be 6X6X1. Then applying the kernel on it, the convolved matrix will be found. This is called valid padding. However, the same padding is the conventional rule which follows without padding.

3. **Activation layer:** The activation function is a function where a node is usually used between or end of the neural network. This function determines whether a neuron will fire or not. This activation function is a non linear transformation that is utilized over the input signal. One transformed output is sent into another layer as input.

There are different types of activation function which are used in the neural network such as ReLU, LeakyLeLU, ELU, Sigmoid, Maxout, tanh.

ReLU = $\max(0, x)$

tanh = $\tanh(x)$

Sigmoid, (x) = $11 + ex$

LeakyReLU = $\max(0.1x, x)$

Among the activation functions, ReLU is the common and most widely used function. For not activating all the neurons at a time, makes the activation layer exclusive and provides a huge advantage. In this work, the ReLU function is used in the neural network of GAN.

4. **Pooling layer:** This layer is also liable for decreasing the spatial size of the convolved features like the convolutional layer. The process of data carried out by reducing the dimension for decreasing computational power. Besides, it is helpful to explore features of dominant that are rotational and positional invariant, in this way keeping up the procedure of successfully training the model.

There are two categories of pooling:

a. Max pooling
b. Average pooling

a. Max pooling: It returns maximum value among the values of the kernel portion. In every stride, it returns the maximum value.
b. Average pooling: Average pooling calculates average value among all the values in a kernel of an image.

5. **Fully Connected layer:** The fully connected layer flattened the matrix into vector and then it is fed it in the neural network.

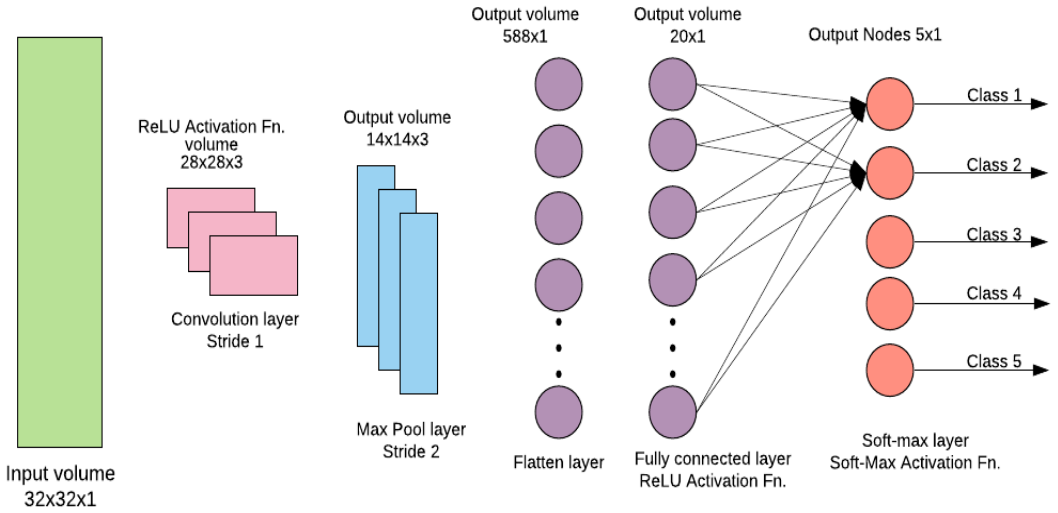


Figure 9: Fully connected layer

CHAPTER 4

Methodology

GAN is a generative model where it consists of a pair of two adversaries: 1. Generator, G 2. Discriminator, D. The Generative model, G captures the distribution of data as random noise vector, z, and the discriminative model D differentiates between the random noise vector and produced data from the generator.

GAN learns the mapping function from the generator over the observed data *x* from the noise distribution *pz(z)* to data space as G(z;θg). On the other hand, the discriminator, D(x;θd), estimates the probability that the sample is received from the training data in lieu of Generator.

G and D trained at a time in the two-player minimax formulated GAN. Generator and discriminator counterfeits to each other where parameter G minimizes log (D(G(z))) to fit the generated value into D which provides the probability whether it is real or fake and D minimizes logD(X) that optimizes the probability of real data. The function of minimax game based GAN V (D, G):

$$\min max\, V(D,G) = \mathbb{E}_{x\sim p_{data}(x)}[logD(x)] + \mathbb{E}_{z\sim p_z(z)}\left[\log\left(1 - D\left(G(z)\right)\right)\right]$$

4.1 Conditional Generative Adversarial Network (cGAN)

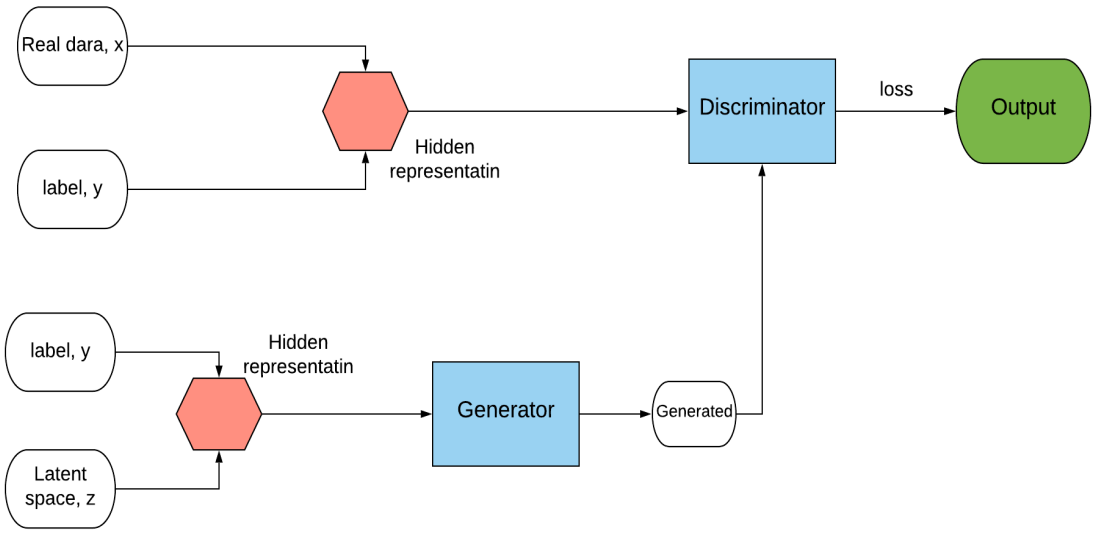


Figure 10: Conditional Generative Adversarial Network

Conditional GAN can be performed using an additional condition in both of the network generator, G and discriminator, D. The aim of this paper is to synthesize a clear image of the criminals from a blurred crime image constructing cGAN. The goal of the proposed network is to mapping directly from a blurred image to a clear criminal image by adding an additional condition in the network. The network can be performed under any specific condition or characteristics in the generator for the learning process. The condition in both network Generator and discriminator can be applied by feeding some condition class vector y.

In the cGAN, Generator and Discriminator both are adapted by some extra information. Therefore, the two networks are jointly conditioned as the generator, G of z and y and the discriminator D of x and y. In the input layer, generator G takes noise vector z and a conditional class vector y combinedly where the blurred criminal image is the conditional vector y in this occasion. Then the generator, G returns generated synthetic data from the generator. Synthesizing of criminal image by the generator has proceeded in such a way so that it cannot miss or lose any single information of the pixel. Then the discriminator, D distinguishes between the generated image and training dataset (the real image dataset of criminals). The equation of two-player minimax game based on conditional GAN as follows:

$$\min max\, V(D,G) = \mathbb{E}_{x\sim p_{data}(x)}[logD(x|y)] + \mathbb{E}_{z\sim p_z(z)}\left[\log\left(1 - D\big(G(z|y)\big)\right)\right]$$

CHAPTER 5

Dataset Description

5.1 Image Acquisition

We use two cameras in our work. Vivo y81 used for shooting videos and iPhone 6s utilized for snapping photos. A team of six volunteers (all are male) have worked with us to make a criminal dataset whose ages between 19 to 24 years. The volunteers of this dataset given their written assent and expressed their privilege for working with this work. Crime videos are captured like as compatible video surveillance. These videos had snapped in different circumstances with appropriate expression. The background of the videos illustrates a realistic environment under different light variations. The recordings were shot maintaining a proper distance so that it takes to be more realistic like surveillance videos using the Vivo y81. We put a mask on this camera so that it can produce blurry images. However, the real specification of the camera is 13MP, f/2.2, PDAF, LED flash and HDR.

Besides, the photographs of the same volunteers also have been captured by iPhone 6s. The detail of the camera 12 MP Sony Exmor RS IMX315 (1.22μm), autofocus, 4k video recording at 30fps or 1080 at 30 or 60 fps, true-tone flash, facial recognition, digital & optical image stabilization. The photos were taken in a room to get clear images.

5.2 Experimental Dataset Preparation

Our dataset consists of a training dataset and a test dataset. Images have been considered as a training dataset and the videos can be considered as test datasets. Six volunteers are the subject of our dataset and each subject considered as a class. The training dataset consists of total 620 photos where 95 photos of subject 1, 76 photos of subject 2, 95 photos of subject 3, 95 photos of subject 4, 165 photos of subject 5, 94 photos of subject 6. The test dataset consists of 6 videos.

Figure 11: Sample Images

5.3 Ethical Conduct

This article involves data acquisition from 6 human subjects and informed consent was obtained from all these participants included in the study.

CHAPTER 6

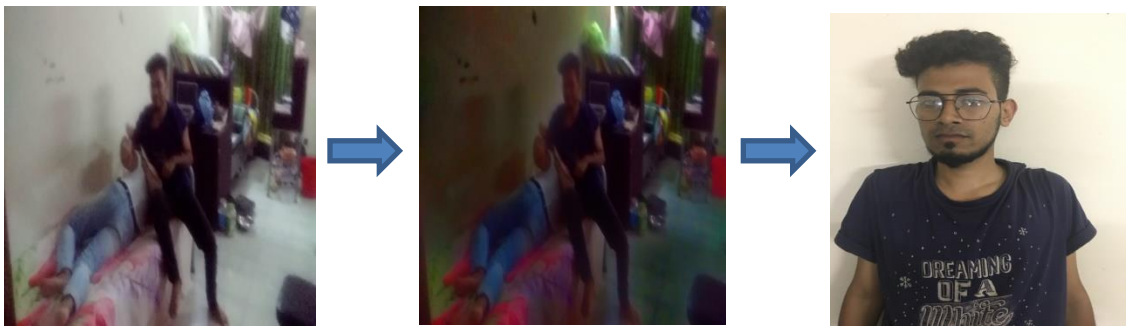
Experiment Results

6.1 Quantitative Result

Table-1: Confusion matrix

	Predicted Class					
Actual Class	97.67	0	0	2.33	0	0
	0	100	0	0	0	0
	4.08	6.12	89.80	0	0	0
	2	38	2	56	2	0
	4	0	20	2	74	0
	0	25.53	0	0	0	74.47

6.2 Qualitative Result



6.3 Accuracy

Table-2: Accuracy

Recognition
Accuracy: 88.11%

CHAPTER 7

Conclusion

Crimes are increasing globally which is hindering the regular lifestyle and making affright of civilians' minds. The video surveillance system is one of the main ways in the digital era to identify the criminal. However, criminal detection using these video recordings are very challenging sometimes because of the video quality. In order to contribute to society by identifying the perpetrator, we proposed a criminal identification model using the conditional generative adversarial network. In case the surveillance camera shows an unclear or blurred image of a criminal, our conditional adversarial model counterfeits with each other (two networks: Generator and Discriminator) to identify and classify the clear criminal image from the blurred, unclear or poor quality surveillance recordings. Data preprocessing is required for identifying the targeted criminal. This approach would be revolutionary in the field of forensic identification.

Law enforcement and investigation agencies can use this model to detect and arrest criminals. However, there are few areas to increase the robustness of the work for getting more accuracy.

Limitations

This method is way much useful when the criminal face is seen or captured. As this method is supervised so, criminal record is needed to train the model. Moreover, mask on criminal face might create identification problem.

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