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A Study on Fuzzy Searching Algorithm and Conditional-GAN for Crime Prediction System

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범죄예측시스템에 대한 퍼지 탐색 알고리즘과 GAN 상태에 관한 연구

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Abstract In this study, artificial intelligence-based algorithms were proposed, which included a fuzzy search for matching suspects between current and historical crimes in order to obtain related cases in criminal history, as well as conditional generative adversarial networks for crime prediction system (CPS) using Timor-Leste as a case study. By comparing the data from the criminal records, the built algorithms transform witness descriptions in the form of sketches into realistic face images. The proposed algorithms and CPS's findings confirmed that they are useful for rapidly reducing both the time and successful duties of police officers in dealing with crimes. Since it is difficult to maintain social safety nets with inadequate human resources and budgets, the proposed implemented system would significantly assist in improving the criminal investigation process in Timor-Leste.

요 약 본 연구에서는 현재 발생한 범죄와 과거 유사 범죄의 기록을 조사하여 용의선상에 오른 자들과 전과자들를 비교 분석하여 범인를 예측하는 시스템을 제안한다. 제안된 시스템은 용의자들과 전과자들의 안면을 비교하기 위하여 조건부 생성 적대 네트워크를 포함하는 퍼지 매칭으로 예상 범인을 선별하는 인공 지능 기반 알고리즘 범죄 예측 시스템(CPS)입니다. 유효성을 증명하기 위하여동 티모르. 범죄 기록의 데이터를 활용하였습니다. 구축 된 알고리즘은 증언을 바탕으로 몽타쥬를 작성하여 범죄 기록상의 전과자 안면과 비교됩니다. 제안 된 알고리즘과 CPS의 결과는 범죄를 처리하는 경찰관의 시간과 노력을 최소화될 뿐만 아니라 신속한 결과를 얻었으므로 유용하다는 것을 확인했습니다. 특히, 동 티므로와 같이 부족한 인적 자원과 예산으로 사회 안전망을 유지하는 것이 어려운 국가에 제안된 시스템의 적용은 미해결 범죄의 감소와 신속한 범죄 수사에 기여할 수 있다.

Key Words : Crime Prediction System, Fuzzy Searching Algorithm, Generative Networks, CGAN, AI

1. Introduction

Nowadays, the crime prediction system(CPS) is being considered as an alternative solution to deal with the various problems related to the unsafe crimes taking place all over the world. One of the characteristics of modern society is that most of the crimes are committed every day, and these frequent crimes make the life of ordinary citizens restless [1]. Although the information and communication technology(ICT) sector in Timor-Leste has great potential to help the national development process. Nevertheless, according to the police, there are many cases of crimes where the police officers have difficulties in dealing with the witness statements[2]. In addition, it was reported that

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the inadequate infrastructure in the legal community reflects the national policy, as the relevant organizations have very few staff and lack of expertise in ICT[3]. The current availability of information technology has made it possible for law enforcement agencies and police to collect detailed information about criminal data. Moreover, when advanced technology and human resources are made available, the police can easily identify the suspected criminal who committed the crime according to the descriptions of the witnesses, it is also possible to handle the classification of complex and difficult crimes efficiently. To overcome these problems, this paper performs an artificial intelligence(AI) by applying the algorithms of fuzzy matching and conditional GAN which have proven to be useful for crime systems while their ability to detect crimes and help to ensure better public safety by investigating suspected criminals. These techniques have been applied in many tasks in crime problems to identify criminals in an appropriate manner.

2. Operation Method of Algorithm for Crime Prediction Systems

The proposed algorithm is divided into two parts, the first part is the fuzzy searching to match the similar cases between the new and old crimes in the criminal records, and the conditional generative adversarial network(CGAN) to convert the considered sketches into realistic face photos, which is shown in Fig. 1. The detailed proposed algorithm for identifying suspected criminals is as follows:

[Step 1] Performs a fuzzy query interpreter for structural query language(SQL) conversion. [Step 1] starts by selecting the exact match of the data, if no exact match is found or the number of search fields is 0, the number of search fields is decreased and the required similarity threshold is increased. And if one or more matches are found, the first step is completed, if not, it continues with step[2].

[Step 2] Applies a description of the reliable eyewitness to the sketch image and trains a CGAN based model to predict the realistic image based on the input sketch image.

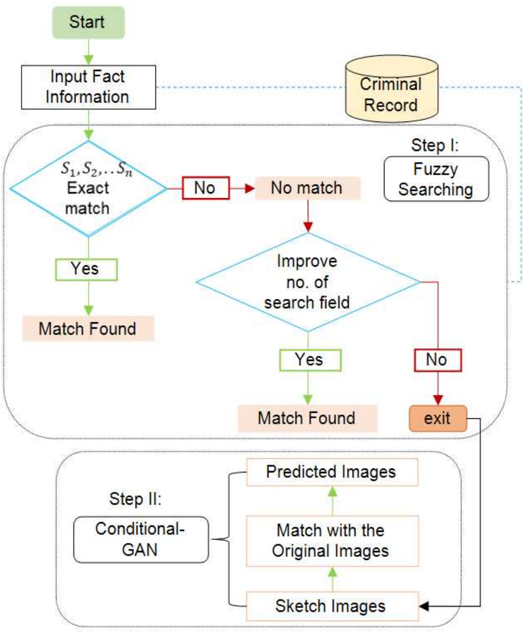


Fig. 1. Overall concept of crime prediction system

2.1. Operation Method of Fuzzy Algorithm based on Trigram Search

A trigram algorithm is one of the general search methods for Big Data problems like texting mining, information retrieval, and also many others[4]. This method plays a role as keywords for representing the phrases as words used in a document. The similarity of the phrases is further calculated using a vector cosine similarity measure. The string is categorized into terms at spaces and these individual terms are assembled into trigrams. Strings of length $k+1$ are obtained from $k+3$ with overlapping trigram. Meanwhile, any string of length 3 or shorter is taken as a trigram, although it should refer to trigrams with only one or two letters. Where the global weights of the form expressed in Eq. (1) are given to the entire attributes.

$$\sqrt{\log\left(\frac{N}{n_t}\right)} \tag{1}$$

Namely, these are relatively standard inverse document frequency weights, while N stands for the size of the collection of strings in the case of the number in certain phrases. Here, the value n_t is the frequency of occurrence in the entire collection of the weighted attribute. Each attribute is given a local weight as expressed in Eq. (2).

$$\log(1+f_t) \tag{2}$$

where f_t is the number of descriptions in the particular phrase in which the local weighting is applied. When the total attributes in each phrase are weighted which represented by the vector of local times in the global weights. Often these attributes have occurred in a phrase with non-zero coordinates in the vector representation.

2.2. Operation Method of CGAN Algorithm

The CGAN model is an extension of the Generator Adversarial Nets(GAN), which is a machine learning technique used to train generative models. In the CGAN model, it is necessary to add the information y to the generator and discriminator to possibly transform the model into conditional nets[5]. Here, y is considered as class labels or data from the other method and also as a condition which is performed by giving y to both network differentiator and generator which is provided with additional input layer. By combining random noise vector $p_z(z)$ and label y as inputs, the generator produces a fake sample $x|y$ that attempts to be realistic or similar to the label. Meanwhile, the discriminator accepts real samples(x) compared to labels(y), and fake samples along with the label used to synthesize$(x|y, y)$. Moreover, it can yield a probability indicating whether the input pair is real or fake. The objective function of a two-player minimax game is expressed in Eq. (3).

$$\max_G \min_D V(D,G) = E_{x-pdata(x)}[\log D(x|y)] + E_{z-pz(z)}[\log(1-D(G(z|y)))] \tag{3}$$

3. Implementation of Fuzzy Searching and CGAN Algorithms

3.1. Preprocessing data of Fuzzy Searching Algorithm

In order to create a set for searchable data using a fuzzy search algorithm, this work creates the real criminal records collected from the National Police of Timor Leste(PNTL). Therefore, preprocessing is required for each record in the database, and then the tables are created with a searchable string and list representing all these attributes. In this case, the datasets consist of tables that contain crime types, criminals, evidence, and previous prison stays. The details are illustrated in the following tables.

Table 1. Details of criminal information background

items	contents		
criminal	id_criminal	sub-district	height(cm)
	id_crime	village	weight(kg)
	name	race	mannerism
	gender	complexion	sidenote
	birthday	image	contact
	place_of_birth	eye_color	mother's_name
	district	hair_color	father's_name
	crime_method		

To improve the structure of the effective tables for the historical data, this study comes out with a systematic analysis of the policy document in each area, including the criminal personal information, as shown in Table 1. After the above data collection, this study analyzes the relevant factors are indicated in Table 2 and Table 3. These factors are considered as crimes and previous prison tables in which the criminals were committed.

Table 2. Crime attributes

items	contents
crime	id_crime
	crime_types

Table 3. Prior prison specifications

items	contents
prison-prior	id_prison
	id_criminal
	Detention_place
	Detention_free
	Detention_date
	Description

Furthermore, according to the interview with the police officer, it is concluded some essential factors related to the criminal history such as the confession of the defendant, physical and expert evidence are established. In this way, this research identified twelve variables that significantly correlate with police archives. These factors are the defendant's confession, scientific, physical, or trace evidence of the defendant, digital, expert opinion, documentary, demonstrative evidence, and the frequency of crimes as demonstrated in Table 4. Therefore, in this study, these factors were found significant to be included in the database based on Sabahi[6] which was used for testing the role of validity measures in automated judicial decision making with fuzzy probabilistic. In general, for the majority of cases, the defendant's confession and physical or scientific evidence are the most important factors compared to others for sentencing issues. However, the current guidelines cannot list all the evidence and information on the crime cases. Therefore, this research proposes new relationship data with the most important factors by considering the necessary archival document.

Table 4. Details of evidence list

items	contents	
evidence	id criminal	demonstrative evidence
	defendant confession	expert opinion
	scientific evidence	crime frequency
	physical evidence	fingerprint
	tire track evidence	palm-print
	biological evidence	footprint
	digital evidence	CCTV footage
	documentary evidence	

3.1.1 Data Relationship

In this research, processing of the fuzzy queries related to the functions of approximate string matching is performed. In this section, the analysis of the occurrence of fuzzy values in SQL queries directed to the databases is presented. These relational data perform the fuzzy queries in terms of searching for the possible matching records, where the first step is to design a database to simply learn about the system and discover data needed to support the system, thus obtaining an entity-relationship model(ER) that translates the model into the relationship schema shown in Fig. 2.

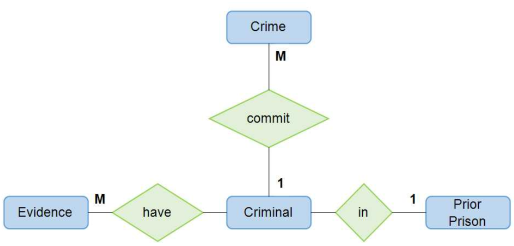


Fig. 2. Concept of entity relationship schema

3.1.2 Fuzzy Searching Algorithm

This section focuses on the method for identifying phrases that have a high probability of synonyms. Where the string query represents each phrase with a trigram of characters extracted from the phrase. Then a phrase can occur only once, and to solve the matching problem in this way, each phrase is considered. Here the similarity between the two phrases is calculated as the cosine of the angle between them. It keeps within a number between 0 and 1. Therefore, in this study confirmed that when the value is approximately 0.7 or greater, the probability becomes higher that the two phrases are the same. A detailed description is demonstrated in algorithm 1.

Apart from finding all possible words within the k range, it is found that the similarity of the keyword is counted with the specific times, and also allows to present more records while maintaining the fast search times and then the cost of accuracy on the criminal records.

3.2. Proposed Method of CGAN Algorithm

The detailed architecture of the proposed CGAN model, which consists of two main networks such as the generator(G) placed in the block(A) and the discriminator(D) in the bottom block(B), is shown in Fig. 3. In this study, a CGAN-based generator model is used to generate a realistic photo constraint for single face photo view.

Algorithm 1. Find matching strings similarity

```
procedure SET-LIMIT FUNCTIONAL REQUIREMENT (0.3, 0.5, 0.7)
set f to search fields
set s to required similarity
if there is match =>1 or exact match
  then
     return match
else
     while no match found or
            number of f = 0 do
            decrease number of f and
            increase s > 0.3
       if there is => 1 match then
          return match
       end if
     end while
end if
     return empty list or null
end procedure
```

Specifically, this model first encodes the 2D view photo into a low dimensional vector and then decodes in the reverse direction to recover the 3D view condition. Moreover, the 3D view structure is passed to the discriminator process to distinguish whether the 3D view is real or fake. The method proposed here is divided into two sections, including network architecture and model training.

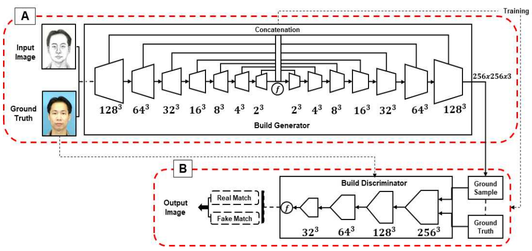


Fig. 3. Architecture of Conditional Adversarial Network

3.2.1 Generator Network

The generator is generally based on an auto-encoder with skip-connections between the encoder and the decoder, and it synthesizes data from the hidden distribution of the 2D structure, as shown above in Fig. 3 of block A. In particular, the encoder has seven 3D convolutional layers that generate a representation of the 256x256x3 dimensions of the image as a vector of 512 features. Indeed, each block of the encoder has a set of 4x4x4 filters with step sizes of 2x2x2 followed by the activation function of the Convolution-Batch-Norm-Leaky-ReLU layer. Moreover, the number of output channels in the max-pooling layer starts from 128 doublings at each subsequent layer. After encoding the image into its feature representation, the decoder consists of seven connected up-convolutional layers, as shown in Fig. 3 on the right side of block A. Here, ReLU activations follow with the exception of the last layer with the Convolution-Batch-Norm-Droupouts-Tanh layer. In addition, skip-connections between the encoder and decoder provide propagation of local structures in the 2D input view. Furthermore, the two fully connected layers and skip-connections are used for the encoding and decoding layers to represent a complete 3D structure. Moreover, it can help the generator to reconstruct the brightness image which is similar to the input image.

3.2.2 Discriminator Network

Based on the aforementioned conditional GAN, this section introduces the discriminator that takes input from both real and fake reconstruction pairs. To be precise, it consists of four 3D deconvolution layers, each layer has a set of 4x4x4 filters with steps of 1x1x1 followed by the activation function of Leaky-ReLU. The number of output channels in each layer is identical to the encoder section described in Fig. 3 of block B. However, this discriminator should not be interpreted as a binary discriminator to simply classify fake images as opposed to real reconstructions. On the other hand, only two categories are considered to distinguish fake and real images, which are not able to capture the geometric details of the object. And it is unlikely that the discrimination loss will benefit the generator by backpropagation. In contrast, this discriminator is designed to output a vector representing the distributions of real and fake reconstructions.

3.2. Training Model

The model is implemented in Python 3.7 with a TensorFlow backend[7]. A mini-batch SGD and an Adam optimizer were used and set to a learning rate of 0.0002 and a momentum parameter of 0.5. The G and D networks are trained simultaneously. In addition, the batch size and epoch were set to 1 and 1000, respectively. All the experiments were conducted in a server with memory RAM 128GB and NVIDIA GeForce RTX 2080 Ti GPU.

4. Results and Discussions

4.1 Characteristics Result of Fuzzy Searching Algorithm

In this research, three different attempts are conducted to evaluate the proposed algorithm. Where the search time depends on the size of the indexed data is shown in Table 5 and Table 6. Here, the number of operational requirements for finding different words and the different accuracy for the given query are also presented. The data used for the experiment is a dataset which has already been mentioned in the data processing up to 300 records.

1st Attempt

To analyze the results of the algorithm by applying the fuzzy search, as mentioned earlier. With the description of the reliable witness, this research accumulates the factual information of the characteristics of the suspected criminal such as complexion, eye color, hair color, height, weight, gender, sidenote, mannerism, and method as shown in Tables 5 and 6. And also the type of crime to match this information with the criminal records to get similar cases from the historical data and essentially identify the potential criminal that exists in the records data. Moreover, this collected real information is derived from a fuzzy match to describe the degree of similarity and approximation of each string. Tables 5 and 6 show the result of giving new information for fuzzy search query and matching with criminal records data.

Table 5. List of the 1st record

1.1. Record	
pg_similarity	0.61950376558338
pg_match_level	2
g_complexion	Black
pg_eyecolor	Black
pg_haircolor	Black
g_height_cm	170
pg_weight_kg	87
pg_gender	Male
pg_sidenote	Tattoo/hand
pg_mannerism	Normal
pg_method	Stabbing
pg_crimetype	Homicide

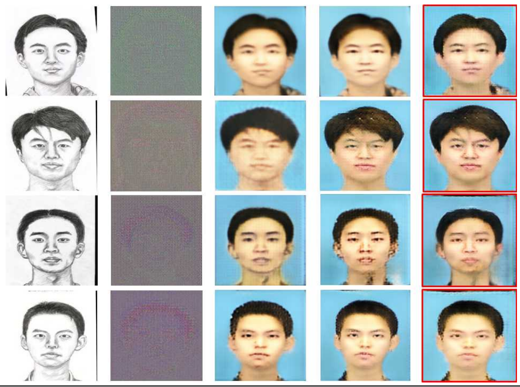
Table 6. List of the 2nd record

1.2. Record	
pg_similarity	0.4885714364051
pg_match_level	2
pg_complexion	White
pg_eyecolor	Black
pg_haircolor	Black
pg_height_cm	172
pg_weight_kg	75
pg_gender	Male
pg_sidenote	Scars on the neck
pg_mannerism	Temperament
pg_method	Fighting
pg_crimetype	Homicide

2nd Attempt

In this second attempt, the same features and attributes are given for the process of the similar query, but it focused more on the crime method, where the fuzzy algorithm tends to search based on the crime methodology and find out the possible match according to the set parameter. For example, considering stabbing as the crime method, this search method can give entire similar crime methods with the particular information of the criminals.

3rd Attempt



Input 0 56 135 197

Fig. 5. Predicted images achieved by CycleGAN method using dataset A

Input 11 25 75

Fig. 6. Predicted images achieved by CycleGAN method using dataset B

On the other hand, if no match is found after the 1st and 2nd attempts, then the result should be an empty list or null for all attributes.

4.1.1 Characteristics Result of Time Interval

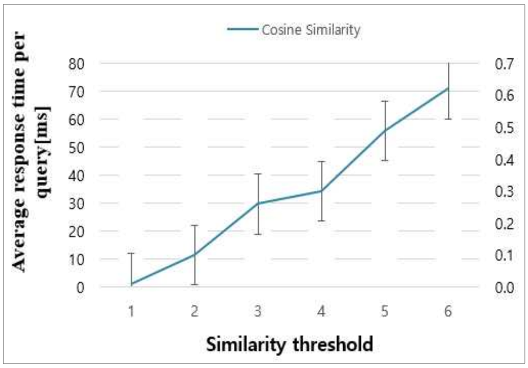


Fig. 4. The average response time each query

Figure 4 shows the average response time of applying trigram search for different similarity tests and threshold values. The index threshold is started from (α = 0.3, 0.5, 0.7). Based on the experimental result, it is obtained 6 records with different similarity and match numbers with t=67.45 ms.

4.2 Characteristics Result of CGAN Algorithm

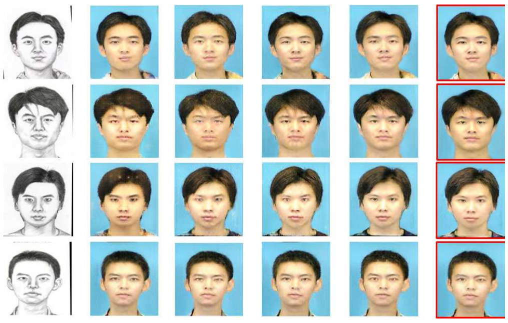


Fig. 7. Results of applied CGAN method using dataset A

This study uses qualitative and quantitative evaluations for the comparative model and proposed model in dataset A and dataset B to evaluate each performance. Dataset A is the CUHK Face Sketch(CUFS) database, which contains 188 face photos from the Chinese University of Hong Kong(CUHK)[8]. And dataset B is the CUHK Face Sketch FERET(CUFSF) database which contains 1194 face photos [9]. This dataset contains a variety of illuminations for each image and a sketch drawn by an artist while viewing the photo with different facial expressions. The proposed method is compared with the state-of-art CycleGAN based image-to-image Translation[10]. This approach allows training without the need for paired data. Nevertheless, it can translate from one domain to another without a one-to-one mapping between the source and target domains. In this study, applied the paired sketch and color images were used to train the model.

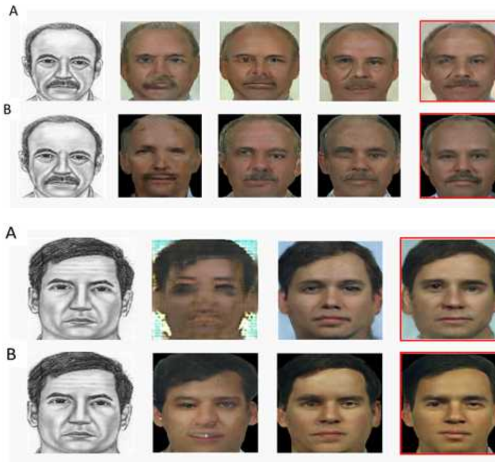


Fig. 8. Results of applied CGAN method using dataset B

For the qualitative comparison, the method is evaluated on the randomly selected images with different time epoch as well as the different data of image pairs on the validation images of datasets A and B, and the performance of the proposed method is compared with a state-of-the-art method. All methods are compared with the labeled ground truth. Figures 5-8 show the predicted images of the comparison method for datasets A and B, respectively. In this study, a random number of noise samples z were used and repeatedly sampled by the generator with these noise values during training. The numbers under each column show the time (epoch) at which the sample was taken. Figures 7 and 8 show the predicted images obtained by the proposed methods for test images from dataset B, and the output of the generator(G) when trained on cropped face images. The figure is divided into two parts as above(A) and below(B). Figure A shows the predicted image under the condition that the light and background are different in each input photo. While figure B shows the segmented input images and the training images for the CGAN model. The figures clearly show that the proposed method performs better than another state-of-art method.

Table 7. Error metrics of predicted face-image test set after the generative models trained.

Models	The test set of error metric (RMSE)	
	Dataset A	Dataset B
CycleGAN	2.118	2.950
Conditional GAN	1.015	2.034

For quantitative evaluation, this study introduces Root Mean Square Error(RMSE) as a tool to calculate the difference between the predicted image and the ground truth by using image samples from the generative models. Moreover, RMSE represents the mean difference in pixels across all images, which means that the lower the number, the better the prediction results[11-12]. In this study, the error metric for numerical predictions is calculated under the RMSE function, where O_i : observations, S_i : predicted values of images, n : considered as the number of observations available for analysis. Table 7 shows the quantitative comparison of the results of the proposed method with the CycleGAN method on datasets A and B, where the value of the error measure of the CGAN model obtained a lower number compared to the state-of-the-art CycleGAN method. As a result, this paper confirmed that the CGAN method outperforms the CycleGAN method quantitatively and qualitatively.

4.2.1 Analysis Results of Proposed Method

Regardless of the small size of the training dataset, Conditional-GAN does an overall good task of converting from the black and white(sketch) input images to the color version, with very convincing shading and colors that match the ground truth photos very well. Some observations:

[1] In testing, Conditional-GAN is able to derive reasonable shading in the output image, e.g. the middle image in Figs. 7. and Fig. 8.

[2] The color and texture of the lips show convincing shapes, even though they are not given details in the input image in Fig. 7.

[3] In most of the ground truth photos, the subject shows the application of chicks and nose shadows. In Figs. 8 (B), although

the input images show few signs of chicks (especially in the middle of the face), Conditional-GAN was still able to correctly apply convincing chicks and nose shades.

5. Conclusions

In this paper, the predictive models such as fuzzy search and conditional-GAN were analyzed for identifying a potential criminal based on the descriptions of eyewitnesses. The main purpose of this research is to investigate the criminal suspect after obtaining factual information from the reliable witnesses of the crime scenes. And the information is used to develop a new relational to capture the historical data that can be detected the similarity between the new case and the criminal data. The other purpose of this research is to evaluate by converting the sketch face image into a realistic image. Moreover, the sketch image can be drawn by a police forensics' artist. To achieve these objectives, two algorithms including fuzzy match and conditional GAN were applied in this research work. The results show that the proposed method is a useful and practical tool for solving law enforcement problems.

The limitation of this study is the small number of the dataset. However, it is not easy to collect these entire data, especially when it is related to the identity of a person. Also, it is necessary to improve the performance of fuzzy search algorithms by applying more search methods under fuzzy algorithms to evaluate the performances.

Therefore, in future work, more dataset of the available will be studied, and also the performance of the effective proposed algorithm will be improved.

REFERENCES

[1] Pratibha, A. Gahalot, Uprant, S. Dhiman, L. Chouhan, "Crime Prediction and Analysis", *Proc. of 2^{nd} International Conference on Data, Engineering and Applications(IDEA)*, February 2020.
DOI: 10.1109/IDEA49133.2020.917073

[2] C. Reiger, M. Wierda, "The Serious Crimes Process in Timor-Leste: In Retrospect", *Proc. of International Center for Transitional Justice(ICTJ)*, March 2006.

[3] D. Souter, T. Kelly, "The Role of Information and Communication Technologies in Postconflict Reconstruction", *Proc. of World Bank Studies*, May 2014.
DOI: https://doi.org/10.1596/978-1-4648-0074-0

[4] R. Kumar, R. C. Tripathi, "Text mining and similarity search using extended tri-gram algorithm in the reference based local repository dataset", *Proc. of International Conference on Communication, Management and Information Technology(ICCMIT)*, 2015.
DOI: 10.1016/j.procs.2015.09.062

[5] M. Mirza, S. Osindero, "Conditional Adversarial Nets", *Proc. of Computer Vision and Pattern Recognition(CVPR)*, November 2014.
DOI: https://arxiv.org/abs/1411.1784

[6] F. Sabahi, Mohammad-R Akbarzadeh-T, "Introduction validity in fuzzy probability for judicial decision-making", *International Journal of Approximate Reasoning*, vol. 55, Issue 6, September 2014, Pages 1383-1403.
DOI: https://doi.org/10.1016/j.ijar.2013.12.003

[7] P. Isola, J-Y Zhu, T. Zhou, A. A. Efros, "Image-to-Image Translation with

Conditional Adversarial Networks", *Proc. of IEEE Conference on Computer Vision and Pattern Recognition(CVPR),* pp. 5967-5976, 2017.

DOI 10.1109/CVPR.2017.632

[8] A. Martinez, R. Benavente, "The AR Face Database", *Computer Vision Center Technical Report #24,* June 1998.

DOI: https://arxiv.org/abs/1703.10593

[9] P. J. Phillips, H. Moon, S. A. Rizvi, P.J. Rauss, "The FERET Evaluation Methodology for Face-Recognition Algorithms", *Proc. of IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol: 22, Issue: 10, October 2000.

DOI: 10.1109/34.879790

[10] J-Y Zhu, T. Park, P. Isola, A. A. Efros, "Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks", *Proc. of IEEE International Conference on Computer Vision(ICCV).* pp. 2242-2252, 2017.

DOI: https://arxiv.org/abs/1703.10593

[11] T. Nanavati, H. Modi, D. Patel, V. Parikh, J. Gupta, "Generative Adversarial Networks: A Comparative Analysis", *International Journal of Advanced Research in Computer Engineering & Technology(IJARCET),* Vol. 9, Issue 4, April 2020, ISSN: 2278-1323

[12] S. P. Neill, M. R. Hashemi, "Ocean Modelling for Resource Characterization", *Book of Fundamentals of Ocean Renewable Energy,* vol. e-business solutions, pp. 271~309, 2018.

DOI: https://sciencedirect.com/book/9780128104484/

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