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The System Recognizes the Digital Image of Pistol Shell Casings by Developing Algorithms Combined with Deep Learning

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Abstract

Gun-related violence in Thailand is in a high rate. Resume reports showed that most of them caused by gun-shooting. Thus, Firearms and bullets are important evidence in the judicial process to link the events and the perpetrators. Therefore, the aim of this study was to present the system recognizes the digital image of pistol shell casings by developing algorithms combined with deep learning. The objectives of this forensic study were to 1) analyze, design, and develop a Pistol Identification System (PIS) based on breech face marks of cartridge case digital images, and 2) achieve a guideline or an alternative method for facilitating an expert to investigate firearms linked to the offender. In this research the PIS that was designed with programming language applied to develop algorithms for identification of the breech face marks of cartridge case digital images. In addition to that, MATLAB's tools were applied in the deep learning process to achieve the final PIS model. The steps of deep learning technique were composed of designing a training and repeat the experiments over multiple cycles (Epoch) for the purpose of confirming, test and adjust the proportions of the hidden layers until reaching the ratio of 80:10:10 and accomplishing a satisfied averaged accuracy rate. The PIS model was subsequently used for comparison and predict the image pair through database management technology. Materials used in this study were composed of 50,000 images of rear plates of .38 Cartridge case, Camera, Mobile Phone, Computer, MATLAB language and Microsoft Access software. The findings showed that the PIS developed is of satisfactory accuracy capable of accurately matching the pairs of images stored in the database and could also be traced back to the gun used at the scene and gun owners. The results of this study would apply as the alternative or guideline to PIS and even would help forensic practitioners to cross-checking and investigating firearms in relation to the offender.

Keywords: Pistol, Shelling gun, Breech Face Digital Image, Image of pistol shell casings

1. Introduction

Investigations are carried out until the perpetrators are arrested and punished in accordance with the legal procedure. It is an extremely important task for law enforcement. This task requires the knowledge and competence of experts in the field of forensic work. The use of science and technology tools combined with forensics is essential to facilitate the accurate, accurate and timely work of experts. It affects the acceptance of stakeholders. And it can bring the wrong people to punishment. Forensic science is therefore useful to conclude the case based on the evidence correctly. From the above points. Police Forensic Science Center7 (2015) therefore discusses the scope of applying forensic science in general, such as (1) crime scene investigations and forensics, (2) fingerprinting, palmprint, footprint, (3) documents such as signatures, handwriting, (4) forensic ballistics, (5) forensic chemistry, such as the chemical composition of a variety of substances, (6) forensic physics, such as

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vehicle collision detection, (7) biological trace evidence such as hair, blood, sperm (8) forensic medicine, including forensic pathology, forensics, biochemistry, personal proof, medical imaging.

In Thailand, there is evidence of firearms, with relevant research such as “Breech Face Digital Images Recognition System” by developing an algorithm for identifying the identity of the digital trace image of the end plate of the shell casing to be used to in-depth the prediction of the image of the end plate of the shell casing. The results from the dual image predictions are quite accurate (Jivorarak, Meethongjan, & Kunides, 2021). “Firearm Identification System based on Bullet Image Analysis”. It is a firearms verification system based on bullet head images. Find attribute values based on derived lines. To analyze the surface characteristics of an image in two different ways: two-dimensional spectrum and GLCM. Then compare the results to find an appropriate method. The results from the dual image predictions are quite accurate (Thammavarin, 2013). “Firearm identification based on fir system characterizing rotation invariant features of cartridge case image” This research proposes a method for examining firearms based on a limited impulse response system that shows unchanged properties based on the rotation of the shell casing image. The vehicle inspects firearms using Fisher's linear classification function. The effectiveness of the proposed method can be demonstrated by the results of experiments with verification of firearms from sample casings on crimes committed with firearms (Prasit, 2010). February 22, 2016. The Elite+ (2016) indicates a population ratio of 100,000, the country with the highest gun-related deaths is the Philippines (7.42). Thailand (4.45) is higher than the United States (3.85), and the Asian Correspondent website (2016) recently reported that Thailand also has a high record of firearms crimes. Most motives are identified as "faceless" or "business conflicts."

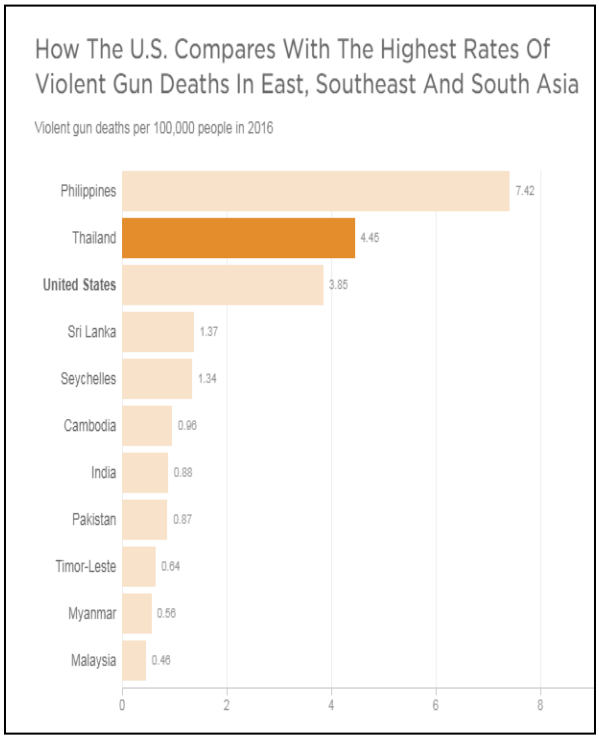

Figure 1. Statistics on firearm deaths in 2016 in Asia and the United States of America per 100,000 population (NPR, 2016).

According to the study, life-threatening mischief Property and peace of the people of Thailand Some of the perpetrators were found to have used firearms in the attack, as evidenced by statistics from the Royal Thai Police between 2005 and 2015. The Royal Thai Police More and more firearms can be arrested. At present, there is evidence related to cases used in forensic science, such as firearms information, cartridge cases, information about gun owners, etc. Forensic examination of witnesses is generally based on the eyes and the individual. This leaves them vulnerable to deviations and impacts the investigative process to find the culprit. Practical procedures should enable experts to identify connections automatically. “the system recognizes the digital image of pistol shell casings by

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developing algorithms combined with deep learning". That could be an option for facilitating specialists.

Table 1. Statistics on firearm arrests 2005 to 2015.

Year	Catch/Case		Catch/Person	
	Firearms	Weapon of war	Firearms	Weapon of war
2005	17,777	1,242	18,924	1,182
2006	18,701	1,455	19,535	1,411
2007	21,023	1,049	21,846	1,161
2008	22,169	773	23,190	882
2009	25,087	855	25,798	900
2010	21,463	699	22,214	759
2011	23,941	546	25,740	667
2012	28,134	605	30,257	796
2013	34,895	620	37,015	815
2014	35,280	713	37,554	931
2015	31,232	570	33,420	755

Source: National Statistical Office (2016).

2. Research Methodology

In this research, the researchers researched and compiled academic papers containing the contents of the pistol verification system from digital trace photographs of the end of the shell casings to be framed. Designs and applications in research. consist of theoretical concepts connected with projectiles. Bullets, shell casings Traces formed on the end plate of the shell casing. Bullet Comparison Machine and automatic shell casings, database theory, digital images, digital image processing with MATLAB languages, converting image data in two dimensions, Scrolling of images, artificial intelligence, machine learning, neural network with MATLAB language, deep learning, related research, and the conceptual framework of research. Then create a database and store the data, firearm information, shell casing information, and gun owner information. Then find the identity of each image using an algorithm developed using language MATLAB to pass on to the system for in-depth learning. This research used 50,000 learning samples, there was a rotating image, each of which was added to noise, 80% samples were used in training, 10% in validation and 10% in testing and 50 Hidden had complex calculations for highly performing work, image classification. It can predict visual pairs by providing a higher level of accuracy, so deep learning algorithms are required to work.

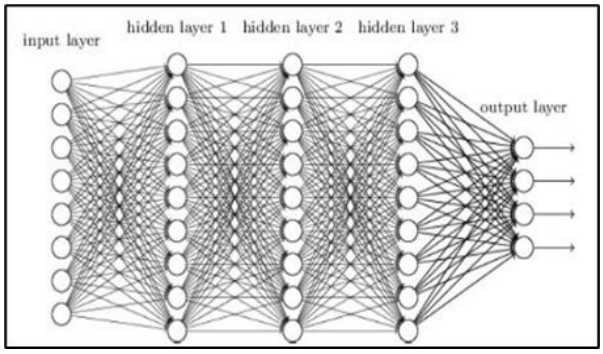

Figure 2. Training deep neural networks (Towards Data Science, 2018).

3. Research Framework

Based on the conceptual framework, it can be described as Firing pin marks and Breech Marks. It can be used through an algorithm to determine the uniqueness of the bullet casing footplate image, which includes the area of the explosion from the slate needle, the length of the circumference, the width and length of the image where the explosion occurred. The widest length of the image that exploded. The average sum of RGB colors in the middle, store it in the database, and then go through an in-depth learning process to get a model for predicting a pair of images, then goes through a deep learning process to obtain a model for predicting an image pair. Incidentally, in this modeling, the researchers selected the goal is to use the area of the explosion from the slate needle, and the prediction through the model uses predictive results in combination with firearm data and firearm owner data stored in the database to identify the gun registration used to shoot, which can be linked to the offender. The tool consists of 50,000 images of the end plate of the shell casing, camera, Compute, Use MATLAB to develop the system by connecting to the database

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management system. This research was experimental research.

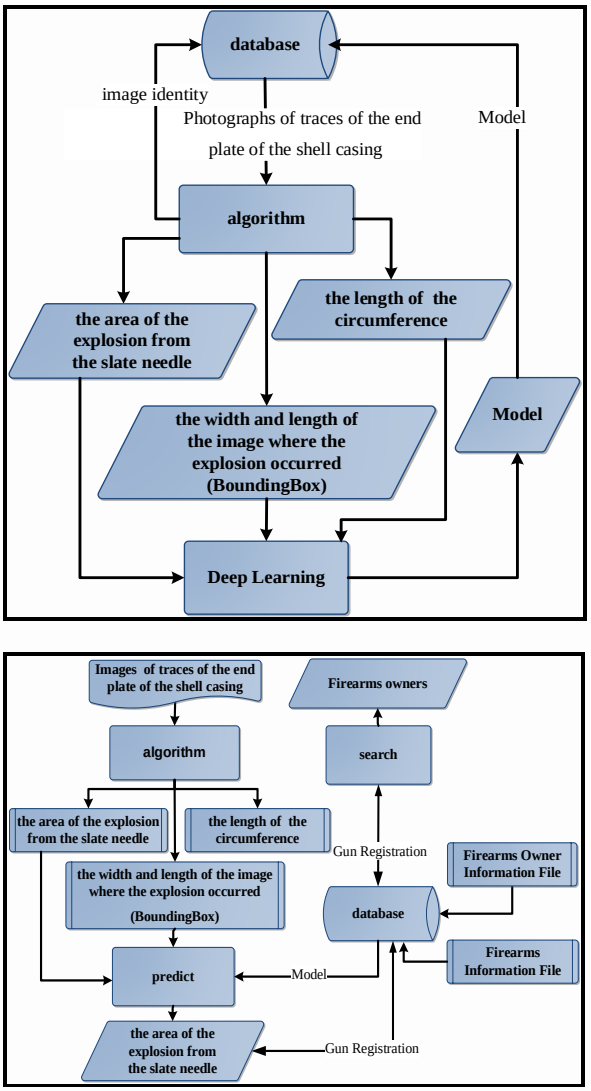


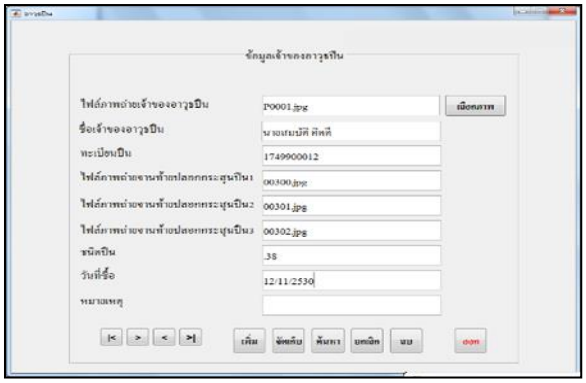
Figure 3. Research framework.

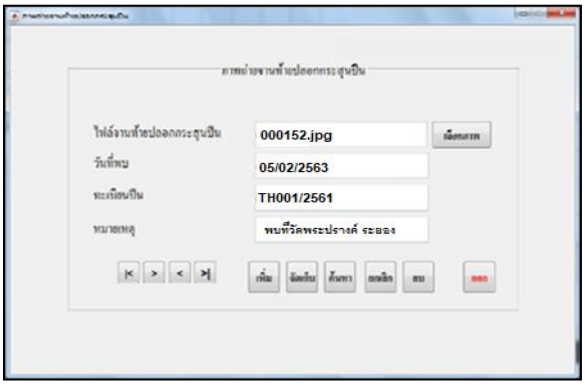
4. Research Result

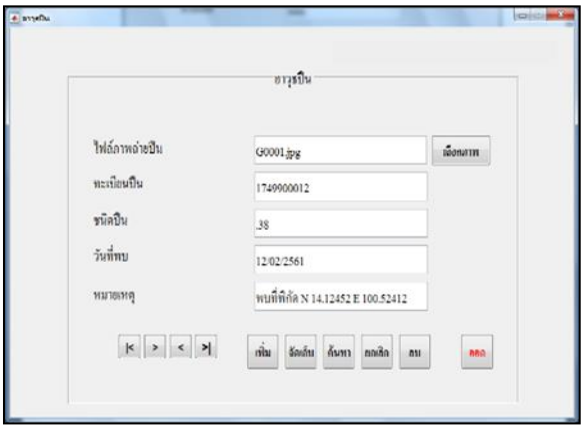
Development The system recognizes the digital image of pistol shell casings by developing algorithms combined with deep learning. it uses algorithms to identify images in combination with deep learning to predict digital images in a database using database management technology. These operations may be broken down into 4 processes. (1) Image DataSet for Deep Learning (2) Identity from the images (3) Deep Learning and Training (4) Use model to predict pairs of digital images.

4.1 Image DataSet for Deep Learning

The database contains information about firearms, shell casings and gun owners. When capturing firearm information, the system verifies if it is a digital image of the cartridge case. Otherwise, you will be warned that this is not a digital image, and this research will include 400 digital cartridge case images.







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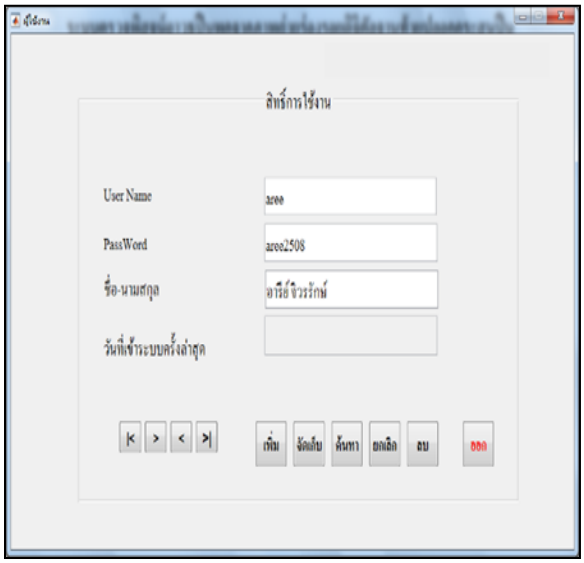

Figure 4. Record form.

Figure 5. Breech Face Digital Image store in database.

4.2 Identity from the image

We can retrieve the images from the Breech Face Digital Image, the casing stored all over the database. To find out the uniqueness of the images through the algorithm that sets it up. With a total of 400 frames, and divide the image density into 5 groups to get a coefficient to equalize the brightness of each image. Composed of 1) fewer than 700 pixels, 2) 701 to 1500 pixels, 3) 1501 to 1900 pixels, 4) 1901 to 2700 pixels, and 5) more than 2701 pixels, then turn at 0, 15, 30, 45 and 60 degrees. Every single degree turn will put types of Gaussians, Salt & Pepper, and Speckle noise. Every noise has a density of 4%, 6%, 8%, 10%, 12%, 14% and 16%. This resulted in a total of 50,000 sample images.

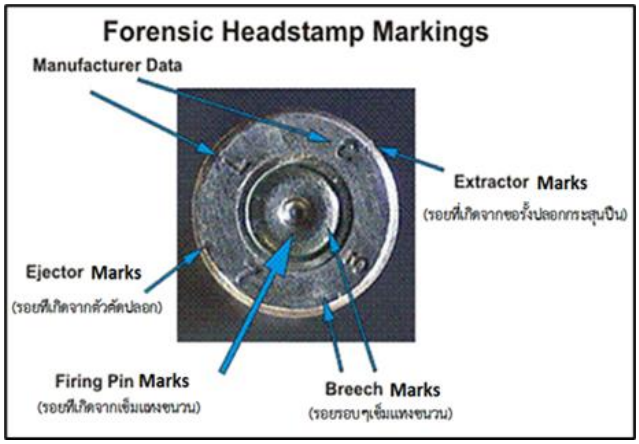

Figure 6. The trace on Breech face (Jivorarak, Meethongjan, & Kunides, 2021).

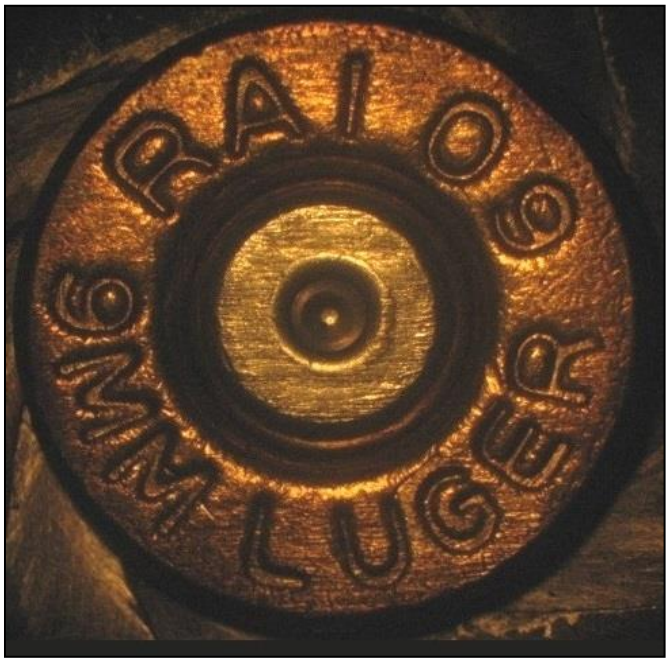

Figure 7. The rows of breech face.

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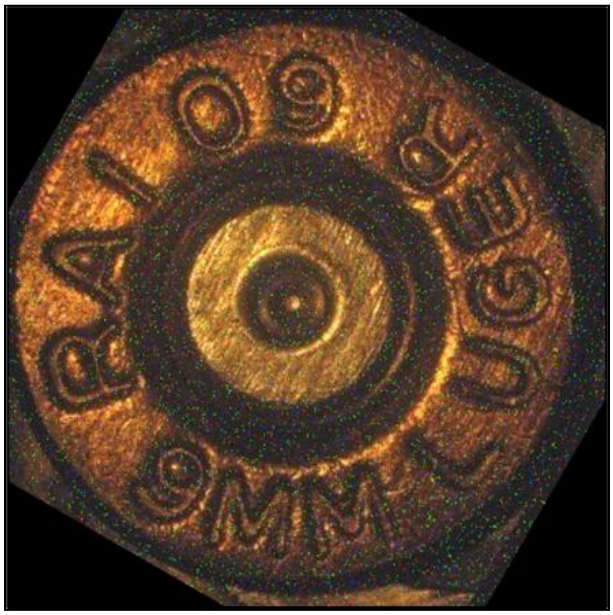

Figure 8. The Breech face after adding noise.

Next, bring 50,000 digital images are processed through algorithms developed with the following processes:

(1) Eliminate noise.

(2) Adjust the images to be parallel with the make from explosion to the line of sight.

Figure 9. Adjust the images parallel to the line of sight.

(3) Adjust the image brightness more accurately.

Figure 10. Adjust the images brightness.

(4) Select the outermost circle and resize the image to 1000*1000.

Figure 11. Resize the image to 1000*1000.

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(5) Copy the frame of the circle to the bottom of the deepest front.

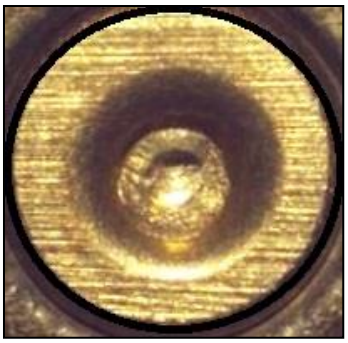

Figure 12: The circle in the breech face part.

(6) Resize image at 600*600 for make horizon line clearer.

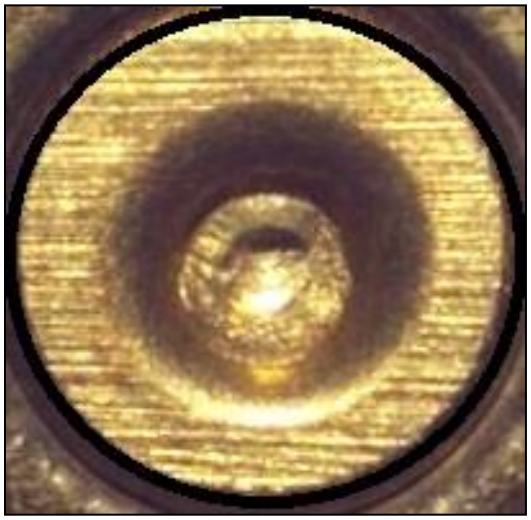

Figure 13. Resize image to 600*600.

(7) Converts the image to grey scale and next to it converts to binary.

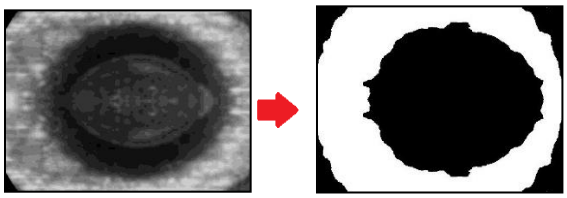

Figure 14. Converts the image to grey scale and binary.

(8) Find the edge and cut the edge. to make a smooth image.

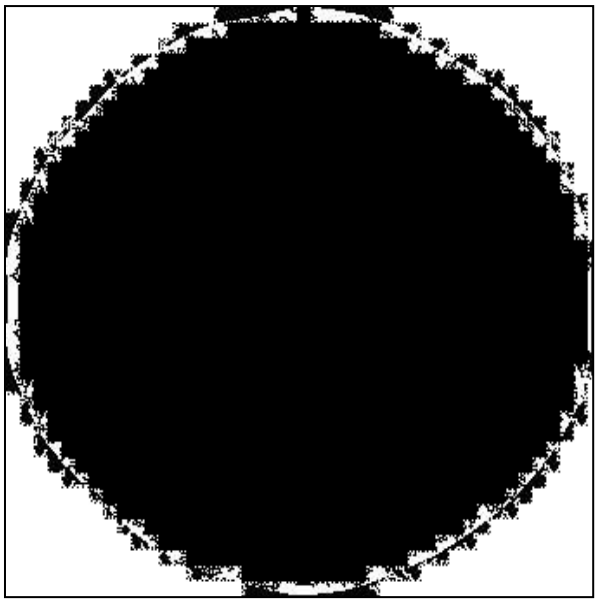

Figure 15. Smooth image.

(9) Select the useful part for Deep learning considers from image at the white area.

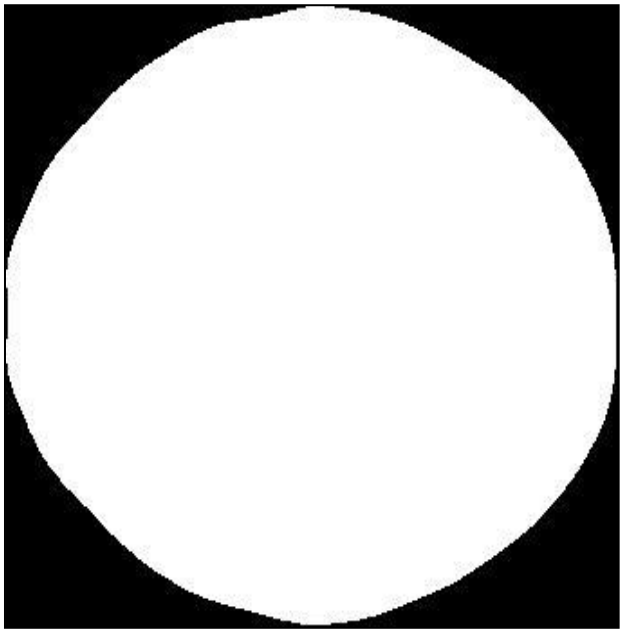

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Figure 16. White area for use.

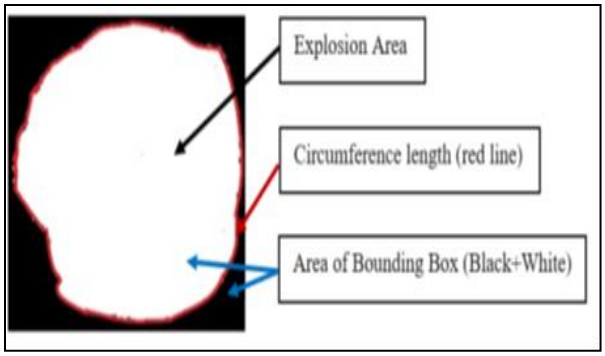

Figure 17. Visual identity applied in deep learning (Jivorarak, Meethongjan, & Kunides, 2021).

The result of identity from the image is the final result according to Figure 17, which is caused by the algorithm for finding the identity of the image. The values are given in Table 2 below.

Table 2. Values brought to training.

No	inputs				target	
	Breech Face Digital Images Files name	Explosion Area x1	Bounding Area Box x2	Circumference length x3	Explosion Area y	Breech Face Digital Images Files name
62552	00100.jpg	63177	79424	126549.433838339	63649.2751510352	00100.jpg
62553	00100-00-1500.jpg	63915	81885	127870.889600899	63984.7254361182	00100.jpg
62554	00100-00-3000.jpg	63965	85995	127959.581371709	63444.5591499887	00100.jpg
62555	00100-00-4500.jpg	69743	91808	139651.56744847	68690.2864799438	00100.jpg
62556	00100-00-6000.jpg	70716	92168	143018.153973714	69662.3672496156	00100.jpg
62557	00100-02-00GS.jpg	63735	82890	127657.887574393	64270.1123138947	00100.jpg
62567	00100-02-00SK.jpg	62182	81204	124520.760406539	63275.096404429	00100.jpg
62562	00100-02-00SP.jpg	63136	79424	126461.106383412	63621.9291345107	00100.jpg
62558	00100-02-15GS.jpg	64225	82415	128479.796339058	64094.8071149126	00100.jpg
62568	00100-02-15SK.jpg	64056	81312	128172.827283629	64111.6034082868	00100.jpg
62563	00100-02-15SP.jpg	64153	82194	128337.944787862	64075.7127226602	00100.jpg
62559	00100-02-30GS.jpg	64073	86858	128188.479152536	63552.961581814	00100.jpg
62569	00100-02-30SK.jpg	80140	104000	160547.555699195	78194.3571414797	00100.jpg
62564	00100-02-30SP.jpg	64368	87216	128782.968111858	63852.000418887	00100.jpg
62560	00100-02-45GS.jpg	69245	90890	138610.417350567	67847.4678855583	00100.jpg
62570	00100-02-45SK.jpg	78749	105168	157882.476211692	78611.1384213362	00100.jpg
62565	00100-02-45SP.jpg	68505	90298	137092.250722377	67225.1622967927	00100.jpg
62561	00100-02-60GS.jpg	71970	94572	145264.135760825	71321.9029902245	00100.jpg
62571	00100-02-60SK.jpg	71698	94004	144407.581257222	70973.5366646101	00100.jpg
62566	00100-02-60SP.jpg	70851	92730	143397.302423617	69957.5869996921	00100.jpg
...	...	...	...	...	...	...
50000	00400-02-60SP.jpg	85410	108360	170871.672547422	74758.7142452141	00400.jpg

4.3 Deep Learning and Training

Deep Learning is an automated learning method with Imitate the function of human neurons by stacking neural networks in layers and learning sample data, which will be used to detect patterns or classify the data (MathWorks, 2022). In this investigation, the data in Table 2 were extracted by choose all three identities (Explosion Area, Bounding Area Box and Circumference Area), including the explosive zone, The selected Explosion Area values are inputs (x1), boundingbox area (x2) and circumference length (x3), while target uses explosive area (y), which is unique to the calculated image, according to Table 2 using MATLAB tools. In this learning, using data for 40,000 training samples, 5,000 validation samples, 5,000 test samples and 100 hidden layers, the learning period is 50.28 minutes. The system switches off at 2000 Epoch. Mean Squares (Training = 10073000.52154, Validation = 0.00000e-0 and Testing = 97223543.32146e-0) Regression (Training = 8.32145e-1, Validation = 0.00000e-0 and Testing = 8.12321e-1) Performance = 1.12e+08 Gradient = 7.51e+06. The resulting recognition accuracy was 95%.

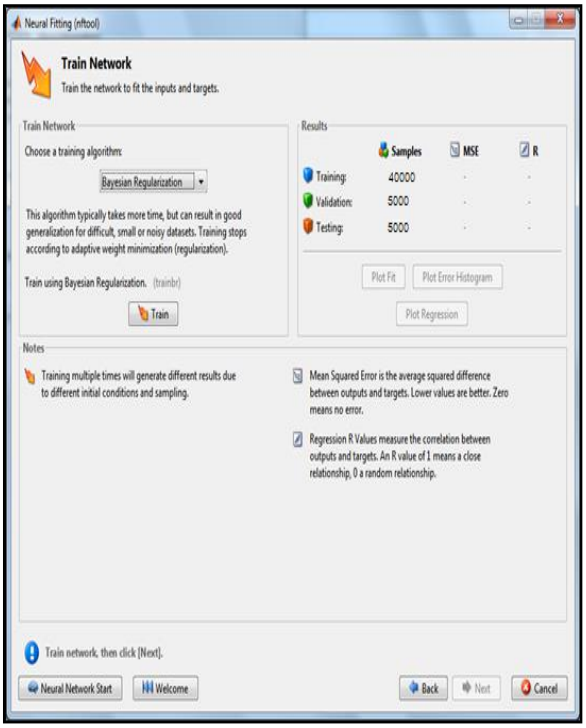

Figure 18. Ratio of data for learning (MATLAB tools).

4.4 Use model to predict pairs of digital images

The formula is as follows:

target = results.net ([inputs1; inputs2; inputs 3])

x1 = inputs1.

x2 = inputs2.

x3 = inputs3.

When input (x 1, x 2, x3) is taken through a model, the target value results are compared in the

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database. The system will display the results as shown below.

Figure 19. The result of using a model to predict a pair of images.

5. Discussion

This research is an alternative to facilitating experts to gather evidence and prove evidence. The objectives are 1) analyze, design, and develop a Pistol Identification System based on breech face marks of cartridge case digital images, and 2) achieve a guideline or an alternative method for facilitating an expert to investigate firearms linked to the offender. The research hypothesis is that digital trace photographs on the end plate of ammunition casings, firearm data, and data Firearm owners can link/compare gun identities and can link to identify firearm owners. By development the algorithm finds the uniqueness of the bullet casing end plate image, combined with deep learning. It started by developing an algorithm from the MATLAB language to store the end plate of the shell casing, Firearms information, and firearm owner information, along with other parts, are stored in the database. Then take 400 bullet casing end plate data to turn at 0, 15, 30, 45 and 60 degrees. Every single degree turn will put types of Gaussians, Salt & Pepper, and Speckle noise. Every noise has a density of 4%, 6%, 8%, 10%, 12%, 14% and 16%. This resulted in a total of 50,000 sample images. Then take each image to find its identity here, select Explosive Area, boundingbox area and circumference length. The target is compared to the same pair to obtain the gun registration number, which must be related to the gun owner. The results of the research showed that: "The system recognizes the digital image of pistol shell casings by developing algorithms combined with deep learning" developed with high accuracy of more than 95%. This is consistent with the research hypothesis that digital trace images on the surface of the end plate of the shell casing, firearm data, and firearm owner information. It can be related or compared to the identification of firearms and can identify firearms owners. This is because the traces on the end plate of the climbing shell casing can be used to find the uniqueness of each image. Here, deep learning algorithms are used together with database management technology. In fact, the researchers studied and collected firearms, casings and related theories. In addition to the theoretical storage of the data correctly. As for the development of the system researcher developed detailed algorithms such as: while recording the ammunition casing end plate data, the system locks and warns if the data entered into the system is not an image of the end plate of the shell casing. Algorithms in the Identity From the image These include: Eliminate Noise, Adjust the images to be parallel with the make from explosion to the line of sight, Adjust the image brightness more accurately, Select the outermost circle and resize the image to 1000*1000, Copy the frame of the circle to the bottom of the deepest front, Resize image at 600*600 for make horizon line clearer, Converts the image to grey scale and next to it converts to binary, Find the edge and cut the edge, to make a smooth image, and Select the useful part for Deep learning considers from image at the white area. These findings are consistent with the research of Jivorarak, Meethongjan, and Kunides (2021), was found that the traces on the plates at the end of the climbing shell casings can be used to find the uniqueness of each image. This research can be used as an alternative to proof of firearms. Consistent with Boonmatham, Kaewkosol, and Thongthae (2016) mentioned about implementing information systems, Computer networks, and Internet communication to provide the opportunity. As a result, the information system is essential and necessary for the organization's or other units' functioning. Predicting a pair of images was presented with many processes and methods which can be developed by many algorithms of digital images (Hongboonmee & Jantawong, 2020). Deep learning,

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Wu, Liu, Li, Jin, and Li (2017) is a set of instructions made for computer learning. set of instructions allows the machine to process large amounts of data that it seeks to learn how to replace it efficiently. Beside that Tongkla (1999) says that "sometimes light conditions and natural weather are conducive to the photograph Photography instruction cannot be completely stomped if there are obstacles such as rain, cloudiness, low light and too much light. The location and timing of the shoot are blatantly based on the lighting conditions at different times of the day". Recommendations The relevant sectors should promote and plan. Develop judicial evidence that complies with international standards. Acceptance of technology, lessons learned from successful countries in forensic evidence with state-of-the-art technology, and knowledge. In addition, there is currently a shortage of experts in this field, so it is proposed to develop both research and personnel who will apply this research in parallel by supporting the budget to expand the training and research institute for police forensics. Relevant agencies to cover all areas with the tools and equipment necessary to prove the evidence completely.

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