International Journal of
Medical Toxicology & Forensic Medicine

April 2024, Volume 14, Number 2

Research Paper

An Application for Wound Type Determination Based on Image Processing in Forensic Cases

Idha Arfianti Wiraagni[1*], Stefanus Trissanto[1], Arso Pranindyo Utomo[1], Elvira Sukma Wahyuni[2], Firdaus[2], Alvita Widya Kustiawan Putri[2], Nisa Agustin Pratiwi Pelu[2], Hendro Widagdo[1], Dhiwangkoro Aji Kadarmo[3]

1. Department of Forensic and Medicolegal, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia.
2. Department of Electrical Engineering, Faculty of Industrial Technology, Universitas Islam Indonesia, Yogyakarta, Indonesia.
3. Bhayangkara Polda DIY Hospital, Yogyakarta, Indonesia.

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Citation Wiraagni IA, Trissanto S, Utomo AP, Wahyuni ES, Firdaus, Putri AWK, et al. An Application for Wound Type Determination Based on Image Processing in Forensic Cases. International Journal of Medical Toxicology and Forensic Medicine. 2024; 14(2):E43899. https://doi.org/10.32598/ijmtfm.v14i2.43899

https://doi.org/10.32598/ijmtfm.v14i2.43899

Article info:
Received: 15 Nov 2023
First Revision: 26 Nov 2023
Accepted: 05 Dec 2023
Published: 19 May 2024

Keywords:
Evaluation, Application, Wound type determination, Image processing.

ABSTRACT

Background: Wound detection is important in forensic science. The development of technology for automatic wound detection in the medical field has not been fully realized. This study aimed to compare the level of knowledge between medical students who utilized an application versus those who studied from textbooks.

Methods: An image processing-based application was developed using a Python program with the YOLO software, version 4 algorithm. The research utilized a cross-sectional study design. The participants were medical students undergoing clinical clerkships at the Forensic and Medicolegal Departments of the Faculty of Medicine, Public Health, and Nursing at Gadjah Mada University. Each group (textbook and application group) comprised at least 35 individuals. Both groups had identical study periods and answered the same questions. Participants then filled out a questionnaire about the application.

Results: The mean scores of the post-test showed significant improvement in both groups compared to their pre-test scores (P=0.00). There was no significant difference in the post-test scores between the groups using the questionnaire and the application (P=0.207).

Conclusion: The application for wound type determination could serve as a preferable alternative to traditional textbooks for learning. It demonstrated an increase in learning outcomes that was significantly comparable to that achieved through textbook study.

*** Corresponding Author:**
Idha Arfianti Wiraagni, PhD.
Address: *Department of Forensic and Medicolegal, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia.*
Tel: *+62 (81) 328067816*
E-mail: *idha.arfianti@ugm.ac.id*

Introduction

The incidence of unnatural deaths has been on the rise year after year, with the World Health Organization (WHO) estimating around 1.6 million deaths due to violence. Every year around 1.3 million die as a result of road traffic accidents. Violence results in 5.8 million deaths each year and is the leading cause of death in younger individuals. Violence-related deaths have been projected to increase to 8 million deaths by 2030. Currently, doctors identify the wound based on a visual examination, describe the wound with geometric measurements, and assess the skin tissue involved [1]. With rapid advancements in technology and the passage of time, the application of object recognition and detection in computer vision has started to span various sectors, including industry and healthcare, particularly in forensic medicine [2].

As deep learning develops, new models for object recognition and detection in computer vision have been developed, including region-based convolutional neural networks (R-CNN), spatial pyramid pooling networks (SPP-Net), fast R-CNN, faster R-CNN, you only look once (YOLO software, version 4), and RetinaNet. These object recognition and detection models can be applied in various fields, ranging from optical character recognition, self-driving cars, object tracking, facial recognition, and detection, identifying verification via iris code, object extraction from images or videos, pedestrian detection, medical imaging, and forensics [3]. Since the onset of the COVID-19 era, there has been a push towards adopting virtual learning methods, including for medical students studying forensics. Learning media using applications is one of the media that helps solve learning problems [4]. Learning using the application offers several advantages: It makes learning easier, quicker, more enjoyable, and both effective and efficient. Besides, the increase in learning outcomes using the application shows significant results and is not inferior to the learning method using a textbook [5].

The application for determining the type of wound is an application that uses the image processing method designed and developed by the Faculty of Electrical Engineering, Islamic University of Indonesia in collaboration with the Department of Forensic Medicine and Medicolegal, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada. This application uses YOLO software, version 4 as an object detector. YOLO software, version 4 was chosen because it has high-precision results in the process of detecting and classifying images [6].

YOLO software, version 4 incorporates a feature extraction technique known as CSPDarknet53 as part of its architecture. This feature extraction has 29 convolutional layers of 3×3, with a receptive field of 725×725 and 27.6 million parameters. Given these specifications, CSPDarknet53 is the optimal model for feature extraction or the backbone of the detector [7]. YOLO software, version 4, a method for object detection, processes images in real-time at forty-five frames per second. The digital image is divided into a grid of dimensions S×S, where each cell in the grid predicts N possible bounding boxes along with their probability values. The box results are then refined by the non-maximum suppression (NMS) process, ensuring the most accurate object positioning as per the YOLO software, version 4 method [8]. Training data aims to produce a weight that will be used in the wound detection process. Dataset training is used so that the model can be used to perform detection according to the configuration that has been done. The training of the model is executed using YOLO software, version 4 and conducted on Google Colaboratory. The training scenario involves a comparison of dataset splitting and learning rates, which yields an outcome characterized by an average intersection over union (IoU) value and minimal loss. YOLO generates predictions in the form of bounding box coordinates (tx, ty, tw, th), confidence, and class probability. The coordinates (tx, ty), represent the center of the box relative to the cell edges, while (tw, th) estimate the image's height and width [8]. Confidence reflects the IoU between the predicted box and the ground truth box. Confidence values are usually described according to equation 6. To get the final prediction, the determining factor is the class confidence score obtained, based on class conditional probabilities and box confidence scores. Class confidence score measures the value of confidence in the classification and localization of objects. The class confidence score gives a specific class confidence value for each box, which encodes the probability of the class appearing in the box and how well the predicted box matches the object [9].

In this study, we aimed to build a simple and free application to assist in wound type determination, with the application's interface displayed in Figure 1. Beyond aiding medical students in understanding different types of wounds, this study could also prove beneficial in future scenarios involving unidentified deaths within the community. The objective was to compare the knowledge levels of medical students using the application to those relying on textbooks for learning.

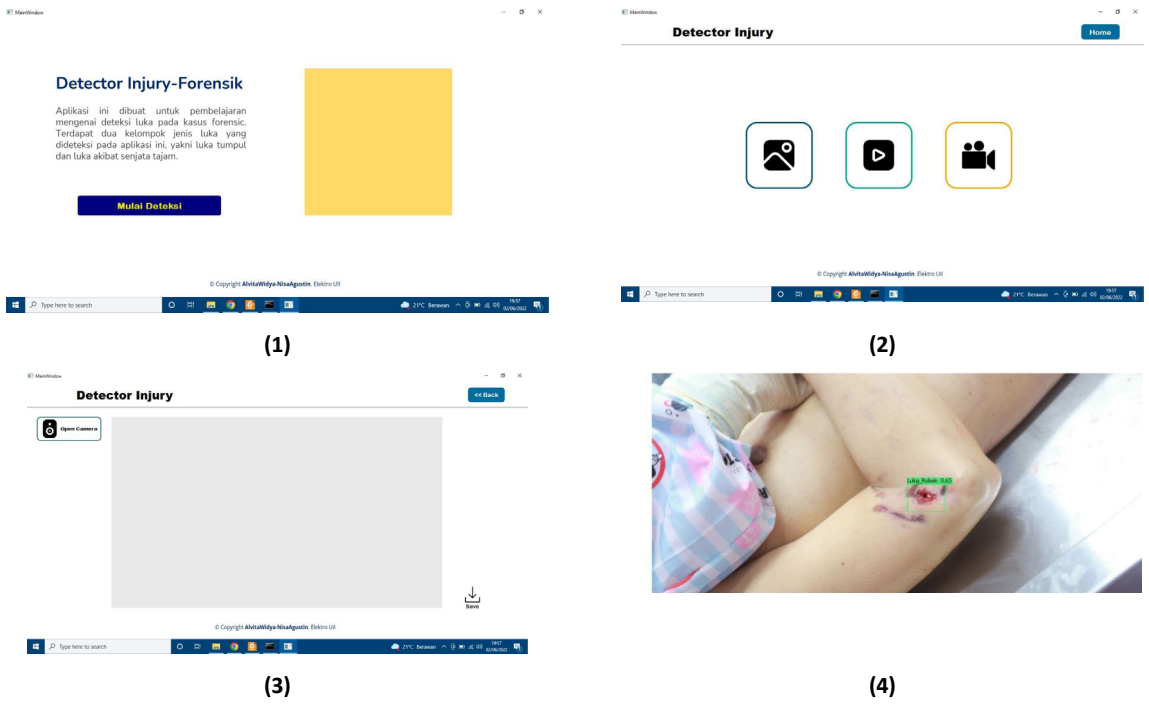

Figure 1. The application operational process interface

Materials and Methods

The participants were medical students undergoing clinical clerkships in the Forensic and Medicolegal Departments at the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada. The research employed a cross-sectional study design. The number of student respondents was determined using the minimum sample size formula based on the Lemeshow formula. Upon calculation, each group (textbook and application group) consisted of at least 35 individuals. The sampling method utilized was total sampling, where all students participating in clinical clerkships at the Forensic and Medicolegal Departments were included in the study until the required sample size was achieved.

At baseline, all participants took a ten-minute pre-test and then were divided into two groups, namely the application and textbook groups. The textbook group then studied the wound type using a forensic pathology book [10]. This book is a national and international reference in forensic learning. In contrast, the application group utilized the study application. Following a 30-minute self-study session, participants from both groups tackled the same post-test questions. This closed-book post-test lasted for 10 minutes. Subsequently, participants in the application group completed a questionnaire evaluating user experience, system quality, and interaction aspects. The data were subjected to both descriptive and comparative analyses of learning outcomes between the two groups, employing SPSS software, version 25 for statistical analysis. To assess user acceptance, questionnaires were validated through product-moment correlation techniques involving 71 respondents. Confounding factors across both groups were controlled by ensuring an equivalent age range among participants and providing identical lectures prior to the experiment.

Results

Digital image

In the digital image collection, samples were classified based on the type of wound captured by the digital camera. The categorization and numbering of wound types were organized according to a predefined coding system: For laceration types, the code starts with an “A” followed by a number, and for bruise types, the code begins with a “B” followed by a number. The parameters considered included digital image size, dimensions, and resolution (Figure 2).

The samples taken were in the form of color images, in JPEG format, totaling 53 digital images of wounds, consisting of 25 digital images of lacerations and 28 digital images of bruises. The size of the laceration images ranged from 2.5 MB to 6.8 MB, averaging 3.924 MB, with a resolution varying from 72×72 to 180×180 and

A001

B001

Figure 2. Categorization and numbering (A001: Laceration; B001: Bruise)

International Journal of
Medical Toxicology & Forensic Medicine

Table 1. Digital image distribution frequency

Digital Image of Laceration Wound		Digital Image of Bruises
Largest size	2.5 MB	2.3 MB
Smallest size	6.8 MB	5.8 MB
Average size	3.924 MB	3.203 MB
Biggest resolution	180×180	300×300
Smallest resolution	72×72	72×72
Largest dimension	5184×2912	5184×2912
Smallest dimension	4128×3096	4023×3024
Amount	25	28

International Journal of
Medical Toxicology & Forensic Medicine

dimensions from 4128×3096 to 5184×2912. The bruise images varied in size from 2.3 MB to 5.8 MB, with an average size of 3.203 MB, resolutions from 72×72 to 300×300, and dimensions ranging from 4023×3024 to 5184×2912 (Table 1).

User acceptance test

The study included participants with an average age of 22.19 years, the youngest being 20 years old and the oldest 24 years old. The participants were undergraduate medical students from two universities. The majority were from Universitas Gadjah Mada (59.2%), followed by Universitas Tarumanegara (40.8%). Regarding their domiciles, over half of the participants were from the

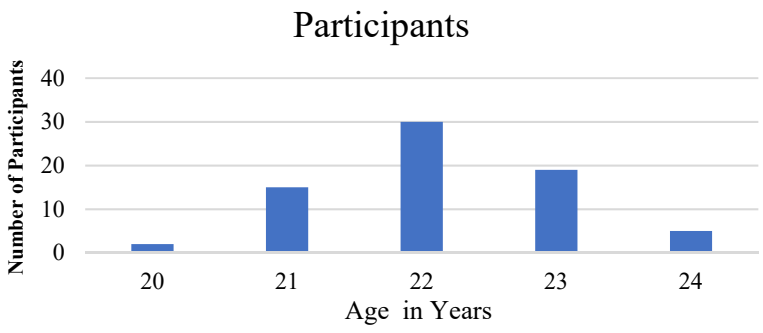

Figure 3. User acceptance test's participants

International Journal of
Medical Toxicology & Forensic Medicine

Table 2. The results of the validity test

Question	Corrected Item Total Correlation (R count)	P	R Table (0.05)	Criteria
1	0.690	0.000	0.2718	Valid
2	0.688	0.000	0.2718	Valid
3	0.505	0.000	0.2718	Valid
4	0.777	0.000	0.2718	Valid
5	0.694	0.000	0.2718	Valid
6	0.672	0.000	0.2718	Valid
7	0.632	0.000	0.2718	Valid
8	0.675	0.000	0.2718	Valid
9	0.623	0.000	0.2718	Valid
10	0.494	0.000	0.2718	Valid

International Journal of
Medical Toxicology & Forensic Medicine

special region of Yogyakarta, with the next largest group coming from Jakarta.

Table 2 shows the validity results of the user acceptance test, which was conducted with 71 participants.

The validity of the usability test questionnaire, comprising 10 questions, was evaluated as follows:

From the validity test calculations, it was observed that all r calculated values were greater than the r table values, indicating that all questions related to usability test variables were valid.

Table 3 shows the result of the user acceptance test, involving a total of 70 respondents. A 5-point Likert scale was employed for this questionnaire, ranging from strongly disagree (1) to strongly agree (5), with most responses falling within the agree and strongly agree categories. The application received positive user acceptance test scores.

Table 3. User acceptance test

No.	Question	Result
1	Is the interface easy to symbolize?	4.38
2	Is the application easy to operate?	4.37
3	Is the color theme of the application easy on the eye?	4.23
4	Is the menu interface in the application easy to navigate?	4.42
5	Is the information available on the application easy to search?	4.3
6	Is the writing readable?	4.45
7	Are the symbols, icons, and pictures in the application easy to understand?	4.52
8	Is the information available on the application easy to access?	4.22
9	Is the function of the application in accordance with the goal?	4.57
10	Is the menu on the application easy to remember?	4.58

International Journal of
Medical Toxicology & Forensic Medicine

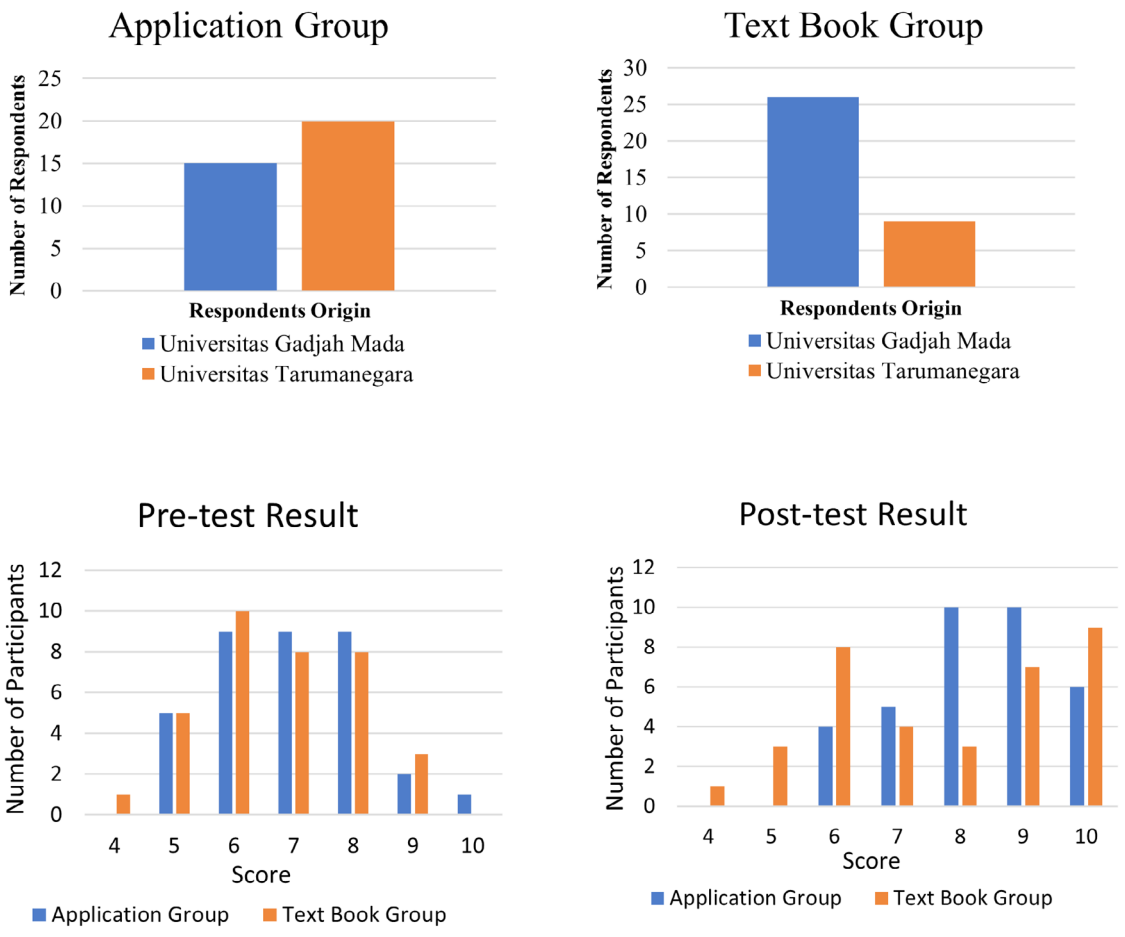

Figure 4. Learning outcome test's respondents

International Journal of
Medical Toxicology & Forensic Medicine

Learning outcome test

The respondents were undergraduate medical students of two universities specifically those undertaking clinical clerkship activities in the Department of Forensic Medicine and Medicolegal at Universitas Gadjah Mada. A total of 70 respondents were involved in this research, with 58.5% from Universitas Gadjah Mada and 41.5% from Universitas Tarumanegara (Figure 4). Furthermore, the respondents were divided into two groups, namely the application group and the book group, each comprising 35 participants.

In the application group, the lowest pre-test score was 5, and the highest pre-test score was 10, with an average score of 7. In the textbook group, the lowest pre-test score was 4, and the highest pre-test score was 9, with an average score of 6.63. In the application group, pre-test scores ranged from a low of 5 to a high of 10, with an average of 7.

We then compared the results of the pre-test and post-test within each group. The application group's average score improved from 6.9 to 8.26, showing a significant increase (P=0.00). Similarly, the textbook group's average score rose from 6.74 to 7.77, also indicating a significant improvement (P=0.00). When comparing the post-test average scores between the two groups, 8.26 for the application group and 7.77 for the textbook group, no significant difference was found, with a P of 0.207 (Figure 5).

Discussion

The COVID-19 pandemic has shifted learning methodologies from traditional classroom settings to online platforms. Various system-based electronic applications have been developed to meet the needs of recent scientific developments [11]. The evaluated application was developed as a training tool for medical students to recognize various types of wounds. The final development stage of this application is the user acceptance test [12,

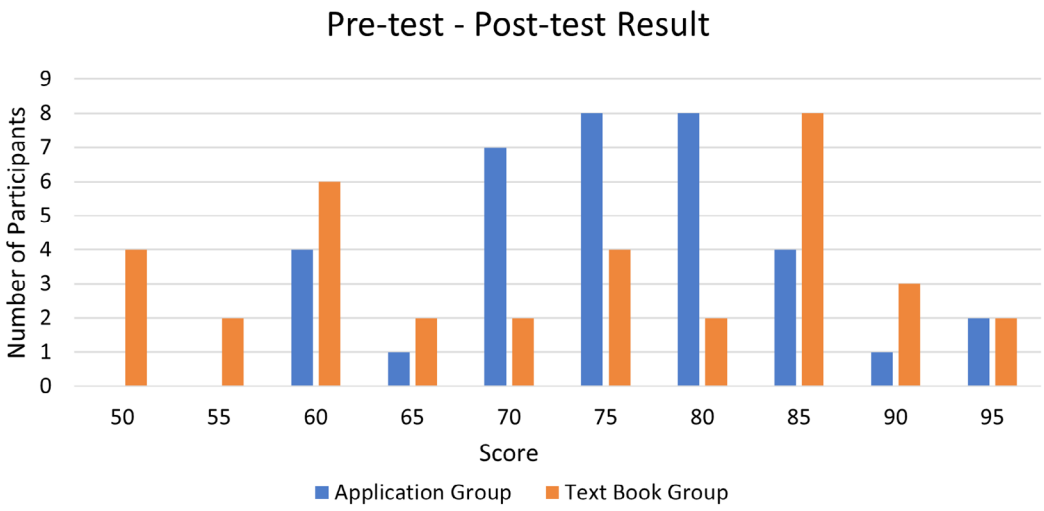

Figure 5. Learning outcome's result

International Journal of
Medical Toxicology & Forensic Medicine

13]. The purpose of this test was to evaluate the ease of use and satisfaction levels of users operating the application. The acceptance test results indicated that respondents highly accepted the application system, with an average rating of 4.4, signifying a very positive reception towards the developed application [14, 15].

In addition to conducting user acceptance tests, this research also compared learning outcomes between the application and textbook groups. The findings of this study align with those of prior research, which suggests that learning with applications produces outcomes comparable to those achieved with textbooks [16]. However, this study found results that differed from research conducted in Iran, where virtual learning was deemed more effective than traditional methods [17]. A notable strength of this research was that learning with the application was faster, more interesting, more effective, and more efficient compared to conventional learning [5]. A limitation of this study was the limited number of photos used in the training process during application development. Future studies should consider expanding the photo dataset to enhance the application's accuracy.

Conclusion

The wound type determination application could offer a superior learning method alternative to textbooks, as it demonstrates an improvement in learning outcomes that is as significant as those achieved with textbooks.

Ethical Considerations

Compliance with ethical guidelines

This study approved by Institutional Review Board of the Medical and Health Research Ethics Committee (MHREC) at the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, DR Sardjito General Hospital (No.: KE/FK/0035/EC/2022).

Funding

Funding for this research was provided by the Ministry of Research and Higher Education (Kemdikbudristek) of the Republic of Indonesia (No.: 010/ST-DirDPPM/70/DPPM/PFR-KEMDIKBUDRISTEK/VI/2023), and by the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada (No.: 772/UN1/FKKMK/PPKE/PT/2023, under the applied research grant scheme for 2023).

Authors' contributions

Conceptualization, study design, data processing, data analysis, and writing the original draft: Idha Arfianti Wiraagni, Elvira, and Firdaus; Data collection: All authors.

Conflict of interest

The authors declared no conflicts of interest.

Acknowledgements

The authors would like to express their deepest appreciation to the Ministry of Research, Technology and

Higher Education of the Republic of Indonesia, and the Faculty of Medicine, Public Health, and Nursing at the Universitas Gadjah Mada, and the Faculty of Industrial Technology at the Islamic University of Indonesia.

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