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TYPINGLESS TICKETING DEVICE INPUT BY AUTOMATIC LICENSE PLATE RECOGNITION SMARTGLASSES

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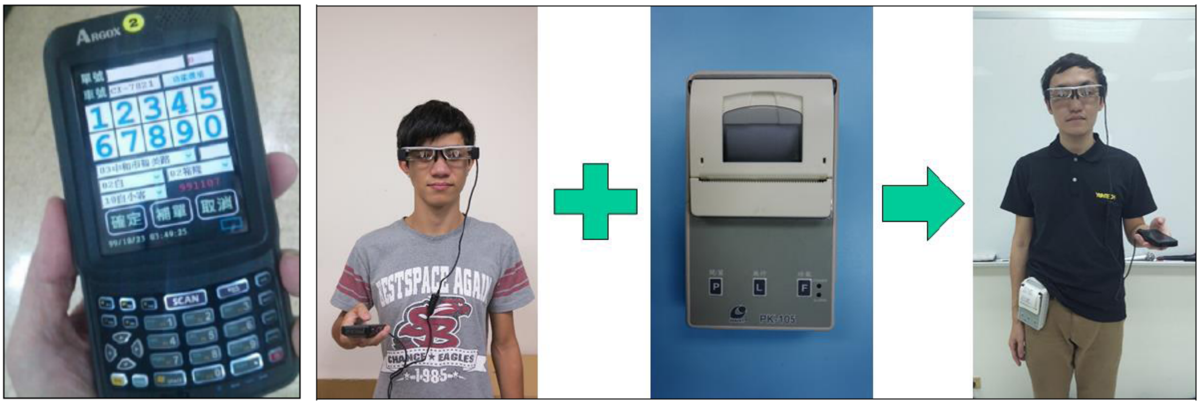
Abstract. *This work is composed of "Android smartglasses" and "portable printer", and integrated with self-developed automatic license plate recognition technology featuring 5 novel methods: Wiener-deconvolution vertical edge enhancement, plate-and-character-based AdaBoost plus vertical-edge license plate detection, CIELAB-differentiated image negative, vertical-edge horizontal-projection histogram-segmentation stain removal, and customized optical character recognition. This work utilizes the smartglasses to recognize the license plate's characters in roadside scenes and thereby inquire the license-plate-related information from the built-in database without typing input. Then, through Bluetooth connection, the smartglasses transmit the license-plate-related information to the portable printer for ticketing of parking lot fee or traffic violation fine. Implementation results show the license plate recognition rate of the smartglasses is over 96% under various complex conditions, and the average execution time takes only 0.5 second per frame.*
Keywords: License plate recognition, Android smartglasses, Portable printer

1. **Introduction.** With the ever-increasing growth of vehicles in Taiwan, especially its total amount gets beyond Taiwan's population of 21 million, the subsequent working load of vehicle management issues, like parking lot fee or traffic violation fine, is getting more and more heavy. However, conventional handheld typing ticketing devices as shown in Figure 1(a) are error-prone to manual typing and time-consuming to typing input. In addition, conventional portable automatic license plate recognition devices are huge-volume to wearable application and printer-unavailable to ticket printing [1-3]. In order to further alleviate these issues of inaccuracy, inefficiency, inconvenience, and inutility, this work composed of "Android smartglasses" and "portable printer" is developed as shown in Figure 1(b), and "Android smartglasses" are integrated with self-developed automatic license plate recognition technology featuring 5 novel methods. After the "Android smartglasses" worn on the user's head recognize the license plate automatically, the "portable printer" hung on the user's waist prints out the tickets of parking lot fee or traffic violation fine promptly, which is as shown in Figure 1(b). This work not only further raises the accuracy and immediateness of license plate character input, but also further improves the wearing convenience and ticketing utility of parking officers or traffic policemen.

In order to solve the faults of conventional handheld typing ticketing devices and conventional portable automatic license plate recognition devices, this work integrates self-developed Automatic License Plate Recognition (ALPR) technology into the smartglasses [4], and replaces the manual typing input with ALPR input for the ticketing device. Figure 2 illustrates the overall algorithm flowchart of this work "Typingless Ticketing Device Input by ALPR Smartglasses" featuring 5 novel methods: Wiener-deconvolution



(a) (b)

FIGURE 1. Appearance of (a) conventional typing ticketing device and (b) self-developed typingless ticketing device input by ALPR smartglasses

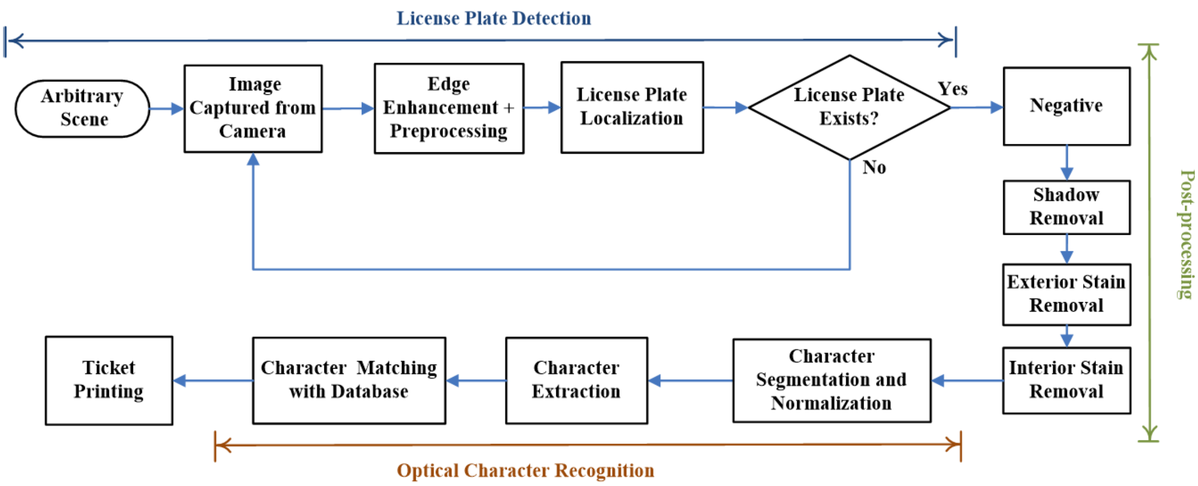


FIGURE 2. Overall algorithm flowchart of this work "Typingless Ticketing Device Input by ALPR Smartglasses"

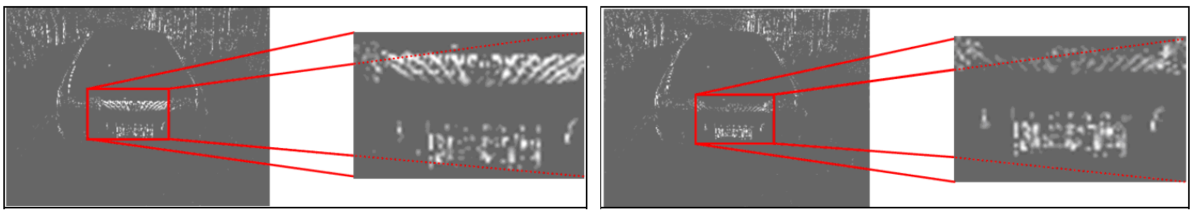
vertical edge enhancement, plate-and-character-based AdaBoost plus vertical-edge license plate detection, CIELAB-differentiated image negative, vertical-edge horizontal-projection histogram-segmentation stain removal, and customized optical character recognition.

The organization of this paper is as follows. Referring to Figure 2, Section 2 introduces 5 novel methods of "ALPR smartglasses" in order and evaluates their experimental results. Section 3 demonstrates the implementation results of this work "Typingless Ticketing Device Input by ALPR Smartglasses", and describes its step-by-step user instruction. Finally, Section 4 draws remarkable conclusions and comprehensive applications.

2. **Novel Automatic License Plate Recognition Smartglasses.** As depicted in Figure 2 except the final step of ticket printing, the algorithm flowchart of ALPR smartglasses is constructed of 3 stages: License Plate Detection (LPD), Post-Processing, and Optical Character Recognition (OCR). In stage of LPD, the image of arbitrary scene is captured by the RGB camera of the smartglasses at first. After some preprocessing to enhance the features of the license plate, the license plate is localized by some computer vision classifiers. If the license plate indeed exists, the stage of Post-Processing is proceeding. Otherwise, the RGB camera of the smartglasses restarts to capture the image of arbitrary scene automatically. In stage of Post-Processing, image negative to adapt to the license plates composed

of lighter characters and darker background, shadow removal to eliminate the shadow distortion to the license plate characters, and stain removal to erase the exterior and interior stains on license plate characters are performed. In stage of OCR, after the license plate characters are successfully segmented, normalized, and extracted, the license plate characters are matched to inquire the detailed information of the license plate from the database. This work proposes 5 novel methods: Wiener-deconvolution vertical edge enhancement, plate-and-character-based AdaBoost plus vertical-edge LPD, CIELAB-differentiated image negative, vertical-edge horizontal-projection histogram-segmentation stain removal, and customized optical character recognition, for better LPD rate and OCR rate. These 5 novel methods are clarified in detail as below.

2.1. **Wiener-deconvolution vertical edge enhancement.** In general, most LPD algorithms make use of the feature of vertical edge density to discriminate the license plate candidate region from the background of the scene image, because most characters on the license plate have higher vertical edge density than the background. Therefore, if some vertical edge enhancement preprocessing method is put on the original scene image in advance, LPD will work better. Because Wiener convolution is originally used for image blurring, this work proposes to deconvolute the scene image with a horizontal-direction Wiener filter for vertical edge enhancement. From Figure 3, the experimental results show the vertical edge density and intensity of the license plate are strengthened by a horizontal-direction Wiener deconvolution method, and those of the background, like radiator grilles, are simultaneously weakened. Furthermore, the detailed experimental results verify the proposed Wiener deconvolution vertical edge enhancement is better than direct inverse filter [5], constrained least squares filter [6], Lucy-Richardson filter [7] and blind deconvolution filter [8].



(a) (b)

FIGURE 3. (a) Original vertical-edge scene image and (b) that enhanced by Wiener deconvolution filter

2.2. **Plate-and-character-based AdaBoost plus vertical-edge license plate detection.** Although AdaBoost cascaded classifier with proper and adequate training of license plate patterns is almost feasible for exact LPD, this work proposes two auxiliary methods to make plate-based AdaBoost LPD more accurate and reliable under various complex conditions of scene backgrounds, environmental illuminations, plate colors, character colors, shadow occlusions, geometric dimensions and perspective skews. One method is character-based AdaBoost license plate verification to filter out the false positive outcomes of plate-based AdaBoost LPD by polling, and the other method is vertical-edge-based alternative LPD which is activated when no license plate candidate can be found by plate-based AdaBoost LPD and character-based AdaBoost license plate verification. The experimental result in Table 1 verifies the proposed plate-and-character-based AdaBoost plus vertical-edge LPD is more effective and efficient than conventional Adaboost with Haar-like features [9], conventional single vertical Sobel LPD [10-12], and conventional 2-level 2D Haar discrete wavelet transform LPD [13,14].

Table 1. Comparison on LPD rate with image samples of 1038 and resolution of 1024×768

LPD methods	LPD rate
Adaboost with Haar-like features LPD	77.84%
Single vertical Sobel LPD	79.38%
2-level 2D Haar discrete wavelet transform LPD	96.24%
Proposed plate-and-character-based AdaBoost plus vertical-edge LPD	99.13%

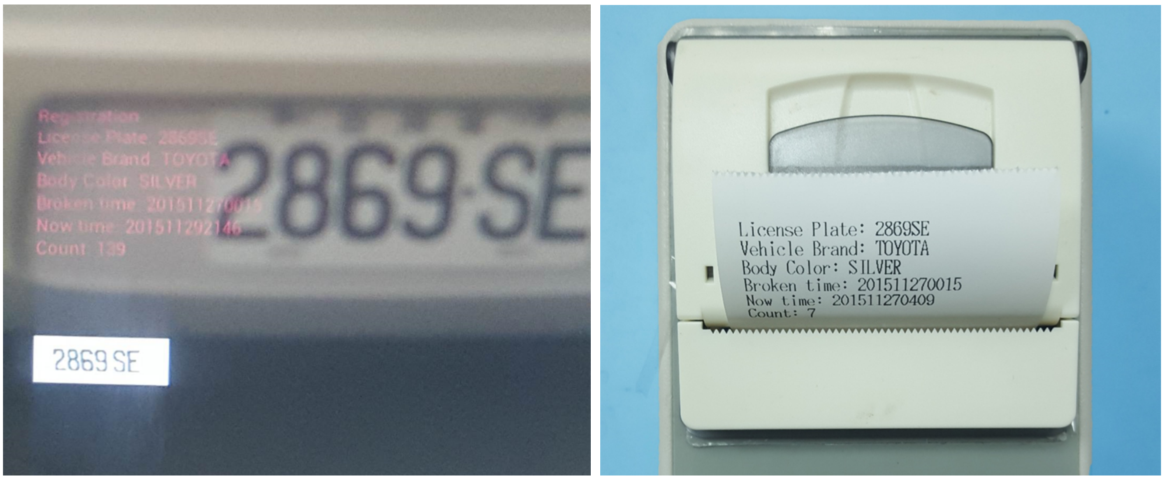
2.3. **CIELAB-differentiated image negative.** Different countries around the world offer different types of license plates, and even each country in itself offers a variety of types of license plates. In Taiwan, there are also a lot of combinations of character/background colors on the license plates, like black/white, white/green, or white/red, for diverse sorts of vehicles or specialties. After the stage of LPD, the candidates of license plate regions are localized and binarized. The license plates composed of darker characters and lighter background must not be transformed to negative images, but the ones composed of lighter characters and darker background must be. Then, original OCR can work well on the license plate images composed of darker characters and lighter background and those composed of lighter characters and darker background after image negative as usual. Specifically, in most countries, like Taiwan, China, Japan, Korea, or United States, green-background or red-background license plates embedding white characters are often available. These two types of license plate images composed of lighter characters and darker background must be negatively transformed for original OCR after the binarization processing. Thus, as shown in Figure 4, CIELAB-differentiated image negative method is proposed to pick out green-background or red-background license plates simply from CIELAB color space for image negative transformation [15,16].

Figure 4. Illustrative flowchart of the proposed CIELAB-differentiated image negative

2.4. **Vertical-edge horizontal-projection histogram-segmentation stain removal.** The localized license plate candidate is inevitably accompanying with some border stains, so the subsequent stage of OCR tends to misunderstand border stains as characters and is prone to make recognition mistakes. It is easier to remove interior stains on the license plate because interior stains are similar to salt and pepper noise, and it can be easily eliminated by mathematical morphology. However, it is quite harder to remove trapezoid border stains residing at the right side or left side, and interlinking border stains at the upside or downside. In this work, vertical-edge horizontal-projection histogram-segmentation stain removal method based on fill-in and connected component labeling is proposed to effectively remove trapezoid border stains at the right side or left side, and interlinking border stains at the upside or downside.

2.5. **Customized optical character recognition.** Because Tesseract OCR open-source library is originally used for OCR of general documents, not for OCR of license plates, this work elaborately retrains the font characteristics of each character on real Taiwanese license plate into the character dictionary of Tesseract OCR [17]. Then, through Java Native Interface (JNI) technique, this work ports license-plate-customized Tesseract OCR onto the Android-based smartglasses platform as a plug-in module of Android operating system. In addition, this work also proposes to adjust hybrid-pitch character segmentation of Tesseract OCR for the font characteristics of Taiwanese license plate. The field trial result of the license plate character recognition rate is over 99%, and it verifies that Tesseract OCR can perform well on ALPR missions in Taiwan or elsewhere by customizing its character dictionary elaborately.

3. **Implementation of Typingless Ticketing Device Input by Automatic License Plate Recognition Smartglasses.** The implementation of this work "Typingless Ticketing Device Input by ALPR Smartglasses" is successfully developed as Figure 1(b) and Figure 5. Figures 5(a) and 5(b) show the implementation results of ALPR smartglasses and portable printer, respectively. Implementation results show the license plate recognition rate of the ALPR smartglasses as shown in Figure 5(a) is over 96% under various complex conditions of scene backgrounds, environmental illuminations, plate colors, character colors, shadow occlusions, geometric dimensions and perspective skews, and the average execution time takes only 0.5 second per frame.



(a) (b)

FIGURE 5. (a) See-through display of ALPR smartglasses, and (b) ticketing paper from the portable printer

The step-by-step user instruction of this work is interpreted as follows. On the see-through display of the smartglasses, there are 3 buttons of function modes on the start menu. The leftmost button is to enter the mode of license plate database management. In this mode, users can add, edit, or delete the license-plate-related information in the built-in database. The middle button is to enter the mode of Bluetooth connection with the portable printer. In this mode, users can link and pair the smartglasses with the portable printer through Bluetooth. The rightmost button is to enter the mode of ALPR. In this mode, the smartglasses are engaged in the ALPR functionality. After the smartglasses are connected with the portable printer successfully, the smartglasses can perform ALPR by tapping the smartglasses' controller. Once the license plate is detected and recognized successfully, the license-plate-related information is inquired from the built-in database, and the license-plate-related information will be shown on the upper-left corner of the see-through display of the smartglasses in highlighted color, as shown in Figure 5(a). Then, through Bluetooth connection, the smartglasses transmit the license-plate-related information to the portable printer for ticketing of parking lot fee or traffic violation fine, as shown in Figure 5(b).

4. **Conclusions.** This work is composed of "Android smartglasses" and "portable printer". This work featuring automatic license plate recognition and prompt ticket paper printing can be applied to versatile vehicle management missions, like parking lot fee or traffic violation fine. This work not only can raise the accuracy and immediateness of license plate character input, but also can improve the wearing convenience and ticketing utility of parking officers or traffic policemen. Besides, standalone "ALPR smartglasses" without portable printer can also be applied to more diverse applications, like stolen vehicle investigation, roadside vehicle inspection, parking lot administration, shipping container logistics, and automotive factory management.

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REFERENCES

[1] H. Caner, H. S. Gecim and A. Z. Alkar, Efficient embedded neural-network-based license plate recognition system, *IEEE Trans. Vehicular Technology*, vol.57, no.5, pp.2675-2683, 2008.
[2] M. Mitchell, M. Hudnall, D. Brown, D. Cordes, R. Smith and A. Parrish, A host architecture for automobile license plate recognition, *Proc. of IEEE International Conference on Intelligence and Security Informatics*, pp.87-94, 2007.
[3] H. N. Do, M. T. Vo, B. Q. Vuong, H. T. Pham, A. H. Nguyen and H. Q. Luong, Automatic license plate recognition using mobile device, *Proc. of International Conference on Advanced Technologies for Communications*, pp.268-271, 2016.
[4] Epson, *Moverio BT-200 Technical Information for Application Developer*, https://tech.moverio.epson.com/en/life/bt-200/pdf/bt200_tiw1405ce.pdf.
[5] C. Zhang, G. Liao and Q. Qi, On PSF for lined motion blurred image, *Proc. of Chinese Control Conference*, pp.357-360, 2008.
[6] W. S. Yeoh and C. Zhang, Constrained least squares filtering algorithm for ultrasound image deconvolution, *IEEE Trans. Biomedical Engineering*, vol.53, no.10, pp.2001-2007, 2006.
[7] Y. Wang, X. Huang, Y. Yan and Y. Zhen, A new method for motion-blurred image blind restoration based on Huber Markov random field, *Proc. of International Conference on Image and Graphics*, pp.51-56, 2009.
[8] S. Qi, H. Wang and L. Wei, An iterative blind deconvolution image restoration algorithm based on adaptive selection of regularization parameter, *Proc. of International Symposium on Intelligent Information Technology Application*, pp.112-115, 2009.
[9] X. Xu, Z. Wang, Y. Zhang and Y. Liang, A method of multi-view vehicle license plates location based on rectangle features, *Proc. of International Conference on Signal Processing*, vol.3, pp.16-20, 2006.
[10] F. Faradji, A. H. Rezaie and M. Ziaratban, A morphological-based license plate location, *Proc. of IEEE International Conference on Image Processing*, pp.57-60, 2007.
[11] C.-N. E. Anagnostopoulos, I. E. Anagnostopoulos, I. D. Psoroulas, V. Loumos and E. Kayafas, License plate recognition from still images and video sequences: A survey, *IEEE Trans. Intelligent Transportation Systems*, vol.9, pp.377-391, 2008.
[12] J. M. Guo and Y. F. Liu, License plate localization and character segmentation with feedback self-learning and hybrid binarization techniques, *IEEE Trans. Vehicular Technology*, vol.57, pp.1417-1424, 2008.
[13] K. M. Hung, H. L. Chuang and C. T. Hsieh, License plate detection based on expanded Haar wavelet transform, *Proc. of International Conference on Fuzzy Systems and Knowledge Discovery*, vol.4, pp.415-419, 2007.
[14] S.-J. Yang, J.-B. Jiang and C. C. Ho, Wiener-deconvolution vertical edge enhancement for vertical-edge-based license plate detection, *ICIC Express Letters, Part B: Applications*, vol.5, no.2, pp.525-529, 2014.
[15] WorkWithColor.com, *Color Converter – RGB to HEX and More*, http://www.workwithcolor.com/color-converter-01.htm.
[16] HunterLab, *Measuring Color Using Hunter L, a, b versus CIE 1976 L*a*b**, http://www.hunterlab.com/appnotes/an02_01.pdf.
[17] Tesseract OCR, *Core Developers*, http://code.google.com/p/tesseract-ocr/.