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Application of Smart Phone for Industrial Barcode Scanner

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***Abstract*— The barcode system is used in various purpose. In industrial sector, barcode is used for identifying product in the manufacturing process. However, the barcode systems in industrial factory requires special barcode reader and the industrial barcode reader is more complicated and expensive than the conventional barcode reader.**

Recently, all smart phone can be applied for barcode reader application but there is no study how to use the smart phone barcode reader application in industrial factory. Therefore, this study would consider how to use the smart phone for industrial barcode reader system. The Android smart phone was used to develop barcode reader application by cooperating with the barcode reader library and the barcode reader system in manufacturing process was simulated. The barcodes for this experiment were 1D barcode and QR code. Moreover, the damaged barcodes were tested in the experiments and each experimental was continue tested nonstop for 24 hours.

The result found that smart phone can read 1D barcode and QR code. The readable rates of 1D barcode (complete and damage barcode) were 100%. The readable rates of QR code at 30 and 50 photos per minute were 92.5% and 85%. Thus, the smart phone has an opportunity to use as 1D barcode reader in industrial factory. For QR code, the readable rate result is low. However, there are many advantages to use smart phone for barcode reader such as price, flexibility, easy to use and reinstall. So, it is a challenge to use smart phone for industrial barcode reader.

Keywords*— *Android smart phone, Image processing, Barcode scanner.

I. INTRODUCTION

In the industrial factory, the barcode systems are used for varying process such as manufacturing process, inventory, logistic etc. The barcode reader can divide to 2 types: laser barcode scanner and camera base barcode scanner. The laser scanner use the laser line light for decode the barcode. For this reason, this scanner type can use with 1D barcode only. The camera base barcode scanner uses the camera for capture barcode image and decode the barcode image by using digital image processing technique. This base barcode scanner can read the both 1D and 2D barcode system. Moreover, the camera base barcode scanner can decode the damage barcode label. Therefore, the camera base barcode scanners are used in industrial factory more than the laser scanner.

The smart phone evolution was adapted to develop the novel algorithm of decoding the barcode by using smart phones. In 2004 Ohbuchi et al. [1] presented the method for detect barcode by detecting the barcode corner. In 2008 Wachenfeld et al. used image recognition for find the barcode location. The bolt researches were improvement the smart phone barcode reader application. In the field of 2D barcode, Szentandr´asi et al. [2] and Belussi et al. [3] developed the Histogram of Oriented Gradients (HOG) for detect QR code. The HOG improve the barcode reading speed. Moreover, many researchers developed the various smart phone applications such as: using smart phone for control industrial device [4], medical propose [5] and human resource management [6]. In additional, the smart phone is continuously improved the software and hardware performance. This is an advantage for apply the smart phone in the research and development.

The smart phone's barcode reader application is a common camera base barcode scanner application. It can decode the 1D and 2D barcode. Moreover smart phone can receive trigger signal via headset jack. In the industrial barcode scanner, this signal is used for starting the barcode reader process. Thus, the smart phone hardware has ability to use as the barcode scanner in the industrial factory.

For this reason, this study proposes to study the possibility for applied smart phone to barcode scanner in the industry factory. If the smart phone has ability to use, that can reduce the device cost and increase the flexibility of barcode reader system in the industry. However, the smart phone barcode reader applications are not qualified for using in the production line. Because in the production line, the products are moved on the conveyor. Thus the barcode reader need the trigger signal and delay time for control the capture and image processing process. Moreover, the auto-focus and auto-exposure functions in the barcode reader application have an effect on processing time and readable rate of barcode decoding. So, it need to turn on the function at necessary only.

In this study, the barcode reader application was developed with the necessary function for reading barcode in the production line. Then the barcode reader application were tested continues 24 hours. The problem when using barcode reader application for long time was the increasing of smart phone's temperature. The cause of the temperature increasing was the screen lighting, so the dimmer of screen lighting was used for solving this problem.

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II. CAMERA BASE BARCODE SCANNER

A. Machine vision system

The machine vision system is applied to various task in industrial factory and the camera base barcode scanner is one of them. The camera is used to capture the barcode image and the image processing is used to decode the barcode symbol. The schematic of machine vision is shown in Figure 1. [7]. The system consists of trigger sensor, camera, lighting and vision software. The trigger sensor is donated to detect the object, when the object moves through, the sensor send the signal to camera and vision software. This signal is used for captured the image and started the image processing process.

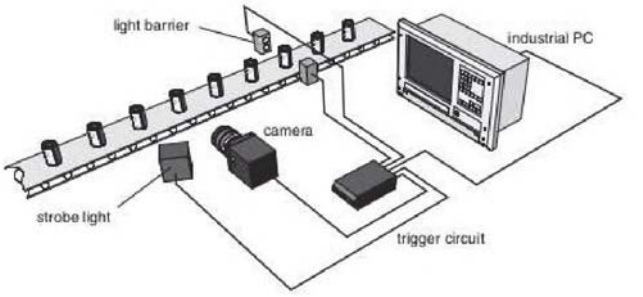

Fig. 1 The machine vision system [7]

The hardware of camera base barcode scanner is the same as the machine vision system. But the software of camera base barcode scanner is developed for decoding barcode symbol only. So, mostly the camera base barcode scanners are smart camera (the camera includes CPU, RAM, SSD in the camera body) and there is no computer for processing. Because the smart camera is more flexible than the computer base vision system.

B. Overview of barcodes

Barcode is used to help machine for reading number and alphabet code. It is printed on product label for identify the product. There are 2 types of barcode: 1D barcode and 2D barcode. 1D barcode is the series of black and white bar. Each bar is difference width. 2D barcode is image of white and black dot with various sizes. A lot of dots are arranged to the 2D barcode image.

There are various standards of 1D barcode such as UPC (EAN), Code39, Code128, etc. This study used 1D barcode EAN-13 for the experimental. The structure of EAN-13 has contained: Margin, Barcode symbol, Barcode, Start character, Data (message), Check digit and stop character. This barcode type contains 12-digit UPC number. The first six digits are manufacturer's identification number. Next five digits are item number and last digit is barcode's checking number.

2D barcode is more complex and contain more data than 1D barcode. It contain vary data such as: price, web address or production's lot number. The laser barcode scanner cannot use with 2D barcode. This barcode need camera base barcode scanner for decoding the barcode symbol. However, smart phones (iPhones and Android phones) can decode this barcode type by using integrated camera and barcode reader application. Recently, there are various types of 2D barcodes: PDF417, Data Matrix, QR code, etc. The QR code is used in widely industrial and this study used QR code for the experimental.

C. The barcode reader library for smart phones

This study used ZBar library for barcode decoding. ZBar is a library for decoding the barcode by using the image processing method. The image enhancement techniques are included in ZBar library so the decoding result is more efficiently. The ZBar can decode 1D barcode and QR code and this library can develop with Windows, Linux, iPhone and android studio.

III. THE EXPERIMENTAL

The simulation of barcode reading in manufacturing process was built. The barcode types in the experiment were 1D barcode, QR code and damage 1D barcode (as show in figure 2).

Fig. 2 The barcode was used in this study

A. The simulation of industrial barcode reader system

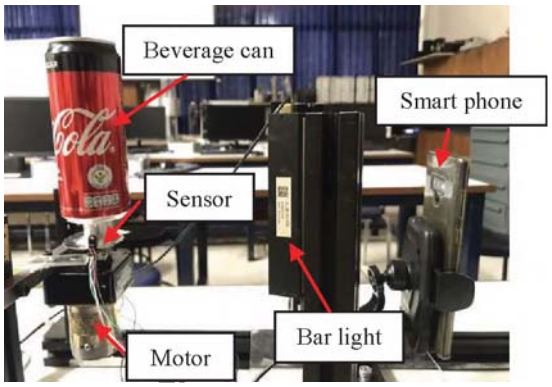

Fig. 3 The smart phone barcode scanner

Figure 3 show the simulation of barcode reader system by using smart phone. The system follows the machine vision concept (as show in figure 1). The system consists of smart phone, trigger sensor, lighting and motor. The smart phone was used for barcode reading. The trigger sensor played role for generate the trigger signal when the object were moved through to sensor. The signal was sent to smart phone via 3.5 mm microphone jack. The industrial bar light was used for illuminated the light for machine vision system. In additional, the lighting can protect the disturbing light from environment and reduce the image blurring. The motor was attached under the beverage can. It was used for rotated the object, as simulate as the barcode were moving in the manufacturing process. The barcode on the can was captured and decoded barcode symbol by smart phone.

During the experiment, the smart phone was set to airplane mode for avoid interrupt application running from income calling or income chat data. The experiment continue tested over 24 hours (non-stop) and tested in the room without air condition.

B. *Android smart phone*

The smart phone "SANSUMG GALAXY Note 9" was used in this study. This phone have 2.8GHz 64-bit Octa-Core Processor, 128GB RAM. The operating system is Android 8.1. The back rear camera are 12 Megapixel, sensor size: 1/2.55". The barcode reader application used the rear camera for captured the barcode image.

C. *The barcode reader application*

The application for this study was developed from Android studio version 2.3.2, SDK tool version 27. The application GUI is shown figure 4. It consist of: "ZOOM IN, ZOOM OUT" buttons for camera zoom in or zoom out, "AUTOFOCUS" for auto adjust camera focus, "AE_MODE" for lock/unlock the capture exposure, "DELAY+, DELAY-" for setting the capture delay time after trigger sensor was turn on, screen for application screen saver and reset button for reset the barcode reading statistic.This application can scanner 1D barcode (EAN-13) and QR code.

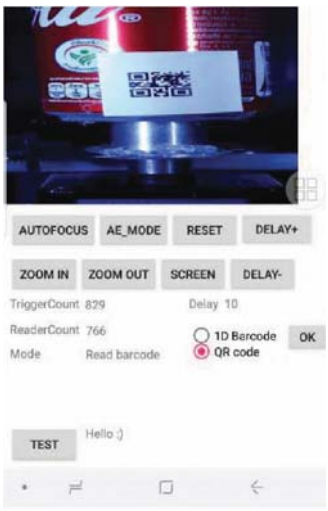

Fig. 4 Barcode scanner application

The barcode scanner application was developed with ZBar Android SDK version 0.2. This application can decode 1D barcode and QR code. The application flowchart is shown in figure 5.

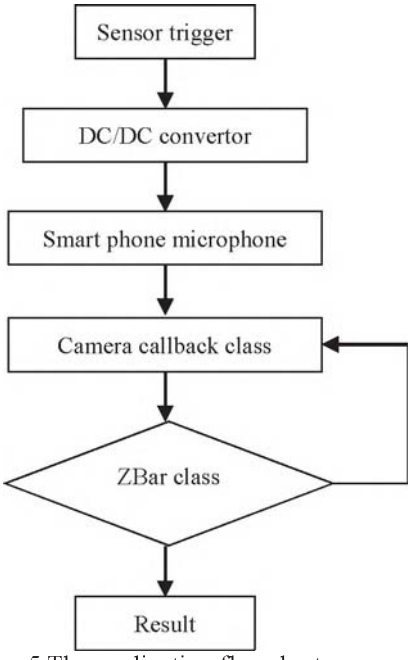

Fig. 5 The application flowchart

Figure 5 show the flowchart of barcode scanner application. The barcode scanner process was started by the trigger signal. This signal was generated from photo sensor that was attached under the workpiece (show in figure 3). This signal from sensor was sent to DC/DC convertor for converting and sent the signal to smart phone via microphone jack. The camera capture and barcode decoding process was started after received the trigger signal. Next, the ZBar class was used for decoding the barcode. This class was developed from the ZBar library. Every time of camera capture, the ZBar class was executed by calling from camera callback function. The processing of ZBar class was looped until the barcode was found or over the limit time. After finish, ZBar class returned the barcode value to the main class and main class displayed the barcode data, barcode readable count and sensor trigger count.

IV. Result and Discussion

A. *The processing time for Barcode reading*

The speed of barcode reading is necessary for barcode system in the manufacturing process. For the barcode scanner by using smart phone, the camera function (auto-focus and auto auto-exposure) have an effect on barcode scanner processing time. Thus, the experimental for studying the barcode reading time by vary camera function were set up. The experiment configured to 4 cases: 1) using auto exposure and auto focus, 2) using only auto exposure, 3) using only auto 4) focus and not using auto exposure and auto focus. The experiments used the hardware in figure2. and timer function was developed by using timer in android studio function. Timer was started when received the trigger signal and stopped when the barcode reading process finish. Each experiment was repeat 3 time. The table 1 show the average result from the experiments.

TABLE I. Barcode Reading Time

Barcode types	Barcode reading time (sec.)			
	using auto exposure and auto focus	*using only auto exposure*	*using only auto focus*	*not using auto exposure and auto focus*
1D barcode	0.77	0.42	0.50	0.40
QR code	1.55	0.60	1.50	0.55
Damage 1D barcode	1.32	0.57	1.25	0.52

The result in table 1 show the auto focus and auto exposure function had an effect to barcode reading time. The average barcode reading time when use the auto focus was increase 54.76% and increase 7.54% when using the auto exposure time. However, in the manufacturing line, products are transfer in the conveyor. The distance between product and barcode scanner are not change. Thus, the auto focus is not necessary. For this reason, the experiment "The barcode readable rate" not used auto focus function.

B. *Barcode readable rate*

The barcode readable rate experiment was simulation of manufacturing production line. The detail of simulation hardware is shown in figure 3. There were 3 types of barcode for testing: 1D barcode, QR code and damage 1D barcode. The 1D barcode and damage 1D barcode were tested at 30, 50 and 100 photos per minute. The QR code was tested at 30 and 50 photos per minute. Each experiment case was continuous tested nonstop for 24 hours and the barcode readable rate was measured. The readable rate was the % of

the number of time the successful barcode reading per overall barcode reading. The number of success time was counted when ZBar class can read barcode and return value to main class. The number of time of overall barcode reading was the time that smart phone received the trigger signal. The result is shown in table 2

TABLE II. BARCODE READABLE RATE

Barcode types	Readable rate (%)		
	30 photo per minute	*50 photo per minute*	*100 photo per minute*
1D barcode	100	100	100
QR code	92.5	85	N.A.
Damage 1D barcode	100	100	100

C. Discussion

Table 2 show the result of the barcode readable rate. The readable rates of 1D barcode and damage 1D barcode are 100%. The readable rates of QR code are 92.5% at 30 photos per minute and 85% at 50 photos per minute. The cause of low readable rates are the cylindrical of the object. In the experiment, the beverage can was used for barcode reading object. The curve of can had an effect on the distortion of QR code photos. As a result, sometime the barcode reading application were not successful. In the other hand, 1D barcode was printed on the long side of the beverage can. So the readable rate of 1D barcode had not effect from the curve of can. Although the readable rate of QR code is low, this study shows the smart phone can be applied for manufacturing barcode scanner. Moreover, smart phones development are continuing. Thus, it is interest to apply smart phone in manufacturing process.

The advantage for using smart phone barcode reader in the production line is decreasing the machine cost. In additional, the smart phones are consisted of vary useful equipment such as: GPS, internet connection module, voice recorder, Bluetooth and motion sensor. These accessories are powerful for developing the industry 4.0 application. In the long term, smart phone is easier to buy and convenient to replace when the barcode reader is broken. So, this reduces the waste time in production line for waiting the new barcode scanner device.

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