DESIGN AND IMPLEMENTATION OF AN EMBEDDED SYSTEM FOR IMAGE ACQUISITION OF INSERTS IN A HEADTOOL MACHINE

Adrián de las Matas de la Fuente
Escuela de Ingenierías Industrial e Informática, Campus de Vegazana s/n 24071 León, Spain,
adelad02@estudiantes.unileon.es

Víctor González-Castro
Centre for Clinical Brain Sciences (CCBS), 49 Little France Crescent, Edinburgh EH16 4SB,
victor.gonzalez@ed.ac.uk

Laura Fernández-Robles
Escuela de Ingenierías Industrial e Informática, Campus de Vegazana s/n 24071 León, Spain,
l.fernandez@unileon.es

Enrique Alegre
Escuela de Ingenierías Industrial e Informática, Campus de Vegazana s/n 24071 León, Spain,
enrique.alegre@unileon.es

ABSTRACT

Based on the idea of combining embedded systems, industrial cameras and image processing, in this paper we present the design of an embedded and portable image acquisition system on a Raspberry PI 2 and other in a notebook. The image acquisition system has been developed using two different programming languages, such as Python and C++. The OpenCV Computer Vision library, in its new 3.0.0 version was used to carry out all the computer vision processing.

Keywords: Embedded System, image acquisition system, Raspberry Pi 2, Windows Embedded, Toshiba notebook, uEye Camera

1 INTRODUCTION

Traditionally image acquisition systems have had the inconvenient of being complex, bulky and excessively expensive. Nowadays technology has improved in both size and price but yet only few people have tried to use those advantages to create new and original image acquisition systems. In order to solve these issues and take advantage of new technologies we propose a new low-cost, embedded and portable image acquisition system.

Recently, the availability of embedded low-cost platforms has increased. Boards like Raspberry, Arduino or even notepads have become more and more popular because of their size, price, low energy consumption and the support of Operating Systems (OS) with low requirements. These features have made easier to create new image acquisition systems that work the lacks we commented above out.

Different portable image acquisition systems have been developed during the last years, being ARM architectures with Linux OS [4][5] one of the most commonly use. However, it is not the only approximation. Some works propose to create micro embedded systems using different hardware components and also Linux OS [3][13].

As we want to resolve the problem set out by FRESVIDA project in collaboration with the manufacturer TECOI and the Spanish government, it is needed to develop an image acquisition system for an application that automatically detects and classify cutting tools into broken or not in order to change them when necessary. To make it possible, the systems has the following requirements: must be portable, easy to install and as cheaper as possible and cameras would be industrial ones.

In this paper we present two different embedded image acquisition systems with two distinctive industrial cameras that can fulfil the requirements above aforementioned. One of them based on a Raspbian distribution on a Raspberry Pi 2 and the other one based on a Windows Embedded POS Ready 2009 (an embedded version of XP OS) on a Toshiba NB-200-12N notebook. Our advantage is that we use low-cost pre-built hardware that is very efficient, powerful and easy to configure.

Actas de las XXXVI Jornadas de Automática, 2 - 4 de septiembre de 2015. Bilbao
ISBN 978-84-15914-12-9 © 2015 Comité Español de Automática de la IFAC (CEA-IFAC)

The rest of the paper is organized as follows, in section 2 the experiments with the two cameras and the two embedded systems will be presented, then the image acquisition systems proposed will be discussed in section 3, and finally the conclusions will be summarized in section 4.

2 MATERIALS

2.1 ACQUISITION SYSTEM LAYOUT

In this section we are going to show the image acquisition system layout explaining the setup and what are an insert and a headtool machine. Figure 1 and 2 shows the sketch of the system. To make the system we used a camera, a headtool machine or cutting head, and three bar lights.

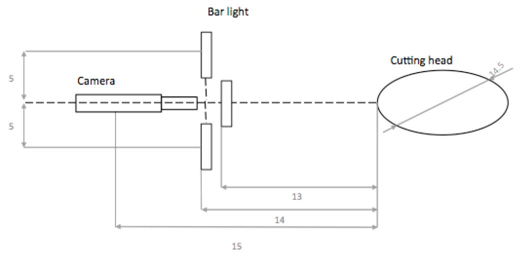

Figure 1: Top view of the system

The figure above shows the plan of the system; the distances are taken in cm.

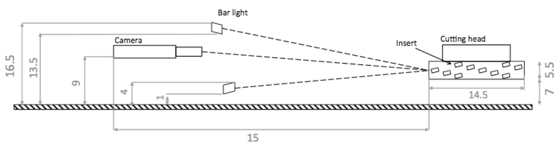

Figure 2: Side view of the system

Figure 2 shows the side view of the image acquisition system, as in figure 1 the distances are taken in cm. In this sketch we can also see what is an insert, a little piece that is in the cutting head and which work is to carry out the cutting process. Cutting head as it can be seen in both figures have the labour of holding the inserts and rotate to cut the metallic piece during the cutting process.

We say that it is a low cost image acquisition system because the combined price of all the parts, the camera, the illumination and the processing system is lower than 3000€.

2.2 PORTABLE HARDWARE

2.2.1 Raspberry PI 2

The Raspberry Pi is a low cost credit card-sized computer. It is a basic piece of hardware that only needs a monitor to show its output and a standard USB mouse and keyboard as input elements [8].

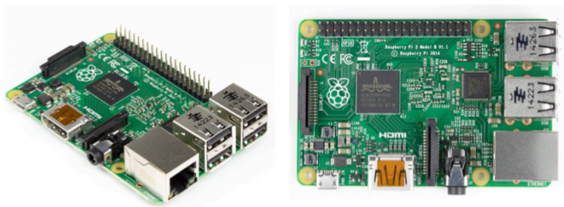

Figure 3: Raspberry Pi 2

In our experiment we worked with the last model, Raspberry PI 2 (Figure 3), which was released in February 2015. Table 1 shows its specifications [9].

Table 1: Raspberry PI 2 specifications

Raspberry PI 2 specifications	
Processor	900MHz quad-core ARM Cortex-A7
RAM	1GB
Input	4 USB 2.0
Output	1 HDMI port, 3.5 mm audio jack and composite video
GPIO	40 pins
Internet Access	Ethernet
Storage Memory	Micro SD card slot
Power Supply	5v micro USB

2.2.2 Toshiba NB200-12N Notebook

The NB200-12N (Figure 4) is a notebook made by Toshiba that allows users to carry out a lightweight personal computer with them. It is remarkable that even though this notebook is not very powerful, it has enough computing capability to make possible our purpose [10].

Figure 4: Toshiba NB200-12N Notebook

Table 2 shows its principal specifications.

Actas de las XXXVI Jornadas de Automática, 2 - 4 de septiembre de 2015. Bilbao
ISBN 978-84-15914-12-9 © 2015 Comité Español de Automática de la IFAC (CEA-IFAC)

Table 2: Toshiba NB200-12N Notebook specifications

Toshiba NB200-12N notebook	
Processor	1.66 GHz Intel® Atom™ N280
RAM	1,024 MB, DDR2 (800 MHz)
Input	3 USB 2.0, 1 multi-card lector, 1stereo jack
Output	1,024 x 600 resolution 10.2’’ screen, 1 VGA port
Internet Access	Ethernet, WiFi card
Storage Memory	250 GB
Power Supply	100/240 V Current adapter

2.3 EMBEDDED SOFTWARE

2.3.1 Raspbian

Raspbian is a free Operating System, an unofficial port based on the Debian distribution but optimized for the Raspberry Pi hardware. It has about 35.000 packages available and pre-compiled software easy to install and use [5].

It was released in June 2012 but the development of the OS is still in progress due to the users’ contribution [2].

2.3.2 Windows Embedded POS Ready 2009

Windows Embedded POS Ready 2009 is a flexible OS that is designed to give point-of-service solution with peripherals, servers and services. It also includes the power and familiarity of Windows XP Professional [12].

It was released in 2009 and nowadays has support until April 9, 2019. Later, the licence will still be available to buy until February 11, 2024 but without official support [7].

2.4 CAMERAS

2.4.1 Genie M1280-1/3

The Genie M1280-1/3 (Figure 5) is a monochromatic Ethernet camera whose sensor has a resolution of 1280x960 pixels.

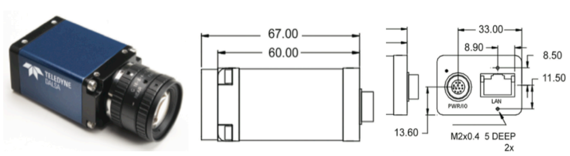

Figure 5: Genie M1280-1/3

Table 3 shows Genie camera specifications:

Table 3: Genie M1280-1/3 specifications

Camera Specifications	
Active Resolution	1280x960
Frame Rate	24fps
Exposure Control	Programmable, or via External Trigger
Output	Gigabit Ethernet, also support 100 Mbps (RJ-45)
Lens Mount	C or CS-mount / Right Angle available
Size	44mm x 29 mm x 67 mm (including lens adapter)
Power Supply	12 to 24 v (4 W)

This camera has a 25mm lens (Figure 6), manual focus and the minimum distance required to capture an image without problems of focus is of 30 cm.

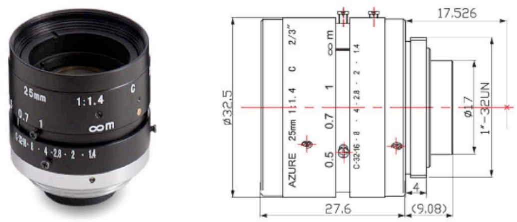

Figure 6: AZURE-2514MM Lens

This camera uses a GigE Vision Standard, which is a global camera interface standard developed to use the Gigabyte Ethernet communication protocol. This standard allows faster image transfer using low cost cables. Nowadays it is widely established in the industry of Vision and a lot of companies develop their cameras using it. The current version is 2.0 and was released in November 2011. In Table 4, we show its main benefits according to [1].

Table 4: GigE benefits.

GigE	
Fast	Bandwidth of 125 MB/s
Abundant	Data transfer up to 100 meters in length
Standard	Low cost standard cables and data connectors
Scalable	Highly scalable due to Ethernet technology
Low cost	Standardized components with easily integration

2.3.2 USB 2 uEye XS Industrial Camera

It is a colour USB 2.0 camera (Figure 7) whose sensor has a resolution of 2592x1944 pixels. Table 5 shows its general specifications:

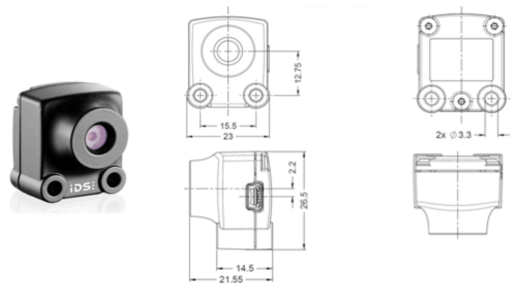

Figure 7: USB 2 uEye XS Industrial Camera

Table 5: USB 2 uEye XS Industrial Camera specifications

Camera Specifications	
Active Resolution	2592x1944
Frame Rate	15fps up to 30
Exposure Control	Programmable, or via External Trigger
Output	USB 2.0
Size	26.5 mm x 23.0 mm x 21.5 mm
Power Supply	USB Cable

Its focus is automatic and it needs a minimum distance to the object to be captured of 10 cm.; also it has auto gain, exposure, contrast correction and white balance [4].

2.5 PROGRAMMING LANGUAGE

To develop our image acquisition system we used two different programming languages C++ and Python to create two different systems but with a common computer vision library OpenCV. This library is cross-platform and works with several programming languages like C, C++, Java, Python, etc. It was written and optimized in C/C++ and can take advantage of multi-core processing.

In our approximations we use OpenCV 3.0.0 beta version, firstl with C++ and later on with Python [6].

3 PROPOSED SOLUTIONS

3.1 Raspberry PI 2 + Raspbian + Genie M1280-1/3

Firstly, we develop a configuration consisting of Raspberry PI 2, Raspbian OS and Genie M1280-1/3 industrial camera. With the specified setup we wanted to develop a portable image acquisition system by using OpenCV 3.0.0 in C++.

In our attempt to connect the Genie M1280-1/3 camera we found out that Raspbian was not able to use the GigE protocol (i.e. GigE is a common industrial camera oriented network protocol used by a lot of manufacturers but not with official support in all OS) in that specific camera. We tried to overcome this problem by creating a bridge from OpenCV 3.0.0 and the camera module of Raspberry PI 2 to communicate between them. Even so, the module was unable to communicate with the camera interface. Therefore, this first configuration was deserted.

The manufacturer does not offer support for Genie camera and Linux/Debian distributions, we believe that this is the main reason we were not able to make possible the communication between hardware (camera) and software (Raspbian).

3.2 Toshiba NB200-12N Notebook + Windows Embedded POS Ready 2009 + Genie M1280-1/3

After our first try, we decided to take another new point of view to deal with the problem. In this new approach we changed the programming language and some components of hardware and software. In this way, instead of using a Raspberry we used a Toshiba NB200-12N notebook, and as OS we used Windows Embedded POS Ready 2009.

Before starting to develop our image acquisition system, we made sure that Genie M1280-1/3 could communicate with the OS and the notebook by testing the example program provided by the distributor. Finally we checked that the Genie camera could be used on that setup, our test was successful and we could obtain frames from the example program (Figure 8).

As we stated before, we changed the programming language of the image acquisition system, so we decided to take Python as primary language but still using OpenCV to make the script that capture images. We chose this new development language to take advantage of two main characteristics Python offers to us. First of all this language is more legible than other high level programming languages like

C++ or Java and secondly it is an interpreted language, which means that the scripts we developed can be run on any machine with the required interpreter.

A new problem appeared in the development process: OpenCV 3.0.0 beta did not offer direct support to communicate cameras that use GigE standard, so even if we could communicate the camera we would not be able to use it to create a portable image acquisition system.

Figure 8: Genie M1280-1/3 Headtool frame with the demo program

3.3 Toshiba NB200-12N Notebook + Windows POS Ready 2009 + USB 2 uEye XS Industrial Camera

Noticing that Genie M1280-1/3 was not the appropriate one for the connection problems a critical settlement was taken by changing the camera.

The new configuration is Toshiba NB200-12N notebook, the same OS as before, and a new industrial camera, a USB 2 uEye XS.

Same as before, first we test the camera communication with the system via an example program and all worked well. Therefore, we decided to use that camera on our first approach (i.e., using the Raspberry Pi 2) before continuing with our second idea (i.e., using the Toshiba notebook) because of the advantages Raspberry Pi offers: has lower power consumption (i.e., we can use a Power Bank to boost it), is cheaper and enough powerful to make possible our image acquisition system and is more portable due to its little size.

3.4 Raspberry PI 2 + Raspbian + USB 2 uEye XS Industrial Camera

The last setup we are going to describe is made up of a Raspberry PI 2, Raspbian OS and the new USB 2 uEye XS Industrial camera.

Like in the approach described in section 3.3, the first step we took was to test the communication between the camera and the Raspberry with a demo program, and we could take images, so everything worked fine.

This uEye XS camera comes with a particular API written in C++, which allows us to create and design new programs to retrieve images. Therefore, we created a new C++ program that used the camera API and OpenCV to develop the image acquisition system. Finally we test successfully that program and we were able to grab single frames (Figure 9).

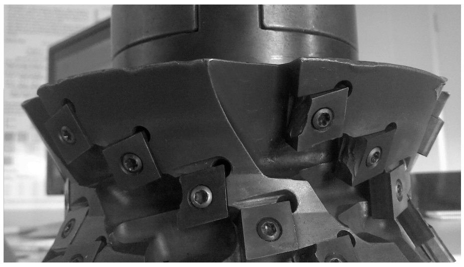

Figure 9: USB 2 uEye XS Headtool frame with the developed image acquisition system

4 CONCLUSIONS

In this paper we have dealt with the development of an embedded image acquisition system to overcome the problems of conventional systems have, i.e., their complexity, cost and lack of portability due to their size. In this development we have adapted the technology available nowadays.

In this paper we want to show how new embedded systems like the Raspberry PI 2 or a notebook could be used to create a simple but efficient embedded image acquisition system. Moreover, we also wanted to demonstrate that it is possible to develop industrial systems using cameras that a common user normally wouldn't have in their homes with low cost hardware compatibility.

Acknowledgements

This work has been supported by grant DPI2012-36166 from the Spanish government.

References

[1] AIA Global Association For Vision Information. "GigE standard" http://www.visiononline.org/vision-standards-details.cfm?type=5 [Online. Last accessed: 2015-06-17]

[2] Distrowatch OS Database (Rasbian) http://distrowatch.com/table.php?distribution=raspbian [Online. Last accessed: 2015-06-17]

[3] Guan, Xiaohan, and Wangyi Shi. "Design of Real-time Image Acquisition and Display System Based on Embedded Linux." First International Conference on Information Sciences, Machinery, Materials and Energy. Atlantis Press, 2015.

[3] Huimin, He. "Research and implementation of embedded image acquisition system." *Advanced Computer Theory and Engineering (ICACTE),* 2010 3rd International Conference on. Vol. 3. IEEE, 2010.

[4] IDS-Imaging https://en.ids-imaging.com/xs-home.html [Online. Last accessed: 2015-06-17]

[5] Liu, Yong-lin, Ying Liang, and Yao-yu Cheng. "Design and implementation of image acquisition system based on ARM and Linux." *Electronics and Optoelectronics (ICEOE), 2011 International Conference on*. Vol. 3. IEEE, 2011.

[6] OpenCV http://opencv.org [Online. Last accessed: 2015-06-17]

[7] Product Lifecycles & Support of Windows Embedded https://www.microsoft.com/windowsembedded/en-us/product-lifecycles.aspx [Online. Last accessed: 2015-06-17]

[8] Raspberry PI https://www.raspberrypi.org/ [Online. Last accessed: 2015-06-17]

[9] Raspberry PI model 2 http://swag.raspberrypi.org/collections/frontpage/products/raspberry-pi-2-model-b [Online. Last accessed: 2015-06-17]

[10] Raspbian OS http://www.raspbian.org [Online. Last accessed: 2015-06-17]

[11] Thosiba Leading Information http://www.toshiba.es/discontinued-products/toshiba-nb200-12n/ [Online. Last accessed: 2015-06-17]

[12] Windows Embedded POSReady 2009 Evaluation https://www.microsoft.com/en-us/download/details.aspx?id=11196 [Online. Last accessed: 2015-06-17]

[13] Yinli, Lu, Yu Hongli, and Zhang Pengpeng. "The implementation of embedded image acquisition based on V4L2." *Electronics, Communications and Control (ICECC)*, 2011 International Conference on. IEEE, 2011.