Digital Image Processing Using LabView

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1. Introduction

Digital Image processing is a topic of great relevance for practically any project, either for basic arrays of photodetectors or complex robotic systems using artificial vision. It is an interesting topic that offers to multimodal systems the capacity to see and understand their environment in order to interact in a natural and more efficient way.

The development of new equipment for high speed image acquisition and with higher resolutions requires a significant effort to develop techniques that process the images in a more efficient way. Besides, medical applications use new image modalities and need algorithms for the interpretation of these images as well as for the registration and fusion of the different modalities, so that the image processing is a productive area for the development of multidisciplinary applications.

The aim of this chapter is to present different digital image processing algorithms using LabView and IMAQ vision toolbox. IMAQ vision toolbox presents a complete set of digital image processing and acquisition functions that improve the efficiency of the projects and reduce the programming effort of the users obtaining better results in shorter time. Therefore, the IMAQ vision toolbox of LabView is an interesting tool to analyze in detail and through this chapter it will be presented different theories about digital image processing and different applications in the field of image acquisition, image transformations.

This chapter includes in first place the image acquisition and some of the most common operations that can be locally or globally applied, the statistical information generated by the image in a histogram is commented later. Finally, the use of tools allowing to segment or filtrate the image are described making special emphasis in the algorithms of pattern recognition and matching template.

2. Digital image acquisition

We generally associate the image to a representation that we make in our brain according to the light incidence into a scene (Bischof & Kropatsc, 2001). Therefore, there are different variables related to the formation of images, such as the light distribution in the scene. Since the image formation depends of the interaction of light with the object in the scene and the emitted energy from one or several light sources changes in its trip (Fig. 1). That is why the

Radiance is the light that travels in the space usually generated by different light sources, and the light that arrives at the object corresponds to the Irradiance. According to the law of energy conservation, a part of the radiant energy that arrives to the object is absorbed by this, other is refracted and another is reflected in form of radiosity:

$$\phi(\lambda) = R(\lambda) + T(\lambda) + A(\lambda) \tag{1}$$

Where $\phi(\lambda)$ represents the incident light on the object, $A(\lambda)$ the absorbed energy by the material of the object, $T(\lambda)$ the refracted flux and $R(\lambda)$ the reflected energy, all of them define the material properties(Fairchild, 2005) at a given wave length (λ) . The radiosity represents the light that leaves a diffuse surface (Forsyth & Ponce, 2002). This way when an image is acquired, the characteristics of this will be affected by the type of light source, the proximity of the same ones, and the diffusion of scene, among others.

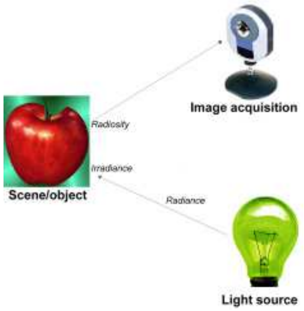


Fig. 1. Light modification at acquisition system.

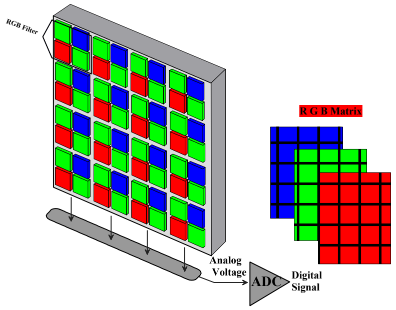


Fig. 2. Colour image acquisition with a CCD.

In the case of the digital images, the acquisition systems require in the first place alight sensitive element, which is usually constituted by a photosensitive matrix arrangement obtained by the image sensor (CCD, CMOS, etc.). These physical devices give an electrical output proportional to the luminous intensity that receives in their input. The number of elements of the photosensitive system of the matrix determines the spatial resolution of the captured image. Moreover, the electric signal generated by the photosensitive elements is sampled and discretized to be stored in a memory slot; this requires the usage of an analog-to-digital converter (ADC). The number of bits used to store the information of the image determines the resolution at intensity of the image.

A colour mask is generally used (RGB Filter) for acquisition of colour images. This filter allows decomposing the light in three bands, Red, Green and Blue. The three matrixes are generated and each one of them stores the light intensity of each RGB channel (Fig. 2).
The next example (presented in Fig. 3) show to acquire video from a webcam using the **NI Vision Acquisition Express**. This block is located in Vision/Vision Express toolbox and it is the easiest way to configure all the characteristics in the camera. Inside this block there are four sections: the first one corresponds to the option of “select acquisition source” which shows all the cameras connected in the computer. The next option is called “select acquisition type” which determines the mode to display the image and there are four modes: single acquisition with processing, continuous acquisition with inline processing, finite acquisition with inline processing, and finite acquisition with post processing. The third section corresponds to the “configure acquisition settings” which represents the size, brightness, contrast, gamma, saturation, etc. of the image and finally in the last option it is possible to select controls and indicators to control different parameters of the last section during the process. In the example presented in Fig. 3 it was selected the continuous acquisition with inline processing, this option will display the acquired image in continuous mode until the user presses the stop button.

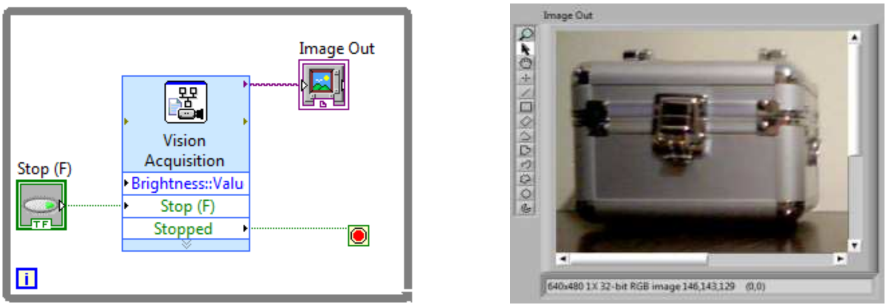


Fig. 3. Video Acquisition using IMAQ Vision Acquisition Express.

3. Mathematical interpretation of a digital image

An image is treated as a matrix of *M*x*N* elements. Each element of the digitized image (pixel) has a value that corresponds to the brightness of the point in the captured scene. An image whose resolution in intensity is of 8 bits, can take values from 0 to 255. In the case of a black and white image images it can take 0 and 1 values. In general, an image is represented in a bidimensional matrix as shown in (2).

$$I = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix} \qquad (2)$$

Since most of the devices acquire the images with a depth of 8 bits, the typical range of levels of gray for an image is from 0 to 255 so that the matrix elements of the image is represented by $x_{ij} \in [0...255]$.At this point it is convenient to say that even if the images are acquired at RGB format, it is frequently transformed in a gray scale matrix and for achieving the transformation from RGB type to gray Grassman level (Wyszecki & Stiles, 1982)is employed:

$$I_{gray} = I_R(0.299) + I_G(0.587) + I_B(0.114) \tag{3}$$

In the example presented in Fig. 4 shows how to acquire a digital image in RGB and grayscale format using the IMAQ toolbox. In this case there are two important blocks: The first one is the **IMAQ Create block** located in Vision and Motion/Vision Utilities/Image Management, this block creates a new image with a specified image type (RGB, Grayscale, HSL, etc.), the second block is the **IMAQ Read Image** which is located in Vision and Motion/Vision Utilities/Files/, the function of this block is to open an image file which is specified previously in the file path of the block and put all the information of this opened image in the new image created by **IMAQ Create**. In other words, in the example presented in Fig. 4 (A) the file picture4.png is opened by the **IMAQ Read Image** and the information this image is saved in a new image called imageColor that corresponds to a RGB (U32) image type.It is very simple to modify the image type of the system, in Fig. 4 (B) the image type is changed to Grayscale (U8) and the image is placed in imageGray.

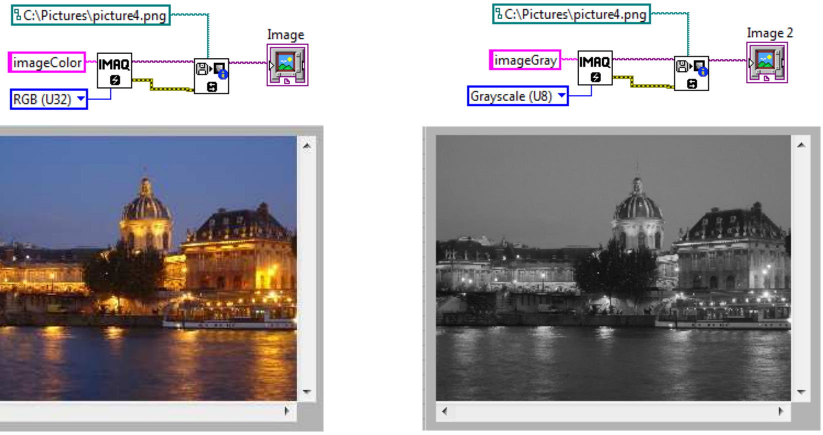


Fig. 4. RGB and Grayscale Image Acquisition.

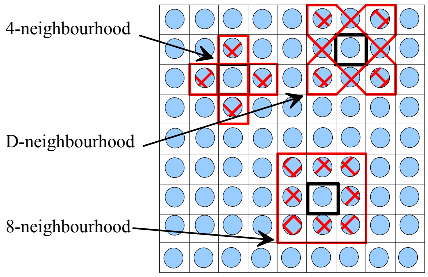


Fig. 5. Neighbourhood of a pixel.

Another important characteristic in the image definition is the neighbourhood of pixels, that could be classified in 3 groups described in (Fig. 5), if the neighbourhood is limited at the four adjacent pixels is named call 4-neighbourhood, the one conformed by the diagonal pixels is the D- neighbourhood and the 8 surrounding pixels is the 8-neighbourhood, the last one includes the 4- and the D-neighbourhood of pixel.

4. Image transformations

The images processing can be seen like a transformation of an image in another, in other words, it obtains a modified image starting from an input image, for improving human perception, or for extraction of information in computer vision. Two kinds of operations can be identified for them:

- Punctual operations. Where each pixel of the output image only depends of the value of a pixel in the input image.
- Grouped operations. In those that each pixel of the output image depends on multiple pixels in the input image, these operations can be local if they depend on the pixels that constitute its neighbourhood, or global if they depend on the whole image or they are applied globally about the values of intensity of the original image.

4.1 Punctual operations

The punctual operations transform an input image *I*, in a new output image *I'* modifying a pixel at the same time without take in account the neighbours pixels value, applying a function *f* to each one of the pixels of the image, so that:

$$I' = f(I) \tag{4}$$

The *f* functions most commonly used are, the identity, the negative, the threshold or binarization and the combinations of these. For all operations the pixels *q* of the new image *I'* depends of value of pixels *p* at the original *I* images.

4.1.1 The identity function

This is the most basic function and generates an output image that is a copy of the input image, this function this defined as:

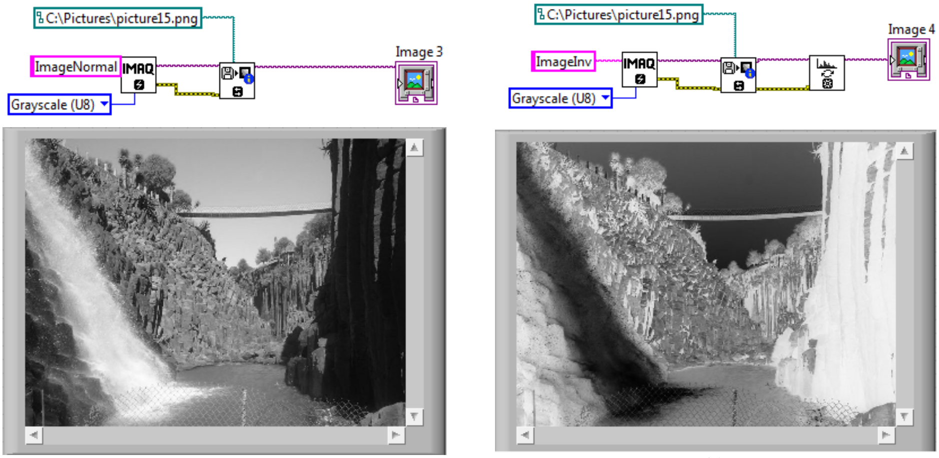
$$q = p \tag{5}$$

4.1.2 The negative function

This function creates a new image that is the inverse of the input image, like the negative of a photo, this function is useful with images generates by absorption of radiation, that is the case of medical image processing. For a gray scale image with values from 0 to 255, this function is defined as:

$$q = 255 - p \tag{6}$$

In Fig. 6 is shown how to inverse the image using the toolbox of Vision and Motion of LabView. As it is observed in Fig. 6 b), the block that carry out the inverse of the image is called IMAQ inverse located in Vision and Motion/Vision Processing/Processing. This block only receives the source image and automatically performed the inverse of the image.



a) b)

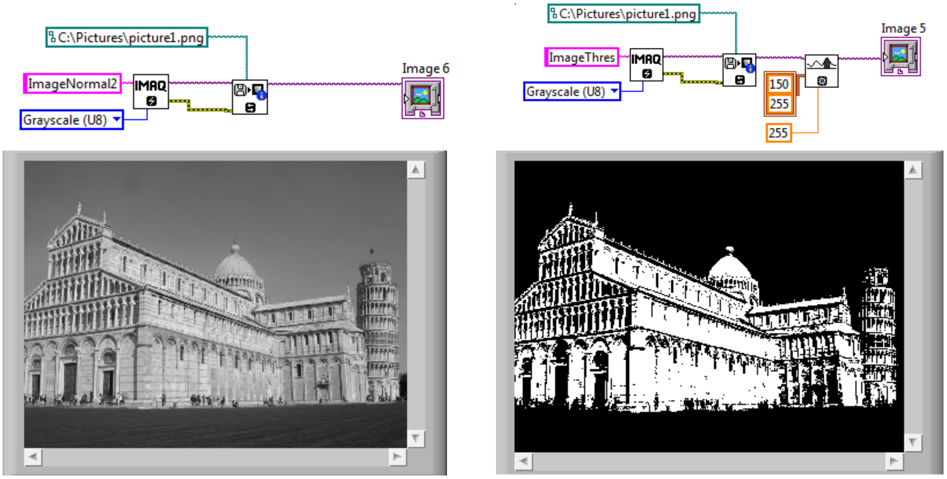
Fig. 6. a) Gray scale image and b) Inverse grayscale image.

4.1.3 The threshold function

This function generates a binary output image from a gray scale input image; the transition level is given by the threshold value *t*, this function this defined as:

$$q = \begin{cases} 0 \quad if \quad p \le t \\ 255 \quad if \quad p > t \end{cases} \tag{7}$$

Fig. 7 b) shows the result of applying the threshold function to image in Fig. 7 a) with a *t* value of 150.



a) b)

Fig. 7. a) Original Image and b) Thresholding Image (150-255).

A variation of threshold function is the gray level reduction function, in this case, some values of threshold are used, and the number of gray levels at the output image is reduced as is shown in (8)

$$q = \begin{cases} 0 & if \quad p \le t_1 \\ q_1 & if \quad t_1 < p \le t_2 \\ q_2 & if \quad t_2 < p \le t_3 \\ \vdots & \vdots \quad\quad \vdots \\ q_n & if \quad t_{n-1} < p \le 255 \end{cases} \tag{8}$$

4.2 Grouped operations

The grouped operations correspond to operations that take in consideration a group of points. In the punctual operations, a pixel *q* of the output image, depends only of a pixel *p* of the input image, however in grouped operations, the result of each pixel *q* in the image *I'* depends on a group of values in the image *I*, usually given by a neighbourhood.

So, if an 8-neighbourhoodis considered, a weighted sum must be done with the 8 neighbours of the corresponding pixel *p* and the result will be assigned to the pixel *q*.

To define the values of weight, different masks or kernels are generally used with constant values; the values of these masks determine the final result of the output image. For example if the mask is done as:

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 1 & 2 \\ -3 & 0 & 3 \end{bmatrix} \tag{9}$$

The value of the pixel *q* in the position *x,y* will be:

$$\begin{array}{rcccccc} & (-1 * p(x-1,y-1)) & + & (0 * p(x,y-1)) & + & (1 * p(x+1,y-1)) \\ q(x,y) = + & (-2 * p(x-1,y)) & + & (1 * p(x,y)) & + & (2 * p(x+1,y)) \\ + & (-3 * p(x-1,y+1)) & + & (0 * p(x,y+1)) & + & (3 * p(x+1,y+1)) \end{array} \tag{10}$$

Since the pixels at border of input image does not have 8 neighbours, the output image *I'* is smaller that the original image *I*.

Inside of grouped operations, a special mention must be done about the image filter. Similar to one-dimensional signal filters, two kinds of filters could be depicted: the high-pass filter and the low-pass filter. They let to pass the high or low frequencies respectively. In the case of the images, the high frequencies are associated to abrupt changes in the intensity of neighbouring pixels, and low frequencies are associated to small changes in the intensity of the same pixels.

A classic mask for a high-pass filter is done by (11):

$$High - pass \equiv \begin{bmatrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{bmatrix} \tag{11}$$

In the same way a low-pass filter is done by (12):

$$Low-pass \equiv \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix} \tag{12}$$

5. Image histogram

The histogram is a graph that contains the number of pixels in an image at different intensity value. In a 8-bit greyscale image a histogram will graphically display 256 numbers showing the distribution of pixels versus the greyscale values as is shown Fig. 8.

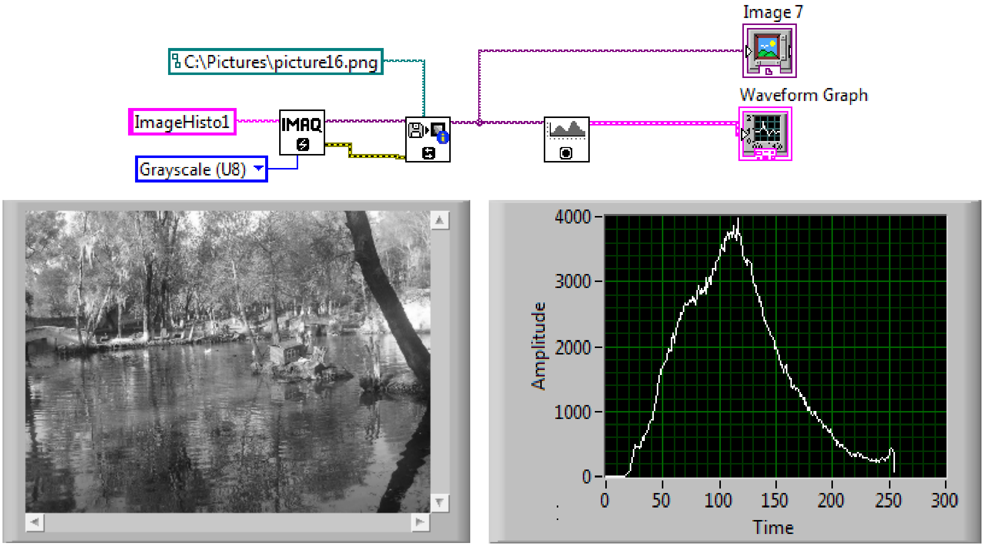


Fig. 8. Histogram Grayscale Image.

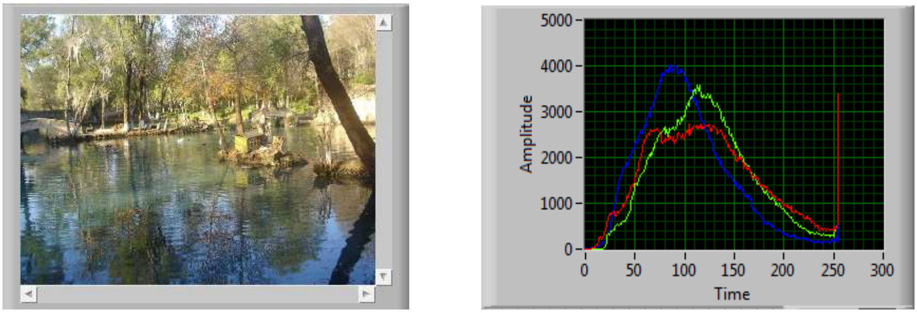


Fig. 9. Histogram RGB Image.

Fig. 8 and Fig. 9 shows the results of the greyscale histogram and RGB histogram using **IMAQ histograph** block located in Image Processing/Analysis. The output of the **IMAQ**

Read Image Block is connected to the input of the **IMAQ histograph** block and then a waveform graph is connected in order to show obtained results.

6. Image segmentation

Prewitt Edge Detector: The prewitt operator has a 3x3 mask and deals better with the noise effect. An approach using the masks of size 3x3 is given by considering the below arrangement of pixels about the pixel *(x , y). In Fig. 10 is shown an example of the Prewitt Edge Detector.*

$$Gx = \left(a_2 + ca_3 + a_4\right) - \left(a_0 + ca_7 + a_6\right) \tag{13}$$

$$Gy = \left(a_6 + ca_s + a_4\right) - \left(a_0 + ca_1 + a_2\right) \tag{14}$$

$$Gx = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \quad Gy = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \tag{15}$$

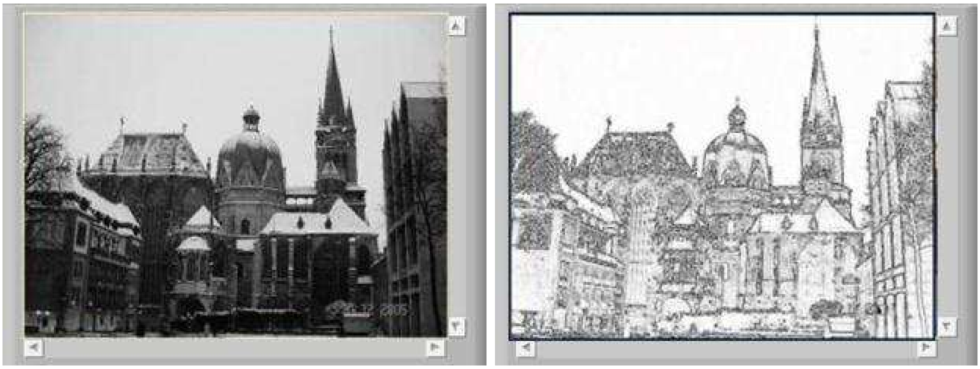


Fig. 10. Prewitt Edge Detector. (a) Grayscale image, (b) Prewitt Transformation.

Sobel Edge Detector: The partial derivatives of the Sobel operator are calculated as

$$Gx = \left(a_2 + 2a_3 + a_4\right) - \left(a_0 + 2a_7 + a_6\right) \tag{16}$$

$$Gx = \left(a_6 + 2a_s + a_4\right) - \left(a_0 + 2a_1 + a_2\right) \tag{17}$$

Therefore the Sobel masks are

$$Gx = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad Gy = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{18}$$

In Fig. 11 and Fig. 12 is shown the image transformation using the Sobel Edge Detector.

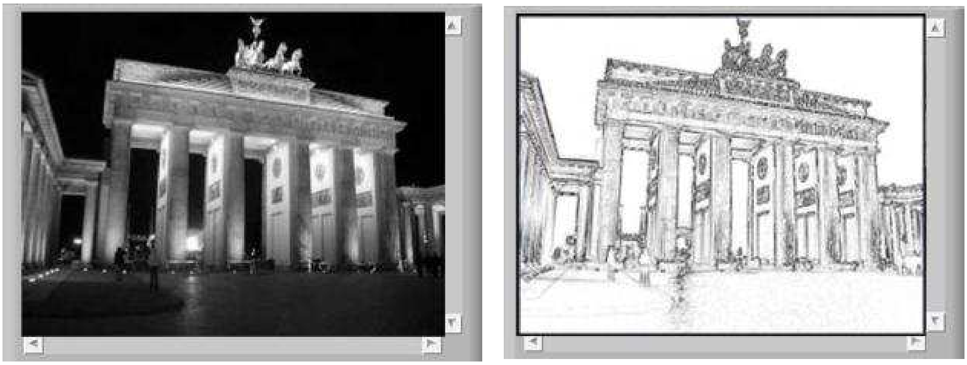


Fig. 11. Sobel Edge Detector. (a) Grayscale image, (b) Sobel Transformation.

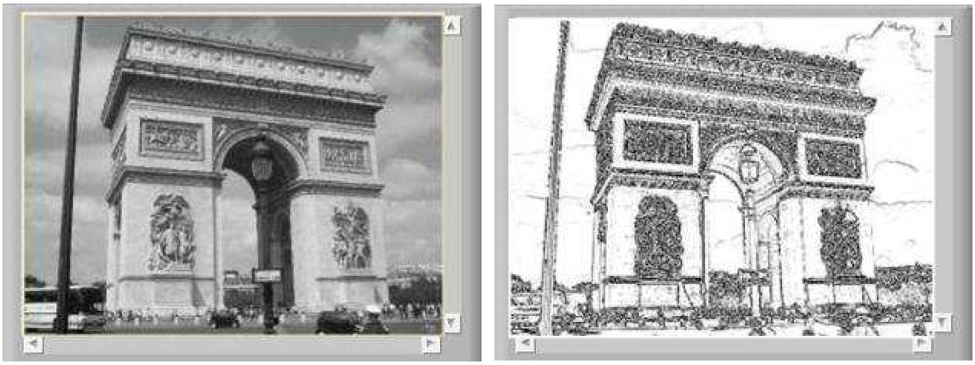


Fig. 12. Sobel Edge Detector. (a) Grayscale image, (b) Sobel Transformation.

7. Smoothing filters

The process of the smoothing filters is carried out moving the filter mask from point to point in an image; this process is known like convolution. Filter a *M*x*N* image with an averaging filter of size *m*x*n* is given by:

$$h(x,y)=\frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b}d(s,t)f(x+s,y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b}d(s,t)} \tag{19}$$

In Fig. 13 is shown a block diagram of a smoothing filter. Although IMAQ vision libraries contain the convolution blocks, this function is presented in order to explain in detail the operation of the smoothing filter. The idea is simple, there is a kernel matrix of *m*x*n* dimension, these elements are multiplied by the each element of a sub-matrix (mxn) contained in the image of *M*x*N* elements. Once the multiplication is done, all the elements are summed and divided by the number of elements in the kernel matrix. The result is saved in a new matrix, and the kernel window is moved to another position in the image to carry out a new operation.

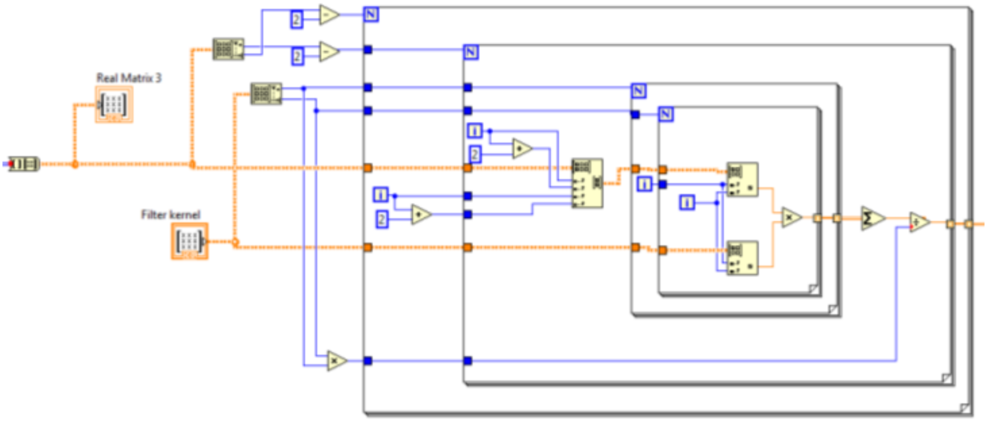
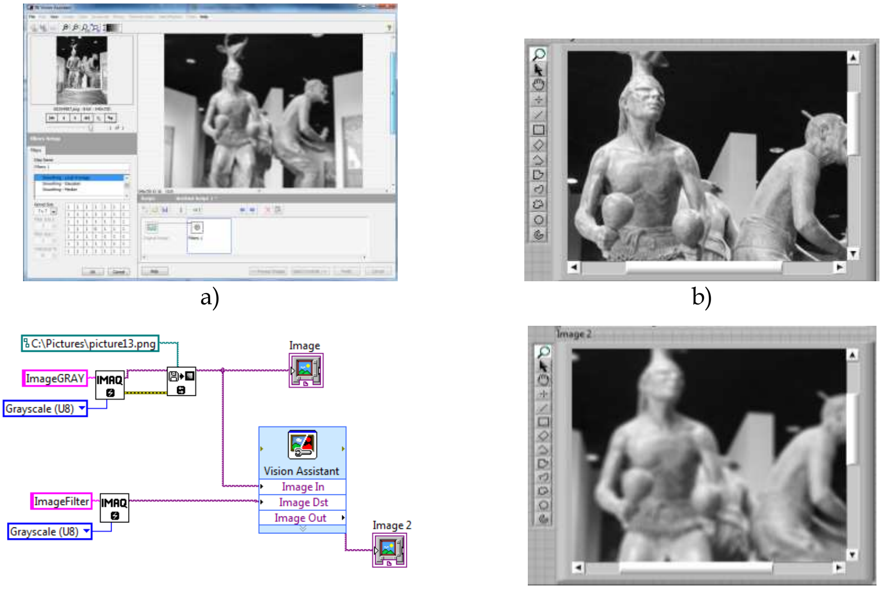


Fig. 13. Block diagram of a Smoothing Filter.

Fig. 14 shows the implementation of smoothing filters using the **Vision Assistant Block**. The image was opened using the **IMAQ Read Image block** and after this was connected to the **Image In** of the Vision Assistance Block. Inside the vision assistant block in the Processing Function Grayscale was chosen the Filters option. In the example of Fig. 14 the filter selected was the **Local Average filter** with a kernel size of 7x7.
In Fig. 14 (d) is observed the effect of the average filter in the image. In this case the resultant image was blurred because the average filters.



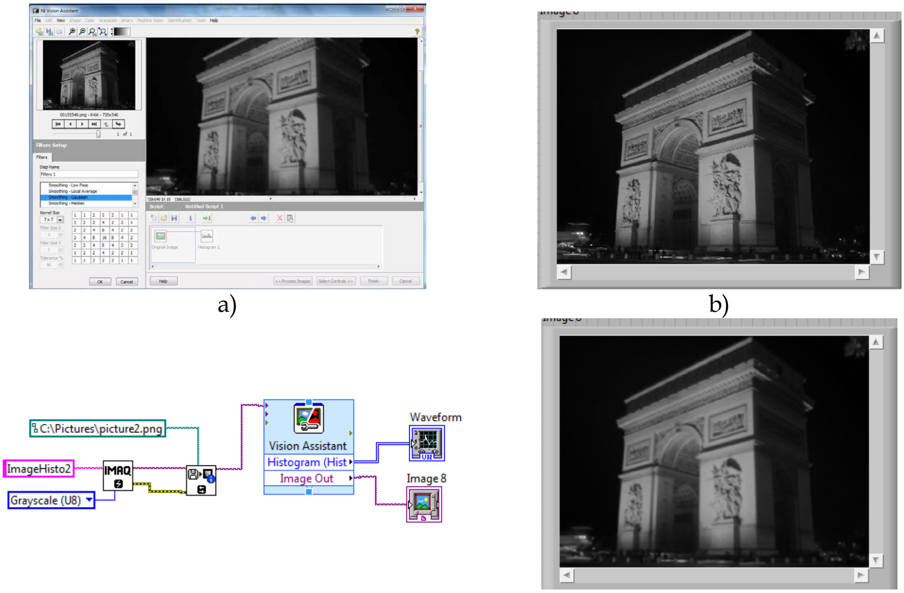
a)

b)

c)

d)

Fig. 14. Local Average Filter, a) Vision Express, b) Original Image, c) block diagram, d) smoothed image.



a) b) c) d)

Fig. 15. Gaussian Filter, a) Vision Express, b) Original Image, c) block diagram, d) smoothed image.

8. Pattern recognition

Pattern recognition is a common technique that can be applied for the detection and recognition of objects. The idea is really simple and consists into find an image according a template image. The algorithm not only searches the exact apparition of the image but also finds a certain grade of variation respect to the pattern. The simplest method is the template matching and it is expressed in the following way:

An image *A* (size (*W*x*H*) and image *P* (size *w*x*h*), is the result of the image *M* (size (*W*-*w*+1)x(*H*-*h*+1)), where each pixel *M*(*x*,*y*) indicates the probability that the rectangle *[x,y]*-*[x+w-1,y+h-1]* of *A* contains the Pattern.

The image *M* is defined by the difference function between the segments of the image:

$$M(x,y)=\sum_{a=0}^{w}\sum_{b=0}^{h}\left(P(a,b)-A(x+a,y+b)\right)^{2} \tag{20}$$

In the literature are found different projects using the template matching technique to solve different problems. Goshtasby presented an invariant template matching using normalized invariant moments, the technique is based on the idea of two-stage template matching (Goshtasby, 2009). Denning studied a model for a real-time intrusion-detection expert system capable of detecting break-ins, penetrations, and other forms of computer(Denning, 2006). Seong-Min presents a paper about the development of vision based automatic inspection system of welded nuts on support hinge used to support the trunk lid of a car(Seong-Min, Young-Choon, & Lee, 2006). Izák introduces an application in image analysis of biomedical images using matching template (Izak & Hrianka).

8.1 Pattern recognition example

In the next example, a pattern recognition system is presented. In Fig. 16 shows the block diagram of the video acquisition and the pattern recognition system. A continuous acquisition from the webcam with inline processing was used, therefore there is a while loop inside the blocks of video acquisition and pattern recognition system. One important parameter is to transform the format of the image in the acquired video into intensity values. One of the methodologies to change RGB values to intensity values is through **IMAQ extract single color plane** located in vision utilities/color utilities/. Once the image has been converted into intensity, this image will be the input for the pattern recognition function.

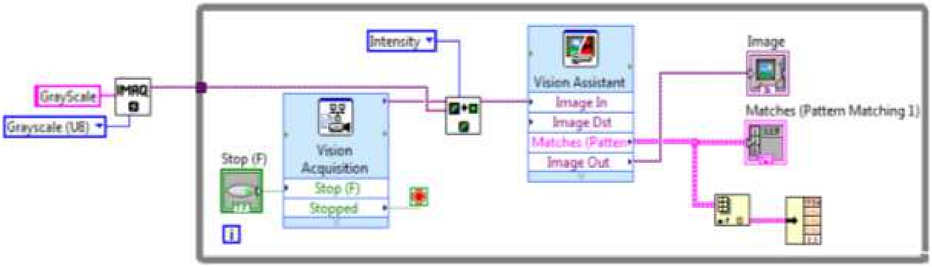
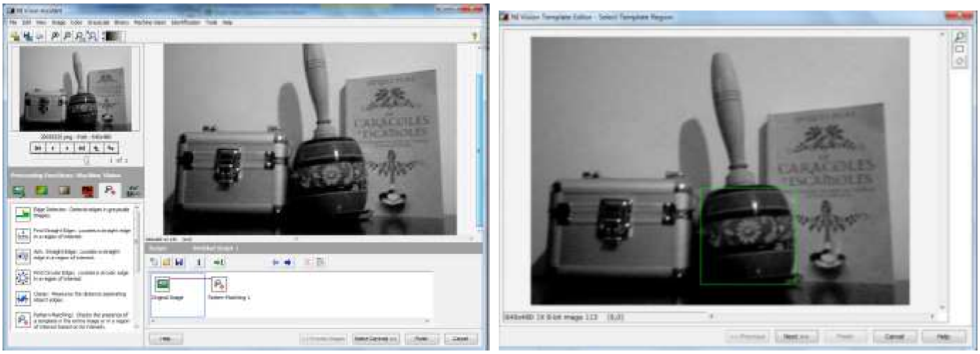


Fig. 16. Block Diagram of Pattern Recognition System.

The vision Assistant was used for the pattern recognition section. A machine vision located in processing function option was selected (Fig. 17 a). The next step is to create a new template clicking in the option new template and select in a box a desired image that will be the object that the algorithm will try to find (Fig. 17 b).



a) b)

Fig. 17. a) Selection of pattern matching, b) creation of new template.

In the last step of the configuration the vision assistant carries out the pattern matching algorithm and identifies the desired object in the whole (Fig. 18 a). Finally when the program is executed in real-time, each frame of the camera identifies the desired object in the scene (Fig. 18 b).

It is important to remark that in order to obtain the output parameters of the recognized matches, it must be selected the checking box Matches inside the control parameters. The output matches is a cluster that contains different information. In order to acquire certain parameters of the cluster is necessary to place an index array block and the unbundle block located in programming/cluster.

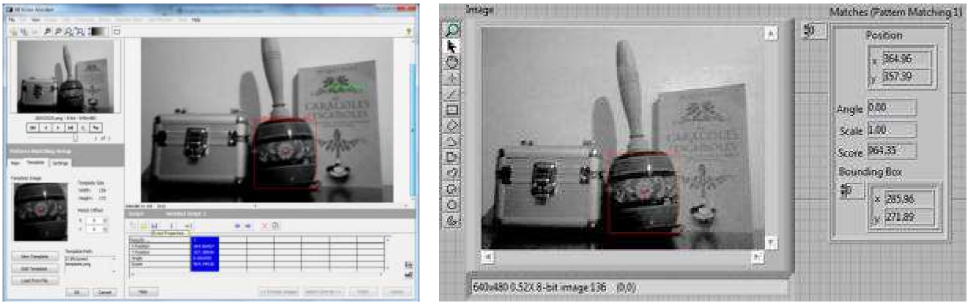


Image
Matches (Pattern Matching 1)
640x480 0.52X 8-bit image 136 (0,0)

Position
x 364.96
y 357.39
Angle 0.00
Scale 1.00
Score 964.35
Bounding Box
x 285.96
y 271.89

a) b)

Fig. 18. a) Recognition of the template in the whole image, b) real-time recognition.

8.2 Machine vision used in a mobile robot

In this section is presented the integration of machine vision algorithms in a mobile robot. This example uses a mobile robot with differential drive and with a robotic gripper mounted in its surface. The principal task of this mobile robot is to recognize objects in the scene through a webcam, when an object is recognized the robot moves through the recognized object and the gripper grasps it. This simple technique produces a kind of artificial intelligence in the system, generating that the robot can know its environment and make decisions according to the circumstances of this environment. This robot can be operated in manual and automatic form. In the manual way a joystick controls all the movements of the robot and in automatic way the digital image processing algorithms obtain information to make decision about the motion of the robot.

A mobile robot with two fixed wheels is one of the simplest mobile robots. This robot rotates around a point normally placed between the two driving wheels. This point is called instantaneous center of curvature (ICC). In order to control this kind of robot, the velocities of the two wheels must be changed producing a movement in the instantaneous center of rotation and different trajectories will be obtained.

In the literature are found different researches about mobile robots using differential drive. Greenwald present an article about robotics using a differential drive control (Greenwald & Jkopena, 2003). Chitsaz presents a method to compute the shortest path for a differential-drive mobile robot(Chitsaz & La Valle, 2006). The odometry is an important topic in mobile robotic,in this field Papadopoulus provides a simple and cheap calibration method to improve the odometry accuracy and to present an alternative method (Papadopoulos & Misailidis, 2008). In the field of control Dongkyoung proposes”a tracking control method for differential-drive wheeled mobile robots with nonholonomic constraints by using a backstepping-like feedback linearization (Dongkyoung, 2003).

The left and right wheels generates a specific trajectories around the ICC with the same angular rate $\omega = \frac{d\vartheta}{dt}$.

$$\omega * R = V_c \tag{21}$$

$$\omega * \left(R - \frac{D}{2} \right) = v_1 \tag{22}$$

$$\omega * \left(R - \frac{D}{2} \right) = v_2 \tag{23}$$

Where v_1 and v_2 are the wheel's velocities, R is the distance from ICC to the midpoint between the two wheels.

$$R = \frac{v_2 + v_1}{v_2 - v_1} * \frac{D}{2} \tag{24}$$

$$\omega = \frac{v_2 - v_1}{D} \tag{25}$$

The velocity in the C Point is the midpoint between the two wheels and can be calculated as the average of the two velocities

$$Vc = \frac{v_1 + v_2}{2} \tag{26}$$

According to these equations if $v_1 = v_2$ the robot will move in a straight line. In the case of different values in the velocities of the motors, the mobile robot will follow a curved trajectory.
Brief description of the system: A picture of the mobile robot is shown in Fig. 19. The mobile robot is dived in five important groups: the mechanical platform, the grasping system, the vision system, the digital control system and power electronics system.

- In mechanical platform were mounted 2 DC motors, each one of the motors has a high torque and a speed of 80 RPMs. Obtaining with these two parameters a high torque and acceptable speed of the mobile robot.
- The grasping system is a mechatronic device with 2 DOF of linear displacements, there are two servos with a torque of 3.6 kg-cm and speed of 100 RPMs.
- The Microsoft webcam Vx-1000 was used for the Vision System section. This webcam offers high-quality images and good stability.
- The digital control system consists in a Microcontroller Microchip PIC18F4431. The velocity of the motors are controlled by Pulse Wide Modulation, therefore, this microcontroller model is important because contains 8 PWMs in hardware and 2 in software (CCP). Moreover, all the sensors of the mobile robot (encoders, pots, force sensors, etc.) are connected to the analog and digital inputs. The interface with the computer is based on the protocol RS232.
- The power electronic system is carried out by 2 H-Bridges model L298. The H-Bridge regulates the output voltage according to the Pulse Wide Modulation input. The motors are connected to this device and the velocity is controlled by the PWM of the microcontroller.

The core of the system remains in the fusion of the computer-microcontroller interface and the vision system. On one hand, the computer-microcontroller interface consists in the serial communication between these two devices, therefore it is important to review how a serial communication can be carried out using LabView. In the other hand, the vision consists in the pattern matching algorithm which find the template of a desired object in an acquired image.

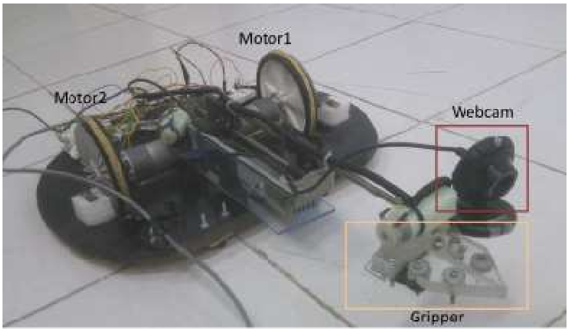


Fig. 19. Mobile Robot.

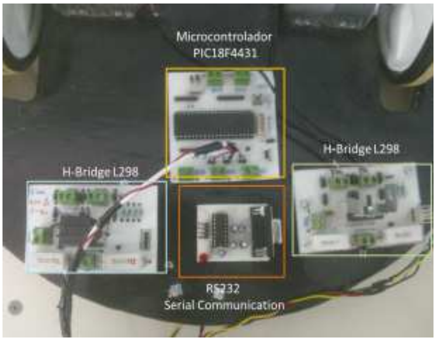


Fig. 20. Electronics Targets.

Fig. 21 presents an example about RS232 communication (write mode). There is an important block for serial communication called VISA configure serial port located in Instrument IO/Serial/. In this block is necessary to place the correct information about the COM, the baudrate, data bits, parity, etc. For this example COM4 was used, with a baudrate of 9600, 8 bits of data and none parity. A timed loop structure was selected to write information in determined time, in this case the timed loop was configured in a period of 50msec. It is important to remark that the data in serial communication is transmitted like string of characters, therefore it is important to convert any numerical value in a string value. The block used for this task is: numeric to decimal string, located in programming/string/string conversion/, this block convert a decimal number into a string and contains two input parameters, the first one is the decimal number to be converted and the second one is the width of this decimal number, all the string conversion outputs are concatenated using the concatenate string block and this information is sent to the write buffer input of the VISA write block. The VISA write block is the responsible to write the string information in the specified serial port. Normally a termination character is very important in the serial communication, in this case it was used the termination character \r. The block VISA property node is the responsible to add a termination character. In this block must be chosen the option TermChar, TermChar En and ASRL End Out. For this example was written 13 in Termchar that corresponds to \r, the TermChar En was activated with a True value and in ASRL end Out was chosen the TermChar option.

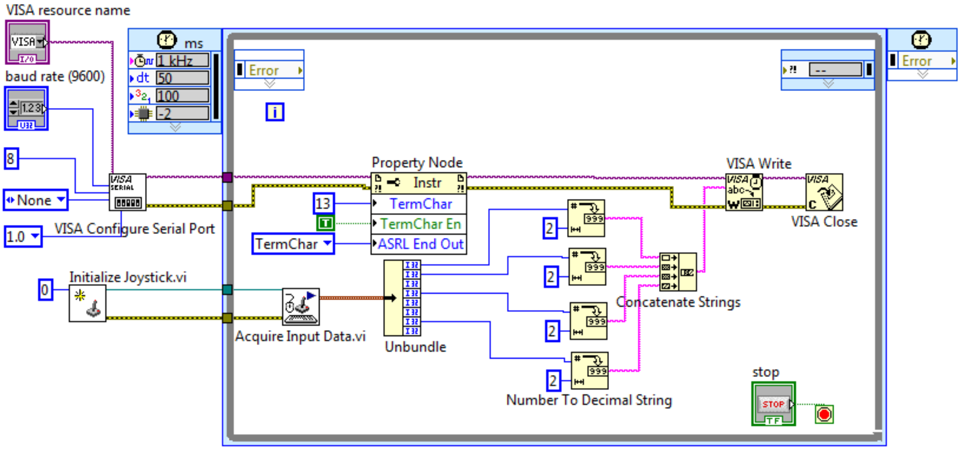


Fig. 21. Serial Communication and Joystick configuration/control.

The mobile robot can work in automatic and manual way, in the manual way the mobile robot can be manipulated through a joystick. The configuration of the joystick is a simple task, there is a block called Initialized Joystick located in connectivity/input device control/. This block needs the index parameter, in this case there is only one joystick connected and the index is 0. Once the joystick is configured, the second step is to acquire the data through the block Acquired Input Data. In data is presented in a cluster format. Therefore an unbundle block is necessary to obtain the parameters in an individual form.

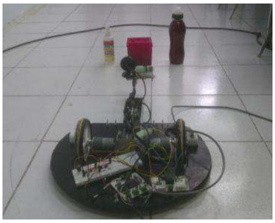


Fig. 22. Mobile robot observing the scene.

The aim of the mobile robot is to recognize a specific object for the environment using machine vision. In order to do this task, a specific object was selected like the pattern image (in this case was the red box Fig. 23) using the Vision Assistant toolbox. Once the pattern image was selected, the algorithm can identify the location of the box in real-time. Fig. 22 shows the mobile robot observing the environment and looking for the desired object. The searching algorithms are inside the microcontroller, if the pattern matching does not recognize any match, the robot moves in different position until a match is recognized. Once the match is recognized the algorithms gives the x,y position of the match in the image. This position is important because the robot will try to center the gripper according to the x,y position of the desired object. There is an infrared sensor that obtains the distance from the gripper to the desired object and the microcontroller moves the gripper to the correct position and grasps the object.

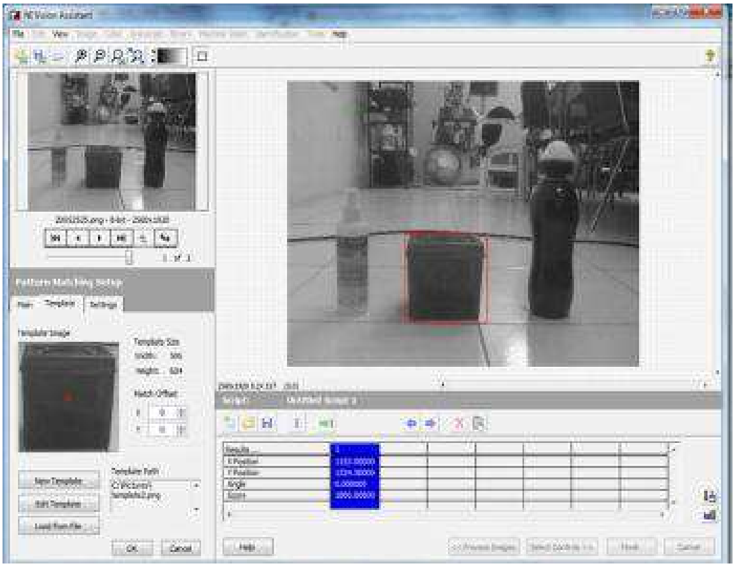


Fig. 23. Pattern Matching configuration.

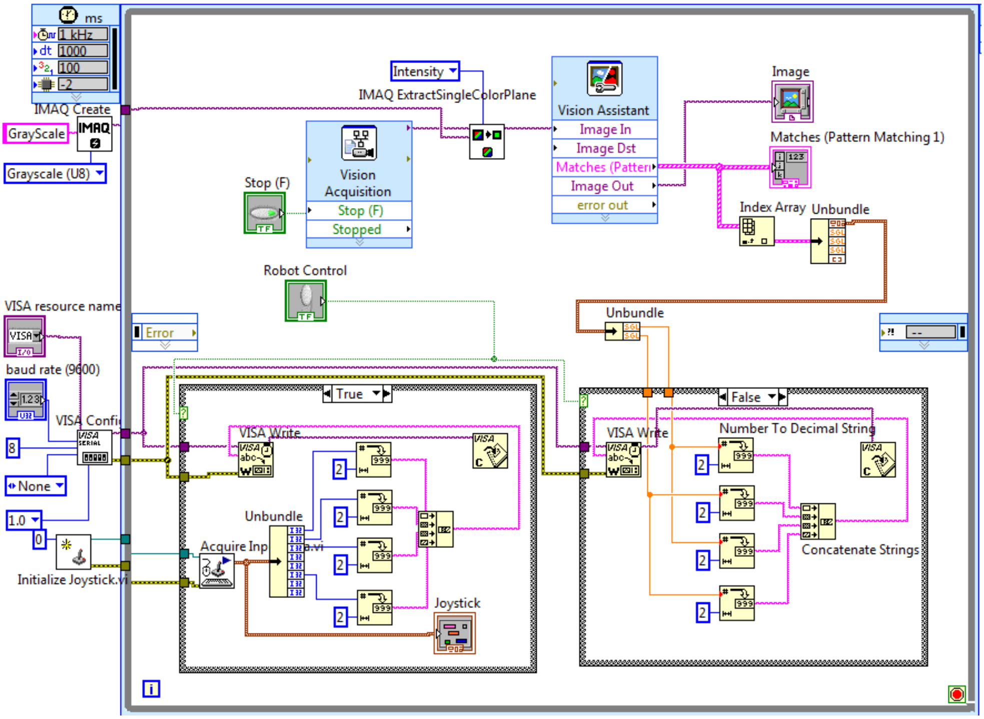
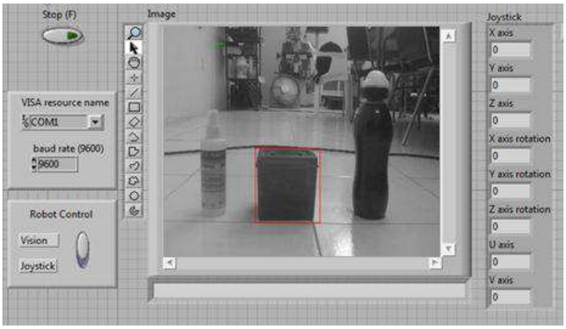


Fig. 24. Block Diagram of the Mobile Robot System.

Fig. 24 shows the complete block diagram of the mobile robot, there is a timed loop where the joystick and serial transmission are performed in a specific interval of time in the same time the vision algorithms are carried out in the same loop. Moreover, there is a selector to switch from manual to automatic control. In the automatic way, the coordinates of the match are sent to the microcontroller and this device runs special routines to orientate the robot in a correct position. In the manual way, the control is carried out by the user using a joystick.



VISA resource name
COM1
baud rate (9600)
9600

Joystick
X axis
0
Y axis
0
Z axis
0
X axis rotation
0
Y axis rotation
0
Z axis rotation
0
U axis
0
V axis
0

Fig. 25. Front Panel of the Mobile Robot System.

Fig. 25 shows the results of the pattern recognition algorithm, the robot was capable to observe its environment and recognize the desired object. This final project presents the integration of different algorithms that were presented and explained in previous sections of this chapter. The block diagram presents the initial configuration of the joystick and the serial port using the Initialize joystick block and the VISA configuration block. In the timed loop is executed the vision algorithms for the object recognition and the serial data transmission using the joystick or using automatic form. In the automatic form the microcontroller receives the x-y position of the object and the carries out all the algorithms of path planning inside the microcontroller to arrive to this object and grasp it.

9. Conclusions

Different basis techniques of digital image processing using LabView have been boarded in this chapter. At the beginning some theoretical concepts about the image generation were discussed for standing out the effects of illumination, scene and acquisition system in the results of image processing.

Then the stages of a classic system of image processing were described as well as the necessary tools of the LabView platform to achieve each stage, from the acquisition of the image to a control of a mobile using the image matching template. The image transformation leave to know how the output image is generated from an input image with the use of punctual and grouped operations, some examples were presented of most comment image transformations.

Finally the pattern recognition section shows how to use an image into a computer vision application, through an example of object detection and the use of other functionalities of LabView suggest that the use of LabView as an excellent platform to develop robotic projects as well as vision and image processing applications. The versatility provided by the software LabView and the capability of IMAQ toolbox increase the possibility to improve the use of digital image processing in any application area.

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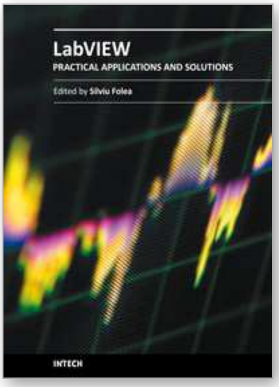

Practical Applications and Solutions Using LabVIEW™ Software
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The book consists of 21 chapters which present interesting applications implemented using the LabVIEW environment, belonging to several distinct fields such as engineering, fault diagnosis, medicine, remote access laboratory, internet communications, chemistry, physics, etc. The virtual instruments designed and implemented in LabVIEW provide the advantages of being more intuitive, of reducing the implementation time and of being portable. The audience for this book includes PhD students, researchers, engineers and professionals who are interested in finding out new tools developed using LabVIEW. Some chapters present interesting ideas and very detailed solutions which offer the immediate possibility of making fast innovations and of generating better products for the market. The effort made by all the scientists who contributed to editing this book was significant and as a result new and viable applications were presented.

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