

Application of Image Processing on DSP TMS320C6713

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Abstract: *Face detection is a very challenging and interesting problem. In this paper, we discussed an application for automatic face detection and tracking on video streams from surveillance cameras in public or commercial places. In many situations it is useful to detect where the people are looking for, e.g. in exhibits, commercial malls, and public places in buildings. So prototype is designed to work with cameras for the face detection and tracking system based on the platforms CCS and OpenCV. The system is based on Haar Cascade Classifier. This system can be used for security purpose to record the visitor face as well as to detect and track the face. A program is developed using OpenCV that can detect people's face and also track from the camera.*

Keywords: TMS320C6713, Code Composer Studio.

1. Introduction

The goal of this article is to provide an easier human-machine interaction to perform certain image processing applications.

Enhancement of the image is necessary to improve the visibility of the image subjectively to remove unwanted flickering, to improve contrast and to find more details. In general there are two major approaches. They are spatial domain, where statistics of grey values of the image are manipulated and the second is frequency domain approach; where spatial frequency contents of the image are manipulated. In spatial domain Histogram Equalization, Principal Component Analysis, Rank Order Filtering, Homomorphism Filtering etc. are generally used to enhance the image. Although these techniques are developed for gray valued images but few of them are also applied to color image for enhancement purpose.

2. Related Work

Image Fusion is a framework where a composite image can be produced, that contains enhanced or simply better information about the target or scene compared to individual source images. Image Fusion had its beginning with the concept of simply averaging the intensities of the corresponding pixels of the set of input images, thus producing a fused image. A lot of advancements have happened in the field of image fusion since then employing advanced methods like Discrete Wavelet Transforms and Pyramidal Methods to fuse images.

Multi-sensor data fusion has become a discipline to which more and more general formal solutions to a number of application cases are demanded. Several situations in image processing simultaneously require high spatial and high spectral information in a single image; especially in the field of remote sensing. However, the instruments are not capable

of providing such information either by design or because of observational constraints. One possible solution for this is data fusion. Image Fusion techniques, though initially developed as an image quality enhancement technique, finds practical application in medical field and satellite imaging.

The concept of multivariate image fusion now promotes research into fusing simple optical images, medical images and satellite images ranging through the multi spectra. For example, in satellite imaging, two types of images are available. Panchromatic image acquired by satellites is transmitted with the maximum resolution available and the multispectral data are transmitted with coarser resolution. This will be usually, two or four times lower. At the receiver station, the panchromatic image is merged with the multispectral data to convey more information. Many methods exist to perform image fusion. The very basic one is the high pass filtering technique. Later techniques are based on DWT, uniform rational filter bank, and pyramidal methods. Image fusion methods can be broadly classified into two - spatial domain fusion and transform domain fusion.

The fusion methods such as averaging method, Brovey method, principal component analysis (PCA) and high pass filtering based technique are examples of spatial domain fusion methods. Here the high frequency details are injected into up sampled version of MS images.

The disadvantage of spatial domain approaches is that they produce spatial distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing, such as classification problem, of the fused image. The spatial distortion can be very well handled by transform domain approaches on image fusion. The multi-resolution analysis has become a very useful tool for analyzing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. Some other fusion methods are also there, such as pyramid based, curvelet transform based etc. These methods show a better

performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion.

3. Description of Tools

In this section the tools and methodology to implement and evaluate face detection and tracking using OpenCV are detailed.

3.1. OpenCV

OpenCV (Open Source Computer Vision Library) is a library of programming functions mainly aimed at real time computer vision, developed by Intel and now supported by Willow Garage [5]. It is free for use under the open source BSD license. The library is cross-platform. It focuses mainly on real-time image processing. If the library finds Intel's Integrated Performance Primitives on the system [6], it will use these proprietary optimized routines to accelerate it. The library was originally written in C and this C interface makes OpenCV portable to some specific platforms such as digital signal processors. Wrappers for languages such as C#, Python, Ruby and Java (using JavaCV) have been developed to encourage adoption by a wider audience [3]. However, since version 2.0, OpenCV includes both its traditional C interface as well as a new C++ interface. This new interface seeks to reduce the number of lines of code necessary to code up vision functionality as well as reduce common programming errors such as memory leaks (through automatic data allocation and de-allocation) that can arise when using OpenCV in C[9].

3.2 Code Composer Studio

Code Composer Studio (CCS) is the integrated development environment (IDE) provided by Texas Instrument. It is based on the Eclipse framework and therefore requires a Java Runtime Environment (JRE).

3.2.1 System Requirements

To use Code Composer Studio, your operating platform must meet the following minimum requirements:

- Windows XP
- 2GB RAM
- 80GB HDD
- Intel processor

3.3 TMS320C6713 DSK

The Texas Instrument TMS320C6713 Digital Signal Processing Starter Kits are low cost development platforms for real - time digital signal and Image processing applications. It comprises a small circuit board containing a TMS320C6713 floating - point digital signal processor and a TLV320AIC23 analog interface circuit (codec) and connect to a host PC via a USB port. PC software in the form of Code Composer language to be compiled and/or assembled, linked, and downloaded to run on the DSK.

The architecture and instruction set of a DSP are optimized for real - time digital signal processing. In many cases, DSPs

resemble microcontrollers insofar as they provide single chip computer solutions incorporating on board volatile and non-volatile memory and a range of peripheral interfaces and have a small footprint, making them ideal for embedded applications. In addition, DSPs tend to have low power consumption requirements. This attribute has been extremely important in establishing the use of DSPs in cellular handsets.

As may be apparent from the foregoing, the distinctions between DSPs and other, more general purpose, microprocessors are blurred. The C6x notation is used to designate a member of the Texas Instruments (TI) TMS320C6000 family of digital signal processors. The architecture of the C6x digital signal processor is very well suited to numerically intensive calculations. Based on a very - long - instruction - word (VLIW) architecture, the C6x is considered to be TI's most powerful processor family. The TMS C6713 is highly compatible with image processing applications.

The DSK comes with a full complement of on-board devices that suit a wide variety of application environments.

Key features

- A Texas Instruments TMS320C6713 DSP operating at 225 MHz.
- An AIC23 stereo codec
- 16 Mbytes of synchronous DRAM
- 512 Kbytes of non-volatile Flash memory (256 Kbytes usable in default configuration)
- 4 user accessible LEDs and DIP switches
- Software board configuration through registers implemented in CPLD
- Configurable boot options
- Standard expansion connectors for daughter card use
- JTAG emulation through on-board JTAG emulator with USB host

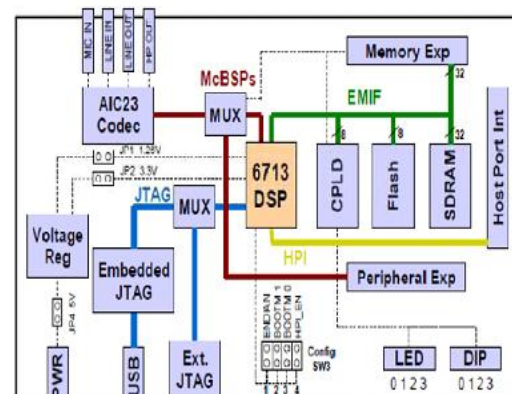


Figure 1: Block Diagram of the C6713 DSK

4. Face Detection

4.1 Image Histogram

An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value. By looking at the histogram for a specific image a viewer will be able to judge the entire tonal distribution at a glance. Image

histograms are present on many modern digital cameras. Photographers can use them as an aid to show the distribution of tones captured, and whether image detail has been lost to blown-out highlights or blacked-out shadows. The horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in that particular tone. The left side of the horizontal axis represents the black and dark areas, the middle represents medium grey and the right hand side represents light and pure white areas. The vertical axis represents the size of the area that is captured in each one of these zones.

4.2 Image Enhancement

Image enhancement problem can be formulated as follows: given an input low quality image and the output high quality image for specific applications. It is well-known that image enhancement as an active topic in medical imaging has received much attention in recent years. The aim is to improve the visual appearance of the image, or to provide a "better" transform representation for future automated image processing, such as analysis, detection, segmentation and recognition. Moreover, it helps analyses background information that is essential to understand object behaviour without requiring expensive human visual inspection. Carrying out image enhancement understanding under low quality image is a challenging problem because of these reasons. Due to low contrast, we cannot clearly extract objects from the dark background. Most color based methods will fail on this matter if the color of the objects and that of the background are similar

4.2.1 Image negative

$image_neg[i] = 255 - image_A[i];$

4.2.2 Image binary

$if(image_A[i] < 128) \quad image_binry[i] = 0;$
 $else \quad image_binry[i] = 255;$

4.2.3 Contrast stretching

Contrast stretching (also called Normalization) attempts to improve an image by stretching the range of intensity values it contains to make full use of possible values. Unlike *histogram equalization*, contrast stretching is restricted to a *linear* mapping of input to output values. The result is less dramatic, but tends to avoid the sometimes artificial appearance of equalized images.

The first step is to determine the limits over which image intensity values will be extended. These lower and upper limits will be called a and b , respectively (for standard 8-bit grayscale pictures, these limits are usually 0 and 255). Next, the histogram of the original image is examined to determine the value limits (lower = c , upper = d) in the unmodified picture.

If the original range covers the full possible set of values, straightforward contrast stretching will achieve nothing, but even then sometimes most of the image data is contained within a restricted range; this restricted range can be stretched linearly, with original values which lie outside the range being set to the appropriate limit of the extended

output range. Then for each pixel, the original value r is mapped to output value s using the function:

$$s = (r - c) \left(\frac{b - a}{d - c} \right) + a$$

(Linear mapping so get equation of a straight line)

4.3 Image Fusion

Nowadays, with the rapid development in high-technology and modern instrumentations, medical imaging has become a vital component of a large number of applications, including diagnosis, research, and treatment. In order to support more accurate clinical information for physicians to deal with medical diagnosis and evaluation, multimodality medical images are needed, such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), and positron emission tomography (PET) images.

These multimodality medical images usually provide complementary and occasionally conflicting information. For example, the CT image can provide dense structures like bones and implants with less distortion, but it cannot detect physiological changes, while the MR image can provide normal and pathological soft tissues information, but it cannot support the bones information. In this case, only one kind of image may not be sufficient to provide accurate clinical requirements for the physicians. Therefore, the fusion of the multimodal medical images is necessary and it has become a promising and very challenging research area in recent years.

Image fusion can be broadly defined as the process of combing multiple input images or some of their features into a single image without the introduction of distortion or loss of information. The aim of image fusion is to integrate complementary as well as redundant information from multiple images to create a fused image output. Therefore, the new image generated should contain a more accurate description of the scene than any of the individual sources images and is more suitable for human visual and machine perception or further image processing and analysis tasks. For medical image fusion, the fusion of images can often lead to additional clinical information not apparent in the separate images.

So far, many techniques for image fusion have been proposed. According to the stage at which the combination mechanism takes place, the image fusion methods can be generally grouped into three categories, namely, pixel level or sensor level, feature level, and decision level.

4.3.1 Image averaging / Mean

$image_avg[i] = (image_A[i] + image_B[i]) / 2 ;$

4.3.2 Weighted Averaging

$image_w_avg[i] = ((0.6 * image_A[i]) + (0.4 * image_B[i])) / 2 ;$

4.3.3 Minimum Criteria

image_min = min(image_A[i],image_B[i]);

4.3.4 Maximum criteria

image_max = max(image_A[i],image_B[i]);

4.4 Edge Detection

Edge information in an image is found by looking at the relationship a pixel has with its neighborhoods. If a pixel's gray-level value is similar to those around it, there is probably not an edge at that point. If a pixel's has neighbors with widely varying gray levels, it may present an edge point. Many are implemented with convolution mask and based on discrete approximations to differential operators. Differential operations measure the rate of change in the image brightness function. Some operators return orientation information. Other only return information about the existence of an edge at each point.

4.4.1 Laplacian

Edge magnitude is approximated in digital images by a convolution sum. The sign of the result (+ or -) from two adjacent pixels provide edge orientation and tells us which side of edge brighter

The Laplacian $L(x,y)$ of an image with pixel intensity values $I(x,y)$ is given by:

$$L(x, y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

0	-1	0
-1	4	-1
0	-1	0

-1	-1	-1
-1	8	-1
-1	-1	-1

4.4.2 Sobel operator

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A \quad \text{and} \quad G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

$$G = \sqrt{G_x^2 + G_y^2}$$

4.5 Transform

1. D C T:

A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.

$$X_k = \frac{1}{2} (x_0 + (-1)^k x_{N-1}) + \sum_{n=1}^{N-2} x_n \cos \left[\frac{\pi}{N-1} nk \right] \quad k = 0, \dots, N-1.$$

2. I D C T:

Using the normalization conventions above, the inverse of DCT-I is DCT-I multiplied by $2/(N-1)$. The inverse of DCT-IV is DCT-IV multiplied by $2/N$. The inverse of DCT-II is DCT-III multiplied by $2/N$ and vice versa

$$X_{k_1, k_2} = \sum_{n_1=0}^{N_1-1} \left(\sum_{n_2=0}^{N_2-1} x_{n_1, n_2} \cos \left[\frac{\pi}{N_2} \left(n_2 + \frac{1}{2} \right) k_2 \right] \right) \cos \left[\frac{\pi}{N_1} \left(n_1 + \frac{1}{2} \right) k_1 \right]$$

$$= \sum_{n_1=0}^{N_1-1} \sum_{n_2=0}^{N_2-1} x_{n_1, n_2} \cos \left[\frac{\pi}{N_1} \left(n_1 + \frac{1}{2} \right) k_1 \right] \cos \left[\frac{\pi}{N_2} \left(n_2 + \frac{1}{2} \right) k_2 \right].$$

5. Experimental Setup

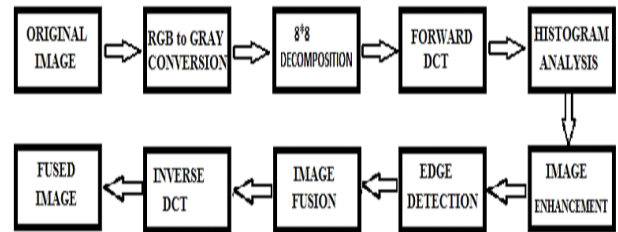


Figure 4: Experimental setup

Above figure 4 shows the working set up of the required model. Here developed algorithm is dumped to the DSP kit using the emulator XDS100v2 and Code Composer Studio. Camera is interfaced with DSP kit which is used to capture the video. The processing takes place in the DSP processor and the face detection output displayed in the monitor. To implement face detection and tracking tools required are:

5.1. Software Required

Code Composer Studio V5, C6000 SYS/BIOS by Texas Instrumentation.

5.2. Hardware Required

PC preferably running windows 7, Texas Instrumentation DSP LCDK kit TMS320C6748, Emulator XDS100v2 and a camera.

6. Results

In this section, the application results of the proposed DCT method for medical image fusion are presented. The performance of the proposed method is compared with those of pixel averaging method, the conventional DCT method with maximum selection rule, DCT method with minimum section rule, and weighted averaging rule. Since image registration is out of scope of this paper, like most of the literatures, in all test cases we assume the source medical images to be in perfect registration. We use the discrete cosine transform with a decomposition level of 1. A 8*8 window size for calculating the variance is considered in this paper, which has been proved to be more effective by many researchers. We have carried out some comparisons on different values of the visual constant and found that the fusion result is insensitive to this parameter. Therefore, the parameter α is chosen to be 0.6 in the project work. The second example is the frequently used normal CT and MR images. The experimental results of the above four method are displayed in Figures, respectively. Compared with the original CT and MR images, it is easy to find that with all the

methods the fused image now contains both the bones information and tissues information, which cannot be seen in the separate CT or MR image. However, after careful manual inspection of Figures, it is indicated that the fused result of the proposed method is the best in the four methods because the information of bones and tissues is clearer than other three methods, while the result of the pixel averaging is the worst because the information of bones and tissues is very blurry or fuzzy. However, the subjective evaluation depends on the expert's experience and some uncertainty is involved because this measure has no rigorous mathematical models and is mainly visual. Considering the drawbacks of the subjective quality evaluation method, quantitative evaluation of the quality of the fused images is thus needed, which will be more objective than the visual inspection. In addition, based on the requirements of fusion algorithm, when we evaluate the performance of the fusion technique, we must pay attention to:

- It should preserve all relevant information of the input images in the fused image (pattern conservation)
- It should minimize any artefacts or inconsistency in the fused image. Only in this case, we can accurately and comprehensively explain which fusion method is more effective.

1. Input Image



Figure 6.1: Input Image

2. Image Enhancement Techniques



Figure 6.2: Negative of the Image



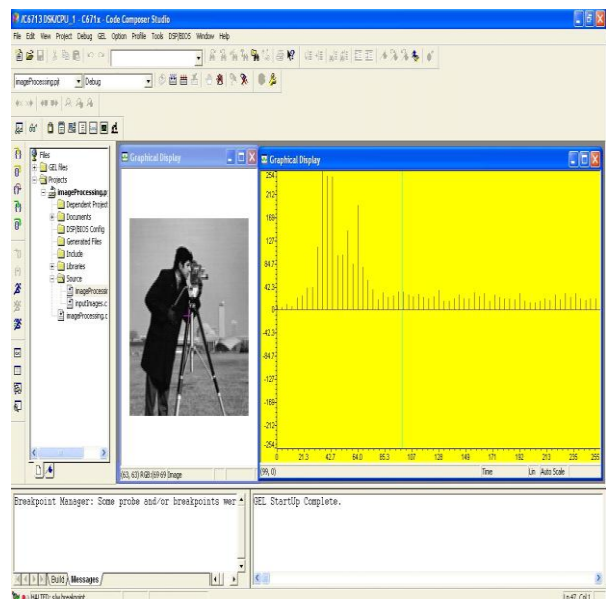
Figure 6.3: Binary Image

3. Contrast Stretching



Figure 6.4: Contrast Stretching of the Image

4. Histogram Plot



7. Conclusion

7.1 Conclusion

We use the histogram to guess the different regions in the images and contrast Enhancement. Like we can see in the examples section, averaging and alpha-blending don't actually provide very good results. Maybe that for some applications this may be enough, but if we think about other examples there will always be one image with poor lighting and thus the quality of an averaged image will obviously decrease. A workaround would be to adapt the parameters of the alpha-blending to the lighting conditions.

7.2 Future Works

The following are some proposed practical advancements possible in the work:

- 1) The present work fused two images of the same scene; it is possible to integrate a larger number of images of the same scene at the different time.
- 2) The fusion theory is inspired by information theoretic concepts with strong foundations in concepts of information complexity. For future improvements in image fusion, the development of hardware along with additional sophisticated software will allow the implementation of algorithms and techniques that require large data volumes and time intensive computations. For example, the involvement of expert systems in a Medical information system (GIS) can support the integration and evaluation of fused data.
- 3) Classification or segmentation medical images to determine the natural extension is also used in several areas, including the physiology, tumours.
- 4) Since the multi-focus image depends on the exact depth of field of the image on three elements (the camera lens aperture, focal length and distance of the objective) can merge two different by of these elements as the picture in different cameras, such as mobile devices.

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