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A Palm-Print Recognition System Based On DM3730

Kamireddy Archana,
Sri Vasavi Engg. College

D.R. Sandeep,
ECE Dept,Sri Vasavi Engg. College

Abstract

This paper presented rapid and effective palm-print Recognition based on DM3730 chip which is multimedia Universal chip. Paper deployed USB camera as a palm-print Images' acquisition equipment, used the ARM + DSP multi-core DM3730 processor technology as palm-print image Recognition processing, and sent the recognition results to the User interface ultimately. Linux Operating System run in the ARM side, DSP/BIOS Operating System service in the DSP side oppositely. This paper's palm-print recognition algorithm based on wavelet reconstruction and local DCT and 2DPCA. And System's software based on DVSDK (Digital Video Software Development Kit) totally. The palm-print recognition algorithm Employed CE (Codec Engine) tools. System can quickly and efficiently identify palm-print.

Keywords—**Palm-print Recognition, Wavelet, 2DPCA, Reconstruction, Local DCT.**

1. Introduction

Compared with fingerprint identification technology, palm-print recognition technology is more difficult and shorter research history. An important issue in palm-print recognition is extraction of palm-print features that can discriminate an individual from another [1]. Compared with other biometric traits, the advantages of palm-prints are the availability of large surface areas of the palm for feature extraction, ease of capture, and higher level of user acceptance [2]. Thought of its complexity, the hardware platform required a high computing power. Therefore, it increases the difficulty of the development of palm-print recognition.

Following the Da Vinci chips DM644x available, Texas Instruments (TI) also launched a series of successive ARM + DSP or ARM + video co-processor, multimedia processor platforms, such as DM643x, DM35x/36x, DM6467, OMAP Lx and so on. They enhanced the overall performance of image processing equipment greatly. In particular, the DM3730 chip that launched recently is such a chip leader. DM3730 processor with 720 MHz ARM ® Cortex ™-A8 core and 520 MHz TMS320C64x + ™ DSP, provide a more comprehensive peripheral interfaces.

Paper has used DM3730 chip as the core, and developed a nice user interface to convenience user to control operations. And to make a secondary development in ARM-side,

2. Palm-Print Recognition Algorithm

First of all, this paper deployed lifting wavelet transform to preprocess palm-print image. The horizontal and diagonal and vertical component of the received image was processed by coefficient threshold processing. Then Lifting Wavelet inverse transform was deployed to enhance reconstruction palm-print image. Pseudo-noise on the main line that caused from the non-planar of the palm has been eliminated, while simplified the computing complexity [3]. However, the palm-print image enhanced by the wavelet reconstruction is very sensitive to noise in certain regions. Based on this, paper deployed the Local DCT for the reconstructed palm-print images, reduced the feature dimension effectively [4], while retained the no-light-sensitive information. Following, paper deployed 2DPCA for the feature extraction [4]. At last, paper had got the results though Nearest Neighbor Classifier.

A. Lifting Wavelet Reconstruction

The traditional wavelet transformation was restricted in the image real-time procession, because of its huge amount of computing. But lifting wavelet transformation has simplified the operation, and retained the multi-resolution characteristics of the traditional wavelet. The basic idea of the lifting wavelet transformation was built on the basic wavelet, and made a more favorable new wavelet. It consisted of following steps: decomposition, prediction and update [5]. In the decomposition step, the data divided into even and odd sequence; in the prediction step, even sequence was deployed to predict odd sequence, and the result of prediction bias was the high frequency component of the transformation; in the update step, the prediction bias was deployed to update the even sequence.

Paper deployed the lifting wavelet transformation for the Palm-print images according to the order of rows and columns Signals. The image was decomposed into four sub-bands, shown in Fig.I. According to wavelet theory, sub-band LL keeps main energy of original image of palm-print, and denotes low-frequency information of the image. Sub-band LH and keep detailed information such as wrinkles, ridges, etc. Subband HH depicts the overall characteristics of the original palm-print image, which is often affected by illumination and the pseudo-principal line that is a result of the arch of the palm-print.

Palm-print image's low-frequency sub-bands were maintained the original palm-print image's main features of the palm-print with appropriate levels of wavelet decomposition. Thought restrained sub-bands HH,L H,HL, paper deployed the lifting wavelet transformation to get the reconstructed image, based on four sub-band images. It can be remove some noise signal information of the image.

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LL	HL
LH	HH

Fig I. Wavelet transformation

For the noise characteristics of each sub-band image, paper preserved parts of the image contour without threshold processing for the sub-band images, and deployed different threshold to process for the different high-frequency sub-band images. From 1 to 2 for each layer, they selected a threshold value. It deployed the non-linear wavelet soft-threshold de-noising processing for each layer's High-frequency co-efficient. In the end, paper used second layer's low frequency coefficients and the first and second layers' high frequency coefficients to reconstruct image.

B. Local DCT (Discrete Cosine Transform)

DCT is a common image data compression method. It has a feature which named energy aggregation. Most of the signal information tends to be concentrated in the low-frequency DCT component, these low-frequency components that have greater magnitude can be used to reconstruct the image.

DCT is DFT (Discrete Fourier Transform)'s special form. If the periodic function is even function, then its Fourier series will contain only the cosine item. If a given sequence was prorogated even symmetry column, its' DFT only contained cosine items.

In the image processing, Fourier Transform was usually deployed to control image noise. The noise often distributed in the high-frequency components. So the component that was less than a certain threshold was taken to zero. Then its anti- DCT transform can be achieved the signal noise suppression. And the DCT does not affect the distance between data points. This means that the DCT does not affect the topology of the Data.

C. 2DPCA (two-dimensional principal component analysis)

After local DCT, the training sample was assumed to be *A Rp c q i M i* , 1,2,..., ∈ ×(+) = . Then paper deployed 2DPCA to obtain projection features of training samples [6]. Training sample's covariance matrix G was defined as

$$G = \frac{1}{M}\sum_{i=1}^{M}(A_i)^T(A_i), G \in R^{(c+q)\times(c+q)}.$$

The solving of covariance matrix's Eigen values and Eigen vectors was

$$U^T G U = \Lambda, \Lambda \in R^{(c+q)\times(c+q)} \quad (1)$$

It expressed diagonal matrix that formed by the Eigen values. U was orthogonal matrix that formed by the eigenvectors, which correspond with eigenvalues. Hypothesis, covariance matrix G's eigenvalues was expressed asλi(i=1, 2, …,c+q), λ1≥λ2≥…≥λ3.The corresponding eigenvector was expressed as ui (i=1, 2, …, c+q), then

$$\Lambda = \begin{bmatrix} \lambda_1 & & & \\ & \lambda_2 & & 0 \\ 0 & & O & \\ & & & \lambda_{c+q} \end{bmatrix},$$

$$U = \begin{bmatrix} u_1 & u_2 & \cdots & u_{c+q} \end{bmatrix}.$$

A Paper choose the eigenvectors ui (i=1, 2, …, d) (d≤c+q), that corresponded former larger d eigenvalues to construct feature vector subspace, then

$$\Lambda_d = \begin{bmatrix} \lambda_1 & & & \\ & \lambda_2 & & 0 \\ 0 & & O & \\ & & & \lambda_d \end{bmatrix},$$

$$U_d = \begin{bmatrix} u_1 & u_2 & \cdots & u_d \end{bmatrix}, \quad U_d \in R^{(c+q)\times d}.$$

paper calculated the main element training samples. That was Yd=AiUd,i=1, 2, …, M. In the formula, $Y_d \in R^{p\times d}$

It was named training samples' projective features, expressed as $Y_d = \begin{bmatrix} y_1 & y_2 & \cdots & y_d \end{bmatrix}$. Random projective feature of test samples was expressed as

$$Y_d' = \begin{bmatrix} y_1' & y_2' & \cdots & y_d' \end{bmatrix}$$

Projective feature of training samples was expressed as $Y_d = \begin{bmatrix} y_1 & y_2 & \cdots & y_d \end{bmatrix}$, So its Euclidean distance was

$$D(Y_d', Y_d) = \sum_{k=1}^{d}\sum_{j=1}^{p}\left\| y_{kj}' - y_{kj} \right\|_2$$

Paper achieved recognition by the nearest neighbor classifier at last.

3. Implementation Procedure

Because of DM3730 chip's rich resources, this paper adopts a higher degree of integration of design. As shown in the Fig.II.

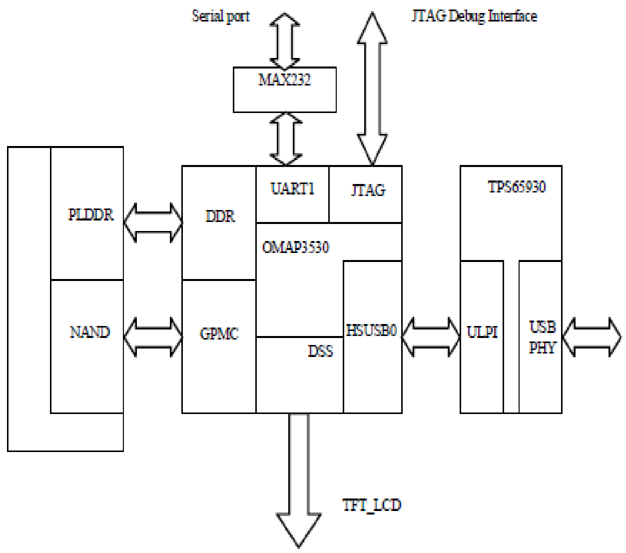

Fig.II. Hardware Schematic Diagram.

Here the focus on an introduction of the development based on the linux operating system [14], Fig.III showed the system software architecture diagram:

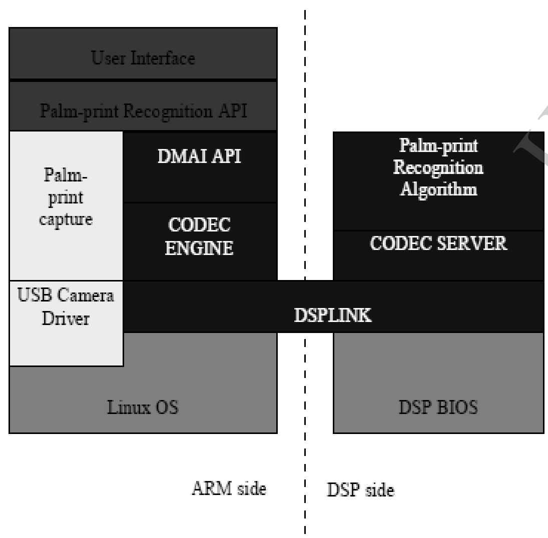

Fig.III. System Software Architecture Diagram.

System used a common USB camera as the palm image capture terminal, which enhanced the system versatility. This paper used the linux OS had supported USB camera driver, so it can be statically compiled USB camera drivers into the kernel image [13]. Paper designed camera capture program based Spcaview and Servfox which both comes from internet, and cross-compiled by the arm-none-linux-gnueabi-gcc in the host computer, at last generated an executable file that can execute on the DM3730. By running the program, System can capture palm-print images in Real-Time.

DVSDK (Digital Video Software Development Kit) Provided by TI included a complete set of tools and much useful resources. It can be easily used to develop an application of ARM + DSP. DVSDK is based on the DSPLINK (DSP / BIOS Link). Paper deployed DSPLINK to develop low-level driver on the DSP side . It can also be understood as a co-processor. System is running in the Linux OS. The DSP side mounted to the system as a device, thought dynamic module loading drive Paper deployed this method to use the DSP side.

CE (Codec Engine) is the core of DVSDK. Other software modules are CE-around . CE is a bridge connected ARM-side and DSP-side. This software module was between the applicationlayer (ARM-sideapplication)and signal-processing layer (DSP side of the algorithm). It will be need the support of CE, when you compiled DSP side executable code and ARM side application code. This system's image processing part was also supported by CE.

CE's low-level communication between ARM-side and DSP-side was based on DSPLINK [8]. DSPLINK also have the ARM part and DSP part. In the ARM part, it have some drives based on the linux OS and library files supplied for the program calls; In the DSP part, DSPLINK run on DSP / BIOS operating system, and DSP executable code need to include DSPLINK's library file.

A large number of data exchange through CMEM achieved: CMEM was used to allocate the continuous physical memory space beyond the Linux OS. It converted the physical address to virtual address, as well as the virtual address to physical address space. In order to avoid multiple copies of data, they need to build data space that shared ARM-side and DSP-side. ARM-side and DSP-side can directly access the data-space through CMEM management. For the ARM-side, CMEM was a driver on the system. It achieved memory allocation or converted address through IOCTL . As the DSP-side can access any physical address space, the pointer that sent from ARM to DSP must be physical address.

As the palm-print images that collected from USB camera was saved in JPEG format, so this paper deployed TI's decoding library to decode the image at first.Paper converted the palm-print image into a grayscale image, which sent to the sections of palm recognition algorithm.

This paper used DMAI (DaVinci Multimedia Application Interface) module for the image data (JPEG format) codec Processing, and developed their own XDM1.0.standard Palm-print recognition Codec based on the example of the Imgdec1_copy decoding provided by CE. Then paper modified the package.xdc 、package.xc 、package.bld and MOD.xdc 、MOD.xc, and added the codec to the cs.x64P which named codec server eventually . Fig.IV shows the palm-print recognition algorithm flowchart.

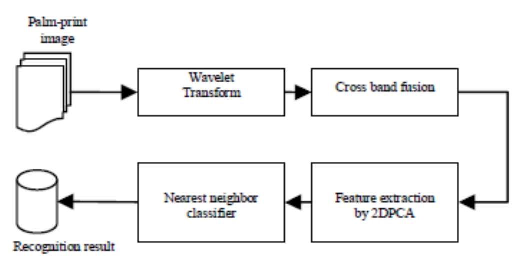

Fig.IV. The Palm-print Recognition Algorithm Flowchart

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At first, Program initialized a codec engine and DMAI for the later call, then called Engine open ( ) API to start a codec engine, in this engine through Idec1_create ( ) and IIMGDEC1_create ( ) and other API to create a JPEG decoding and palm-print recognition processing algorithms, then called XXX_process ( ) to implement the corresponding algorithm, at last, closed algorithm interface and codec engine, freed memory space, outputted palm-print recognition results to the user interface. Fig.V shows the result of palm-print feature extraction.

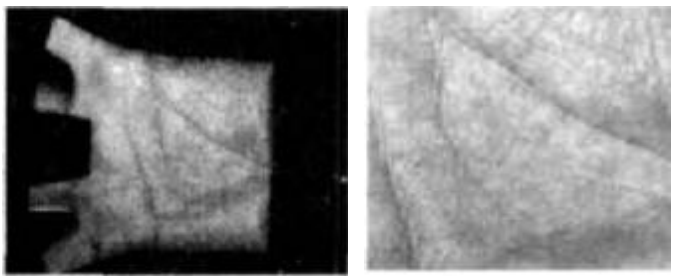

Fig.V **The Result of Palm-print Feature Extraction**

4. Conclusion

This paper's palm-print recognition algorithm based on wavelet reconstruction and local DCT and 2DPCA, supported by the DM3730's development tool DVSDK. To fully exploit the DM3730 multi-core digital signal processing chip's system capacity. This paper expanded the application fields for the DM3730 chips, meanwhile provided a hardware platform which can be more rapid developed an application system like fingerprint recognition system and iris recognition system.

5. References

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