A System for Capturing High Resolution Images

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Abstract. In this paper an Automatic System for Image Digital Capturing (ASIDC) is described. The aim of ASIDC is to create high resolution digital images depicting paintings of large size. The system creates a set of *N* digital images presenting sequential frames of the total picture. By using software we proceed to the mosaicing (pasting) of the images producing the complete detailed digital image.

1. INTRODUCTION

The most common way to convert an analog presentation of an image to a digital form is to use a scanner. However, scanners can have as inputs images on plane papers , photographs or slides. When large pictures (e.g. wall or portable paintings) are digitized, scanners are not useful. The digital camera is a new achievement of digital technology that produces digital photographs from shots of chosen sites. However, their image capture is of low resolution. Even if their resolution increases in the future, it is very likely that they will not be suitable to capture a large painting with all its details. Therefore, we propose an *Automatic System for Image Digital Capturing* (ASIDC) that provides high resolution images from large plane paintings. Partial picture areas are captured and converted to digital frames which, afterwards, are composed to result the final image (mosaicing algorithm). All the system is controlled by a PC and the overall procedure is automatic. Image capture is done through an analog video camera and a frame capture card, but the system can be easily adjusted to be connected with direct digital capture devices.

2. MOSAICING ALGORITHM

Mosaicing is a technique for assembling a set of images in order to obtain a general accurate representation of the entire scene [1]. The individual images represent details of the painting and they must have overlapping parts at their margins. The relative positions of two images in a set of several images can be expressed by the following relationship:

$$W_p = K\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} W_{p-1} + D$$

where W_p represents the coordinates of a pixel from the *p*-th image, *D* is a displacement vector, θ is a rotation angle and *K* is the scaling factor. Several images can be matched after arranging them two by two. A classical approach consists in manually selecting points representing the same details in different images and overlapping the images based on these sets of points.

In this paper we propose a completely automatic mosaicing algorithm which relies on matching regions from neighboring images [2]. Similarly with the block matching algorithm we define a search region $S_x x S_y$ in the plane of the image. The search region must include the overlapping part of the images to be mosaiced. We search for the best matching between various regions from the two images:

$$\underset{i,j,\theta_l}{Min}\left| I(W_p) - I(K\begin{bmatrix} \cos\theta_l & -\sin\theta_l \\ \sin\theta_l & \cos\theta_l \end{bmatrix} W_{p-1} + D_{ij}) \right|$$

where we consider only the pixels from the resulting overlapping region and D_{ij} is the displacement assumed in the range $D_{ij} \in S_x x S_y$ and $\theta_l \in (-\pi, \pi]$ is a rotation angle and *I( )* is the graylevel value, function of the position in the image. In the case when the image acquisition system takes images which are situated on a rectangular grid as that presented in this paper, the scaling factor and the rotation angle are fixed parameters. The only parameters to be found in this case are those corresponding to the dispacement D_{ij}. The proposed matching based mosaicing algorithm is completely automatic. The only necessary data is the search region $S_x x S_y$ which can be derived from the technical parameters of the acquisition system. The pixel intensity from the common regions is equal to a weighted sum of the pixel intensities from various overlapping images. The weights are chosen function of distance from the closest component image such that we have a smooth luminosity transition from one image to the next one [2]. For color images the displacement vector is found from matching images in one channel (e.g. Y-intensity in YUV images) and afterwards, mosaicing is performed for all the channels.

3. DESCRIPTION OF THE SYSTEM

The ASIDC is made up from: a motion system controlled by a PC, hardware devices for image capturing, and the mosaicing algorithm. The ASIDC is described in the following subsections.

3.1. Hardware Components

ASIDC consists of the following hardware/software components and represented in Fig. 1:

HARDWARE	SOFTWARE
Two linear state (axis) positioning system of high precision. (*X&Y*)	
Two driven motors of high resolution (M1 and M2)	Operating system : Windows
Motor driver kid (MDK)	Package for the camera's movement control
Computer (PC)	Commands for the video capture card
Two-axis motor control card for PC (MCC)	Digital image storage library
Video capture card for PC (VCC)	Mosaicing
Camera having PAL/NTSC output (C)	

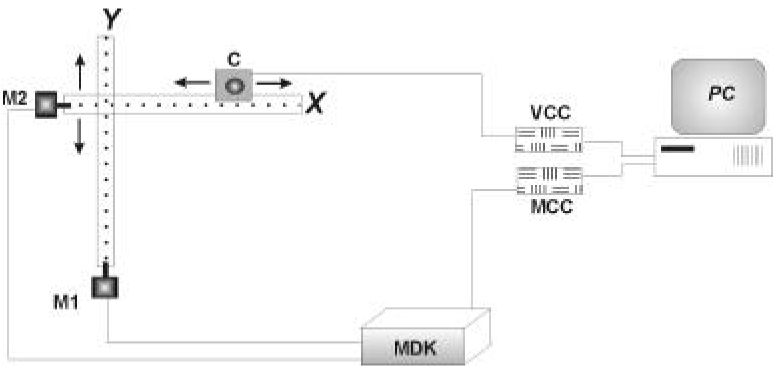

Figure 1. Schematic of the hardware components of the ASIDC

3.2. The Motion System

The motion system is based on the AEROTECH UNIDEX 500 motion controller driven by a PC through a PC-AT ISA bus motion control card and is shown in Fig. 2. Each linear motor stage has a moving plate which is moved by a motor. The first axis is placed on the ground horizontally and on its plate the second axis is fixed vertically. The camera is placed on the plate of the second axis. The PC software generates commands which through the main control unit activate the motors and move the plates of the axes. The first plate moves horizontally and the second one vertically in the front of the paint. In this way, the camera has the ability of moving

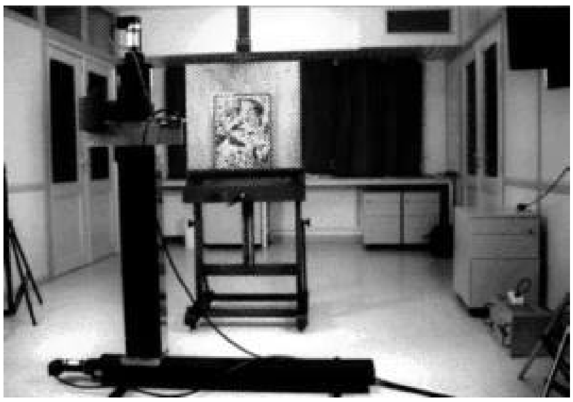

Figure 2. The ASIDC positioning system.

on a vertical plane parallel to that of the paint. The range of the movement for each plate is about 110 cm. The control unit permits the control of the movement, that is, the final or relative position of the plate, acceleration and speed of the movement.

Based on this system, image acquisition and mosaicing software has been developed for generating large images of high resolution by capturing overlapped portions of the paint. Each scan session starts with an initialization procedure. In this procedure, the operator supplies the software with the size (X,Y) of the painting to be scanned and the desired size of the overlapped areas $S_x \times S_y$. The software determines the number of the images that will be captured and starts the capturing procedure. At each step of this procedure, the camera is automatically moved to the proper position in front of the painting and a corresponding portion, called image frame, is included in the camera's capture domain. In Fig. 3 the acquisition process of several frames is shown.

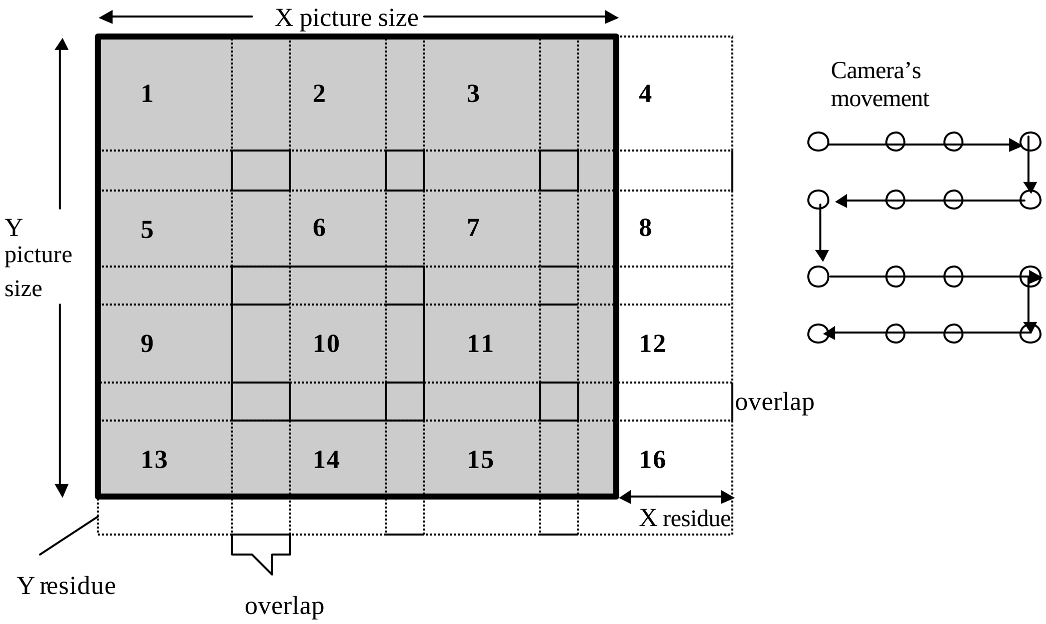

Figure 3. The overlaped captured frames on the picture's plane and the camera's movement. Frames are indexed sequentially starting from the frame at the upper left corner.

3.3. The Image Capture System

Frame capturing and conversion to a digital form is based on SVGA with real time video frame capture. More precisely, we used the IMASCAN Chroma-P module (Daughter Board on PC motherboard) of the IMAGRAPH corporation. Inputs to IMASCAN board are signals of a camera that supports NTSC, PAL,SECAM or RS-170 output. It captures (and displays) images of:

- 24, 16 or 8 bit monochrome or color
- resolution up to 1280x1024 pixels in Windows
- RGB or YUV formats

Access to the buffer of the instant captured frame takes place through software based on *C* subroutines of the IMASCAN SDK [3]. The captured bits are stored in RAM as an array of 8-bit or 16-bit elements for the monochrome and 16-bit color mode respectively, or in three 8-bit arrays that represents the RGB or YUV components. Before capturing, frame freezing is required in order to avoid undesirable effects. The captured image can be converted in an appropriate digital image format and saved on disk. Our system supports TGA and JPEG formats.

We remark that the constant parameters for the motion and capture procedures are stored in initialization files and some of them can be changed through the provided software. The camera's gain level can be set by a software command. Control of contrast, brightness, saturation and hue is also available and set by software at any time.

4. THE OVERALL IMAGE CAPTURE PROCEDURE

The overall procedure for capturing high resolution images is completely automatic. Before starting the capture, the user should proceed carefully to the following actions:

1. The picture, being digitized, is placed front of the motion system and parallel to the motion axes.
2. By using the motion control software, the camera is placed at a reference point where the camera acquires the first frame at the upper left corner of the picture.
3. Through a window dialog box, the user inserts the real size of the picture and the horizontal size of the area captured by the camera and displayed on the monitor. The last parameter it depends on the distance of the camera from the picture and the zoom of the used lens. Also the desirable overlap (in pixels) of the neighbourhood frames is inserted and is usually the same for the horizontal and vertical direction.

The software calculates the distances *dx,dy* for the horizontal and vertical camera's movements respectively. Also outputs the number of frames (horizontally and vertically) to be captured. The residue areas, i.e. the captured areas outside of the picture's area are also given. Such redundant areas can be cropped after mosaicing. When these actions are complete an automated procedure starts including the following steps:

1. The first frame, is acquired by the camera at the reference point (x_0,y_0), freezes and is stored in a memory buffer.
2. The camera passes to an ``acquire'' mode and after some time (of order of *msec*) the same area freezes and it is captured. Totally, *N* frames are captured and the final captured frame results after averaging of all the *N* frames in order to filter the highpass noise generated by the video capture card and camera.
3. The captured frame is stored on disk in TGA or JPEG format using as file name the basic name followed by the frame index.
4. The camera is moved at the next frame and the previous steps are repeated.

When the previous procedure is completed, the mosaicing algorithm is performed and the individual frames of size *n´m* are pasted to create the total image of resolution:

kn-(k-1)s ´ lm-(l-1)s

where *k,l* are the number of frames that covers the picture horizontally and vertically respectively and *s* denotes the overlap distance (in pixels) between neighbouring frames.

5. TESTS AND CONCLUSIONS

The ASIDC has been realized and used for preserving and restoring portable Byzantine images. An example is shown in figure 4 where we had the following parameters:

Picture size	: 950´*1050 mm*	**Output digital image size** ***3394 ´ 3387pixels***
Frame size	: 620´*458 pixels of 24-bit RGB color*	
Number of cover frames	: *6´9*	
Overlap distance	: *50 pixels*	
Mosaicing mode	: *Automatic*	

Special care should be given for achieving geometrical consistency between the real plane of the picture and the pixels of the digital image. The painting plain must be parallel with that of the camera such that no geometrical distortions are produced. The distribution of the light must be uniform and the same for each frame. The system has been used also with an infrared camera for high resolution digital reflectography (infrared imaging) on portable Byzantine images.

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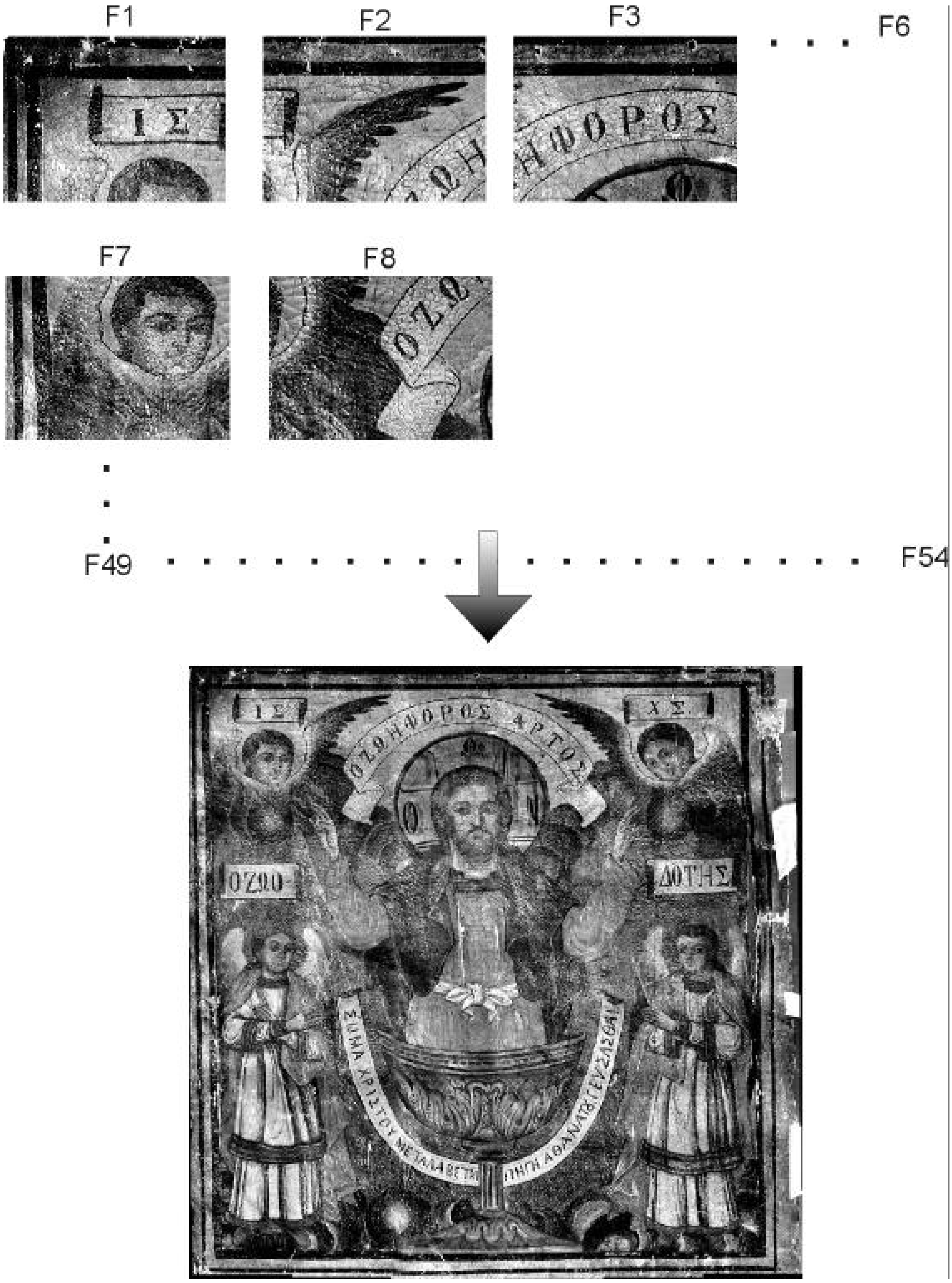

Figure 4. Mosaicing of 54 captured frames from a Byzantine painting on leather. The final digital image, presented here in greyscale mode, is of size 3394×3387.

[3] "IMASCAN SDK User's Guide", IMAGRAPH corporation