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Image Transmission with a Retina-like CMOS Camera

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ABSTRACT

The objective of this paper is to present and discuss the implications deriving from the use of a space-variant visual sensor for image transmission over low-bandwidth communication lines. The project presented is based on results of a EU supported project (SVAVISCA) whose outcome is a space-variant color CMOS sensor (Sandini et al. 1998). The peculiarity of the sensor is that the distribution of the photosites decreases from the center toward the periphery matching the density of cone photoreceptors of the human retina (Ferrari et al. 1995; Sandini and Tagliasco 1980). The resulting image is characterized by high resolution (small pixels) in the center and lower resolution (large pixels) in the periphery of field of view. If one fixates the center of the image the lower peripheral resolution is not very evident because the low resolution in that part of the image matches the low acuity in the corresponding part of the retina of the observer. In principle the sensor could be designed so that the match is perfect and the peripheral loss in resolution is not perceived. The main advantage of this kind of sensors in relation to image transmission is the smaller number of pixels required compared to standard constant-resolution images(Woelders et al. 1997).

The Giotto Camera

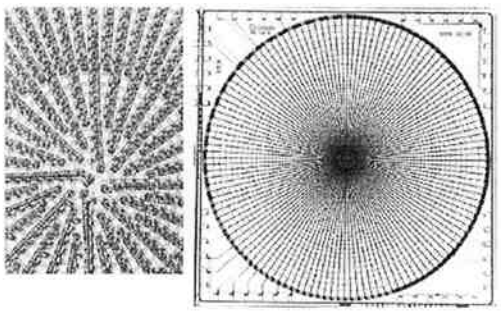
The Giotto camera is based on the SVAVISCA-1 CMOS sensor whose main features are summarized in the following table (Sandini et al. 1998). It is worth noting that the main advantage of the adopted sensor's geometry is the reduced number of pixels arranged in a log-polar topology (Weiman and Chaikin 1979), (Massone et al. 1985). The topology of the sensor's arrangement does not generate new requirements in terms of local processing. Log-polar topology, in fact, is conformal and, consequently, any local operator that can be applied to a "standard geometry" image can be applied as well to a log-polar one. In the sensor shown below the size of the smallest photosite is 14 μm while the largest one is about 200 μm.. The peripheral part of the structure is covered by rings composed of 128 pixels while, due to practical limitations, in the centermost part the number of pixels per ring is smaller. See figure below for the arrangement of the peripheral (right) and foveal (left) part of the sensor.

SVAVISCA-1 Sensor

CMOS, 8013 photosensors, 8 mm diameter

Non-integrating pixels with logarithmic response

Geometry	76 rings in	56 rings with 128 pixels 20 rings with a decreasing number of pixels (64, 32, 16, 8, 4, 2)
Resolution	Equivalent to a 600x600 pixels constant resolution sensor	
Pixel Access	Sequential or Random	



Based upon the SVAVISCA-1 CMOS sensor, a space-variant digital camera was designed and is now commercially available[1]. In this first industrial realization the main objective was to design a flexible and easy to use camera with no specific effort devoted to reduce its overall size and weight. The resulting device (the *Giotto* camera) is shown in the following picture and its main features are summarized in the following table.

Giotto Camera

Software	Windows95, NT 4.0, UNIX	
Interfacing	Parallel port (EPP mode), RS485, RS232	
Transfer Rate	Sensor's Maximum frame rate:	100 frame/sec
	Frame rate through parallel port EPP:	50 frame/sec
	Pixel rate through RS485;	125Kpixel/sec (10 bit @1,25 Mbit/sec)
	Pixel rate through RS232;	11,5Kpixel/sec (10 bit @115,2 Kbit/sec)
Bit per pixel	B/W	8 bit (256 levels)
	Color	24 bit (8 Red, 8 Green, 8 Blue)
Lens	C-mount	
Size	Cylindrical, diameter 65mm, length 75 mm	
Power	12 Vcc @ 0,5 Amax	

The GSM Transmission

Built around the Giotto camera extensive experiments on wireless image transmission were conducted. The set-up was composed of a remote PC running a web server embedded into an application that acquires images from the Giotto camera and compress them following the H.263 recommendation for video coding over low bit rate communication line. The remote station was, in our case, a palmtop PC acting as a client connected to the remote server through a dial up GSM connection (9600 baud). Using a standard browser interface the client can connect to the web server, receive the compressed stream, decompress it and display the resulting images on the screen. Due to the low amount of data to be processed and sent on the line, up to 4 images per second can be transmitted of a traffic scene or a speaking person (see Figure 2). Moreover it is worth noting that the only special-purpose hardware device is the Giotto Camera and all coding/decoding and image remapping is done in software by a Pentium PC. The GSM connection is obtained with an off-the-shelf NOKIA Card connected to the PCMCIA interface of a Toshiba *Libretto* accessing the Omnitel voice communication network. This performance in terms of frame rate, image quality and cost cannot be afforded with systems using conventional cameras.

Figure 1: B/W Image from the Giotto Camera (above) and its remapped version (right). The Giotto image is composed of about 8,000 pixels. The face on right is that of a famous Italian latin lover.

[1] For more information on commercial aspects contact Paolo Questa (pquesta@aitek.it)

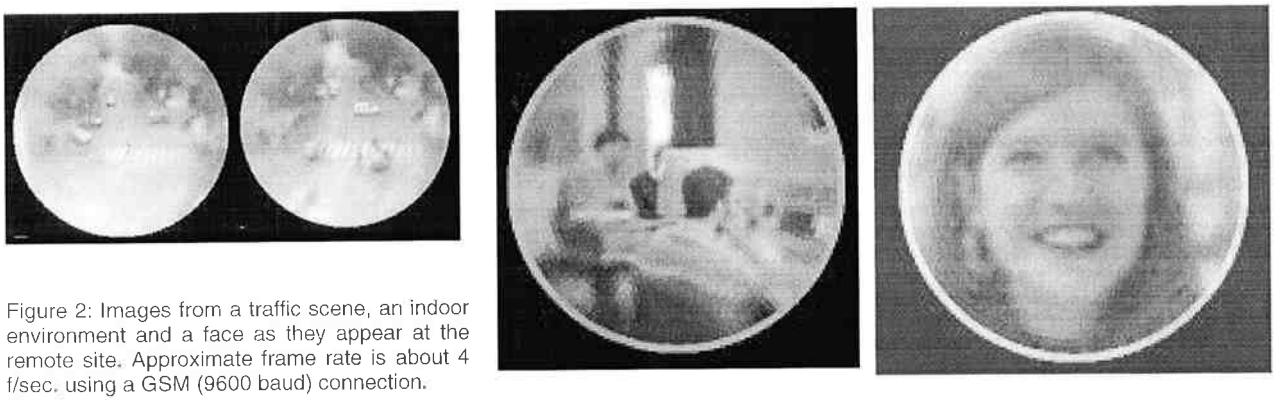


Figure 2: Images from a traffic scene, an indoor environment and a face as they appear at the remote site. Approximate frame rate is about 4 f/sec. using a GSM (9600 baud) connection.

The New SVAVISCA system

The objective of the second phase SVAVISCA project is to realize a miniature, color CMOS space-variant camera with a lens allowing at least 140° field of view and with the maximum number of pixels allowed by a 0.35μm technology. The design and fabrication of the new camera is due to finish in August 2000. At the present stage the design of the new version of the retina-like sensor, the lens and the camera is almost completed. It is expected that the new sensor will have at least 30,000 pixels arranged as the currently used sensor. This project is a further step toward the long-term technological and scientific goal of building an electronic camera with a number of pixels, a spatial arrangement, and a field of view comparable to that of the human eye. This is pursued through the integrated design of the solid state sensor, the lens and the driving electronics in a miniature device.

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