High Speed Digital Image processing using a Picture-Scanning technique on Incremental Plotters.

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ABSTRACT:

A method for high speed digital image processing, using incremental plotters is described. This project involves the use of computer graphics to electronically scan a picture and convert the resultant analogue signals to digital signals, subsequently to be processed on a high resolution TV monitor. The picture scanning attachment consists of a high resolution optical reflective sensor and associated amplification stages. This is in the form of a small probe which replaces the pen and the pen holder in an incremental plotter, and thus allows pictures to be scanned and stored as digital output for subsequent processing by a digital computer. The processing of this digital output could be on a high resolution TV monitor or a printer, using the Grey Scale contrast technique. Relative merits of this scanning technique are discussed. A special mention is made of a possible interface with the Hewlett-Packard Laser Printer software, where the digitising process could be speeded up many fold.

INTRODUCTION:

Digital image processing technology has reached a stage in its development where a considerable impact has been made in most technological fields. In addition to commercial and military applications, it's impact on the medical technology has been far reaching e.g. its use in brain and body scanners, where the resultant digital images are processed on a high resolution TV monitor.

A digital image memory and processor offers a wide range of capabilities. It can digitise and store image data provide scan conversion, improve signal-to-noise ratio (SNR) via frame integration or averaging, detect and accumulate image differences, enhance very low contrast images and provide an interface between video and digital technologies. A well designed system will also have the flexibility to be interfaced with a variety of image sensors, computers, displays and recording devices as well as provide for software expansion for image analysis applications. Figure 1 is a block diagram showing a state-of-art digital image memory and processor with such a range of capabilities.

As it can be envisaged from above, there are various techniques one can employ for digital image processing. This paper examines a very simple and inexpensive picture scanning device in conjunction with an incremental plotter to digitise a picture and process the image on a high resolution TV monitor. The study was a direct result of a requirement for an inexpensive method for inputting shaded images to a digital computer. One of the projects involved the use of these shaded images in comparing the relative merits of Fourier, Walsh and Haar transforms in data compression and noise reduction of images. The mathematics involved is rather complex and beyond the scope of this paper and hence has been omitted for simplicity.

The entire study was carried out in the department of Computer Science at Brunel University.

The outcome of this study offers a good, inexpensive practical avenue for digital image processing, and a possible application with the Hewlett Packard laser printer is mentioned.

THE SENSOR AND PLOTTER:

The picture scanning device, assembled at the Computer Science laboratory of Brunel University, consisted of the HEDS-1000 high resolution optical reflective sensor (Hewlett Packard 1979), mounted at the end of a small plastic tube which replaced the pen and the pen holder on the plotter. Mounted within the tube was the associated circuitary (see figure 2) comprising a current feedback amplifier utilising the sensor's internal transistor, thus providing current gain and bias point stability. Further gain was provided by an operational amplifier with adjustable output voltage level, which allowed for optimum contrast to be selected for any given shaded picture. The output from the sensor was converted by an ADC (Computer Technology 0000a) which was connected to a Modular One computer for storage as a data file.

The incremental plotter used (Computer Technology, 0000b) was a small roller type, rather than the drum or flat-bed construction which was the only one available at the time of this study.

Apart from the low cost aspect of this simple design approach, another favourable feature was that it enabled the employment of standard Calcomp digital plotter software in driving the modified pen carriage during picture scanning.

DIGITISED OUTPUT:

After image processing, the output can be programmatically presented to a line printer or a matrix printer using overprinting techniques, (See figure 3) with an output voltage swing from the sensor of 8v for a high contrast picture, and a noise level of less than 20mv peak-to-peak, a considerable number of grey levels can be achieved. In order to test the sensor, the digital output was initially processed on a matrix printer (Centronix 702) for which sixteen levels of grey were chosen. This produced a rather poor quality of overprinted images but proved to be sufficient to test the sensor. The subsequent image processing was carried out on a high resolution TV monitor.

PROBLEMS ENCOUNTERED:

Apart from the poor quality of overprinted images obtained from the matrix printer, a major problem area was due to picture wrinkling. As the plotter was a roller type, and the pictures were fastened on the plotter paper, there was a tendency for wrinkling to occur which caused image defocusing. A 0.5mm high ridge caused a 50% drop in reflected photo current. This was overcome, for test purposes by using small mint postage stamps (figure 4). (The problem would be non-existant on Hewlett-Packard flat-bed plotter series where the paper is electrostatically held absoutely flat on the plotter.)

CONCLUSION:

The sensor is sufficiently sensitive to detect variations in whiteness (or blackness) quite unnoticed by the naked eye. A high resolution is achievable which also enables line following and other complex scanning routines to be programmed.

APPLICATIONS AND FURTHER WORK:

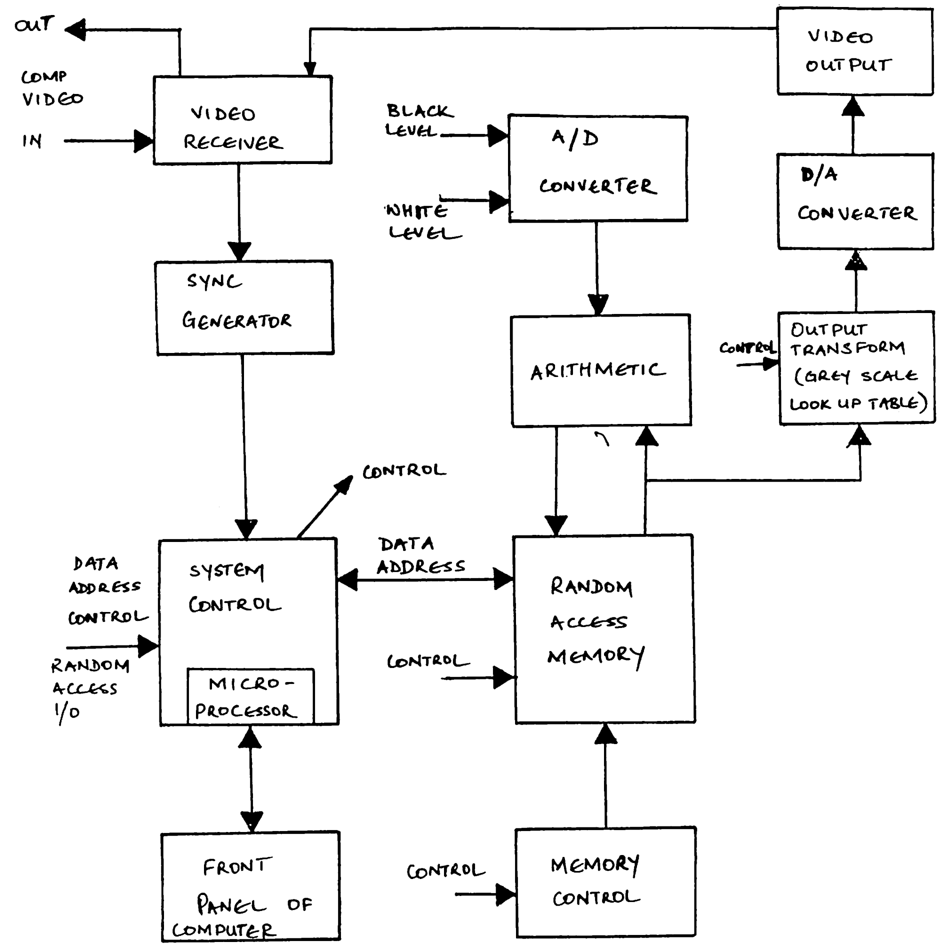
This technique provides a relatively inexpensive method for digital image processing. As a result of a matrix availability on the Hewlett Packard laser printer - 2680 software, a special character set with varying levels of darkness can be generated. Using IDSCHAR, a character designing program provided with the 2680 software, a special set of characters, with each character cell showing a varying shade ranging from total white to total black can be generated. As there are numerous levels of grey achievable by the sensor, these can be associated with the special character set on the laser printer and a TV monitor like resolution is achievable, although further work in this area is necessary.

Similarly, the sensor can be used using the primary colour filters and data stored for each colour, which can be subsequently integrated on a colour monitor. It is also possible to transmit these digital data files across a communications network and process the image remotely.

REFERENCES:

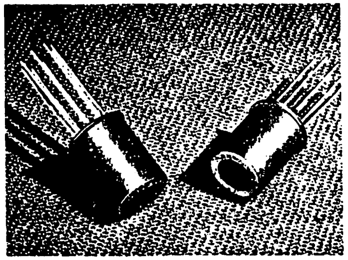
1. MENGERS Paul et al, Research & Development OCT 1977
2. PAGE Ivor & WOOD Robert, The Computer Journal, 24 1981
3. RYAN Daniel, Computer Aided Graphics & Design, MDI New York 1979.
4. HEWLETT PACKARD (1979) - High resolution optical reflective sensor. Data sheet - Hewlett Packard Components.
5. COMPUTER TECHNOLOGY (0000a) 1.722 Analogue input module, outline specification sheet - Computer Technology Ltd.
6. COMPUTER TECHNOLOGY (0000b) 1.43 Incremental Plotter - Modular One interim user handbook, Computer Technology Ltd.

Figure 1.



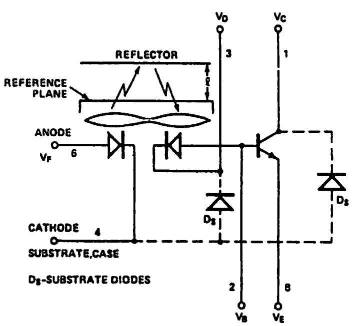
A block diagram shows relationship of elements comprising digital image memory/processor with random access memory.

Figure 2.

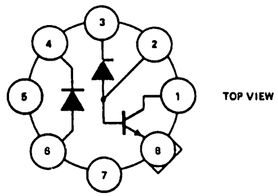


High resolution optical reflective sensor shown enlarged.

SCHEMATIC DIAGRAM



CONNECTION DIAGRAM



PIN	FUNCTION
1	TRANSISTOR COLLECTOR
2	TRANSISTOR BASE, PHOTODIODE ANODE
3	PHOTODIODE CATHODE
4	LED CATHODE, SUBSTRATE, CASE
5	NC
6	LED ANODE
7	NC
8	TRANSISTOR EMITTER

Figure 3.

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      PROGRAM PPRINT
C.  ********************************************************
C.....THIS PROGRAM READS A FILE AND PRINTS OUT A
C.....PICTURE ON THE CENTRONIX 702. THE FILE FORMAT IS :-
C.....  The first char. in the file is the letter N,
C.....  followed by the size of picture matrix (1-128).
C.....  The rest of the file is a string of greyscale
C.....  values in the range 0-15, numbers outside
C.....  this range will be scaled and truncated into it.
C.....     These are read in free format, after the
C.....  last number there should be another 'N' for
C.....  a new picture or an 'E' to terminate the plot.
C.....  The ch. set used is read from a datafile this
C.....  file contains a string of ch. pairs which are
C.....  overprinted to get the required pattern.
C.....  Unit assignment is :-
C.....        2      Console
C.....        3      Datafile
C.....        4      Tty line for centronix.    e.g. /TT8
C.....        5      Char. set file, currently .PCCHSET
      DIMENSION LINE1(128),LINE2(128),IGREY1(16),
     +IGREY2(16),IPICT(128),VALUES(128)
C..... READ CH SET FROM UNIT 5
      DO 15 I=1,16
      READ (5,1015)ICH
1015  FORMAT(A2)
C.....leftshift 1 and rightshift 9 to get top 7 bits
      ! LDA ICH
      ! SFT 49
      ! SFT 41
      ! STA ICH1
C.....left 9 right 9 for bottom 7 bits
      ! LDA ICH
      ! SFT 57
      ! SFT 41
      ! STA ICH2
      IGREY1 (I) = ICH1
      IGREY2 (I) = ICH2
15    CONTINUE
      LN=78
      LE=69
C.....READ SINGLE CHAR FROM DATAFILE
10    READ  (3,1010)ICH
1010  FORMAT(A1)
C.....left 1 & right 9 to convert to 7 bit value
      ! LDA ICH
      ! SFT 49
      ! SFT 41
      ! STA ICH
C.....CHECK FOR N OR E
      IF (ICH.EQ.LE)  GOTO 9999
      IF (ICH.EQ.LN)  GOTO 20
      GOTO 9991
20    CONTINUE
C.....READ SIZE OF SQUARE FROM DATAFILE
      READ  (3,1020)ISQUR
      IF (ISQUR.LE.0) GOTO 9995
      IF (ISQUR.GT.128) GOTO 9995
```

..../2

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C.....READ SCALING FACTOR FROM TERMINAL
      WRITE(2,25)
25    FORMAT(' TYPE SCALING FACTOR? '/)
      READ(2,1020) FACTOR
      DO 200 J=1,ISQUR
      READ  (3,1020)(VALUES(I),I=1,ISQUR)
1020  FORMAT()
      DO 100 I=1,ISQUR
      IPICT  (I) = VALUES(I)*FACTOR
90    IF (IPICT(I).LT.0) IPICT(I)=0
      IF (IPICT(I).GT.15) IPICT(I)=15
      IGREY=IPICT(I)+1
      LINE1 (I) = IGREY1 (IGREY)
100   LINE2 (I) = IGREY2 (IGREY)
      WRITE (4,1050)(LINE1(I),I=1,ISQUR)
      CALL CR
      WRITE (4,1050)(LINE2(I),I=1,ISQUR)
1050  FORMAT (1H+,128A2)
      CALL CR
      CALL LF
200   CONTINUE
      WRITE (4,1055)
1055  FORMAT (1H1)
      GOTO 10
9991  WRITE  (2,2010)
2010  FORMAT (1X,'UNKNOWN CHARACTER'/)
      GOTO 9999
9995  WRITE  (2,2020)ISQUR
2020  FORMAT (1X,'MATRIX SIZE OF ',I6,' IS OUT OF RANGE'/)
9999  STOP
      END

      SUBROUTINE CR
      NULL = 0
      ICR = 13
      WRITE (4,1000)ICR
      DO 100 I1=1,13
100   WRITE (4,1000)NULL
1000  FORMAT (1H+,A2)
      RETURN
      END

      SUBROUTINE LF
      NULL = 0
      ILF  = 10
      WRITE (4,1000)ILF
      DO 100 I2=1,13
100   WRITE (4,1000)NULL
1000  FORMAT (1H+,A2)
      RETURN
      END
```
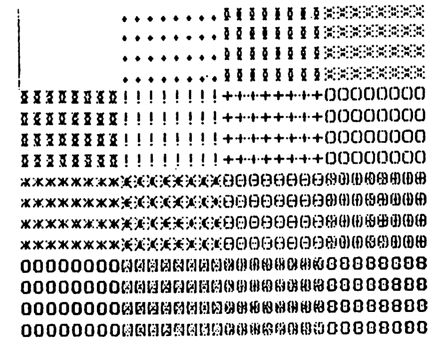
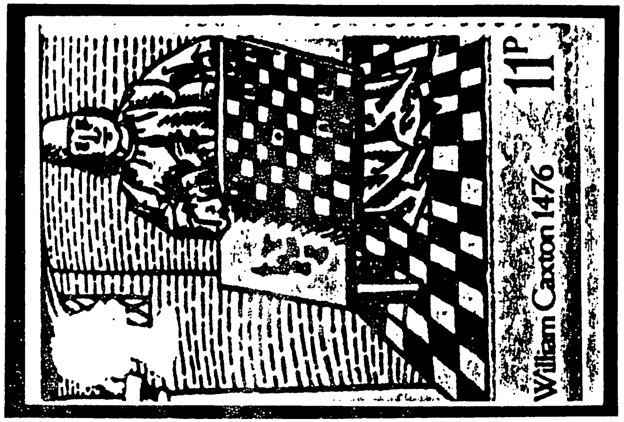

..../3

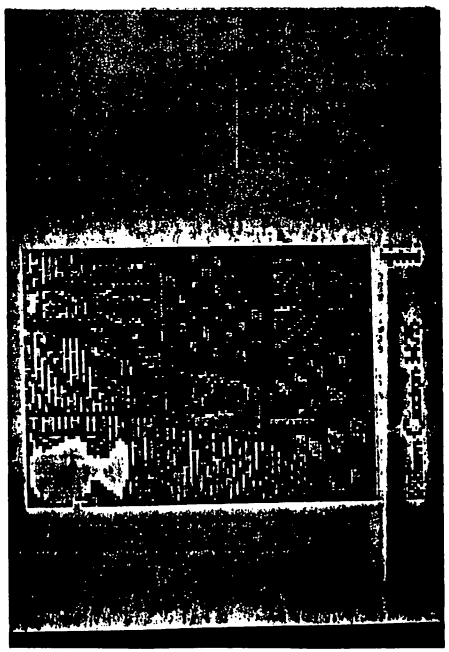


16 Grey Scale values used for digital image numbers

Figure 4.



B. High resolution sample



A. Low resolution sample

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