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A SCAN CONVERTER FOR A SECTOR SCANNING SONAR

Carey-Smith C.M. and Griffiths J.W.R.

Loughborough University of Technology

INTRODUCTION

Previous papers (ref. 1,2) by one of the authors have shown how the use of a scan converter with a sector scanning sonar considerably enhances its performance. The present paper describes a further extension of this work making use of a high speed signal processing chip the TMS32010 for carrying out a conversion from rectangular to polar format in real time making it possible to display a much larger sector than the sector being actively interrogated by the sonar. This alleviates one of the problems associated with these sonars i.e., in the initial design in order to limit the cost a compromise has to be made between angular resolution and the size of the scanned sector. The block diagram of SeaVision - a typical electronic sector scanning sonar system - is shown in figure 1. As is normal with electronic scanning the output is a raster display which in this particular system has a line frequency of 10kHz and a frame rate of about 2 to 4 frames a second depending on the maximum range required. The use of a frame store as a scan converter allows this data to be read out at normal TV scan rates so giving the improvements referred to in references 1 and 2. However since the sonar is illuminating a sector, the width of the display should increase proportionally with range rather than remaining constant and the fact that it does not, means that there is some geometrical distortion on the display. To help mitigate this problem SeaVision has a simple but rather crude method of producing a polar display using a triangular approximation. This unfortunately has the effect of reducing the apparent bearing resolution for the smaller ranges and still does not totally eliminate the geometric distortion. A typical range scan may have about 2000 lines which is obviously too high a resolution for a normal TV display. In SeaVision this is dealt with by storing part of the image at full resolution (the expanded display) and part at a reduced range resolution. In this way the total number of range elements in either display can be limited to 512. The two images are displayed alongside one another as is shown in figure 1. The bearing resolution is determined by the number of elements in the transducer array. In SeaVision there are 15 elements which limit the resolution to only 1/15 of the total scan but in fact 64 bearing samples are used to provide a more continuous image.

THE NEW SYSTEM

The main difference in the new system is that we have two separate stores, one in which the basic sonar data is stored and the other

which is used for the display. Decoupling the two functions in this way allows increased flexibility e.g.for further processing. If the sonar was trained in a particular direction and held stationary then the sonar data store should have 2000 x 64 elements each of 4/8 bits depending on the amplitude resolution required. This basic data can then be processed and fed to the display frame store. The latter store needs to have a resolution compatible with normal TV standards say 512 x 512 pixels. How we place the sonar data on this display is a matter of choice. A relatively simple choice would be the format used in SeaVision i.e. a full resolution display of part of the range alongside a reduced resolution version of the full range but converted to true polar coordinates. The conversion is carried out using a TMS32010 processor board which has been developed in the department particularly for interfacing with the BBC micro-computer. However using the system in this manner gives relatively little improvement over the simpler SeaVision Scan Converter. A much more powerful use is to arrange that the display should cover a much greater sector (the full 360 degrees if required) and to place the data in the display frame store at the appropriate position corresponding to the particular direction in which the sonar is pointing. Now as the sonar is trained in different directions the new sonar data is placed in an appropriate position. Displays constructed in this fashion and arranged to display +/-90 degrees are shown in figures 2 and 3. Figure 2 is made up of adjacent but separate 30 degree sectors whereas figure 3 uses a larger number of overlapping 30 degree sectors which have been integrated together while in rectangular format. This gives obvious visual advantages. The recording was taken in the sonar tank at the University and the sides of the tank can be clearly seen in their true geometric position. There are many artifacts in the display due to the nature of the electronic scanning system which can clearly be identified. It is interesting to note that these are not easy to identify if one is looking at a set of separate unprocessed images. (figure 4)

SCAN CONVERSION PROCESSING SYSTEM

The most important component in the system (figure 5) is the TMS32010 digital signal processor. This is used to calculate all the coordinates required for the scan conversion. The TMS32010 is a slave processor to the BBC micro-computer and the coordinates are used by the BBC to address the polar image framestore when transferring sonar data to it. The sonar data is initially stored in rectangular format having range and bearing coordinates. The coordinate calculations provide X,Y coordinates from the equations

X = Range x sin (Bearing)

Y = Range x cos (Bearing)

The sonar data is stored with 64 discrete samples in the bearing dimension. The calculation is performed N x 64 times per line, where N = 1 for short ranges and increases for longer ranges to

ensure that all pixels are addressed on the polar image. If the same pixel is addressed more than once then the data may be averaged but for the image shown in figure 2 the data is simply overwritten to minimise processing time with little image degradation. In figure 3 the scan conversion process is the same but overlapping rectangular data has been integrated together into the rectangular data store. As well as controlling the TMS32010 the BBC controls the array rotation motor and uses the training angle to integrate the sonar data to the correct address in the rectangular data store. It also performs the bulk data transfer between the rectangular data store and the polar frame store. The image integration of the rectangular sonar data although performed by the BBC for simple integration algorithms has also been carried out by another TMS32010 slave processor enabling more complex algorithms to be used and a significant gain in processing speed. The use of the BBC for data transfer is the slowest link in the processing chain taking approximately 90% of the scan conversion time. However this has been eliminated in a subsequent development reducing the scan conversion time to an order similar to the sonar frame rate.

CONCLUSION

The use of the scan converter with the polar conversion and wider display, gives a much clearer picture to the operator of the environment in which he is operating. Of course only the sector currently insonified is up to date but with the slowly changing nature of the sonar scene this limitation does not prove too restrictive. By interfacing this system with gyro information about the movement of the ship a stabilised display can be obtained. This will be the subject of a later paper.

ACKNOWLEDGEMENTS

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REFERENCES

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2) "Scan Converters in Sonar". Proc. Advanced Signal Processing Seminar. 1984 Warwick U.K., Peter Peregrinus

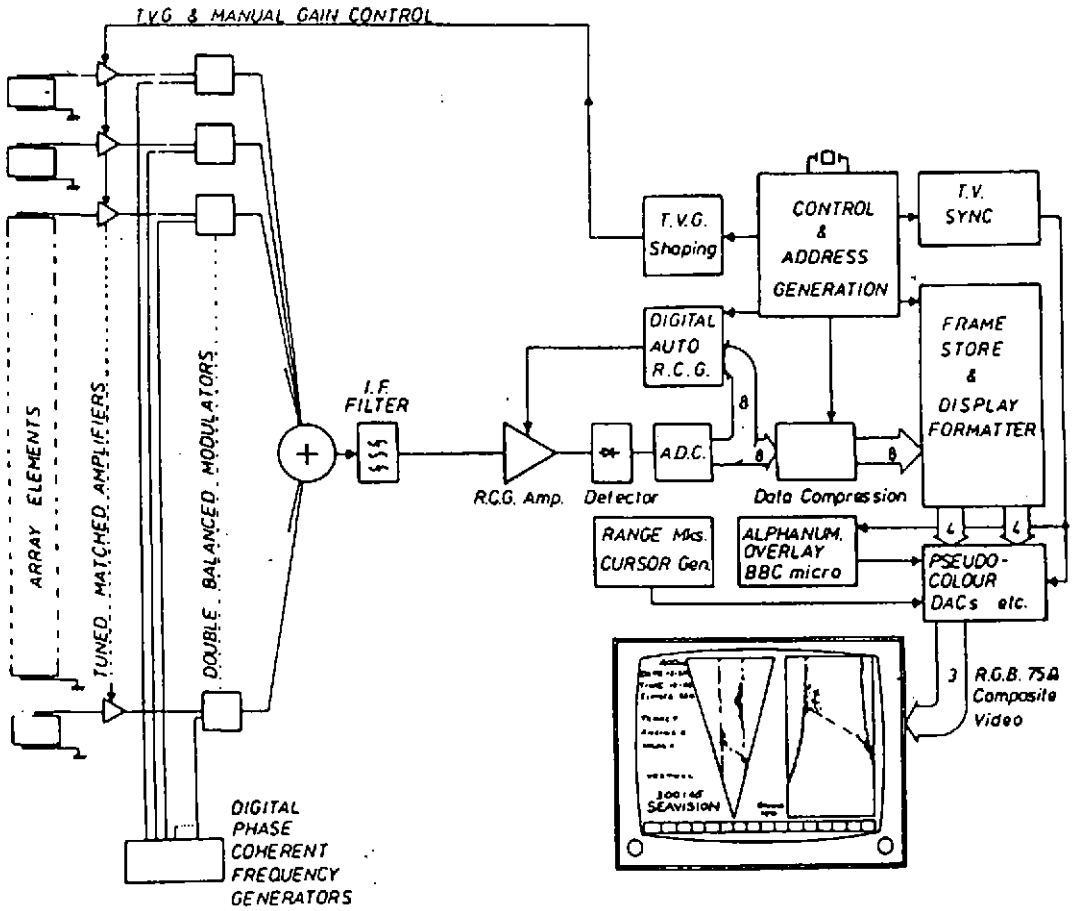

Figure 1. Block Diagram of SEAVISION Showing Display

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Figure 2. 180^{o} Corrected Image of Tank

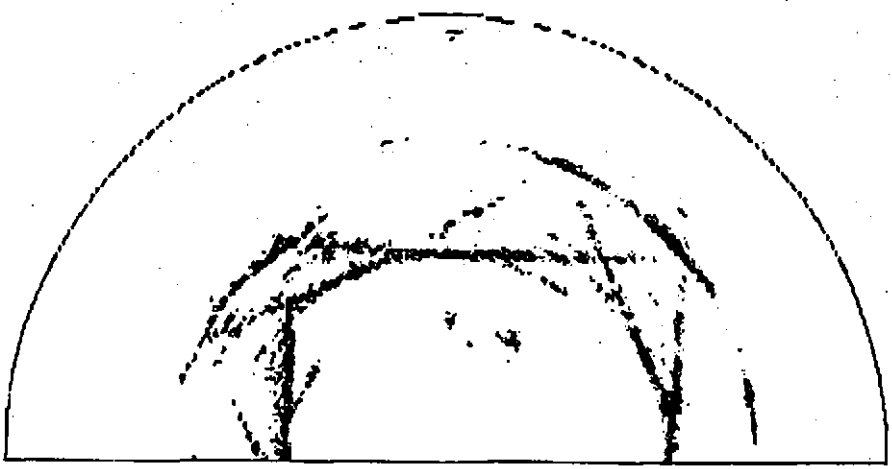

Figure 3. Image of Tank with Image Integration

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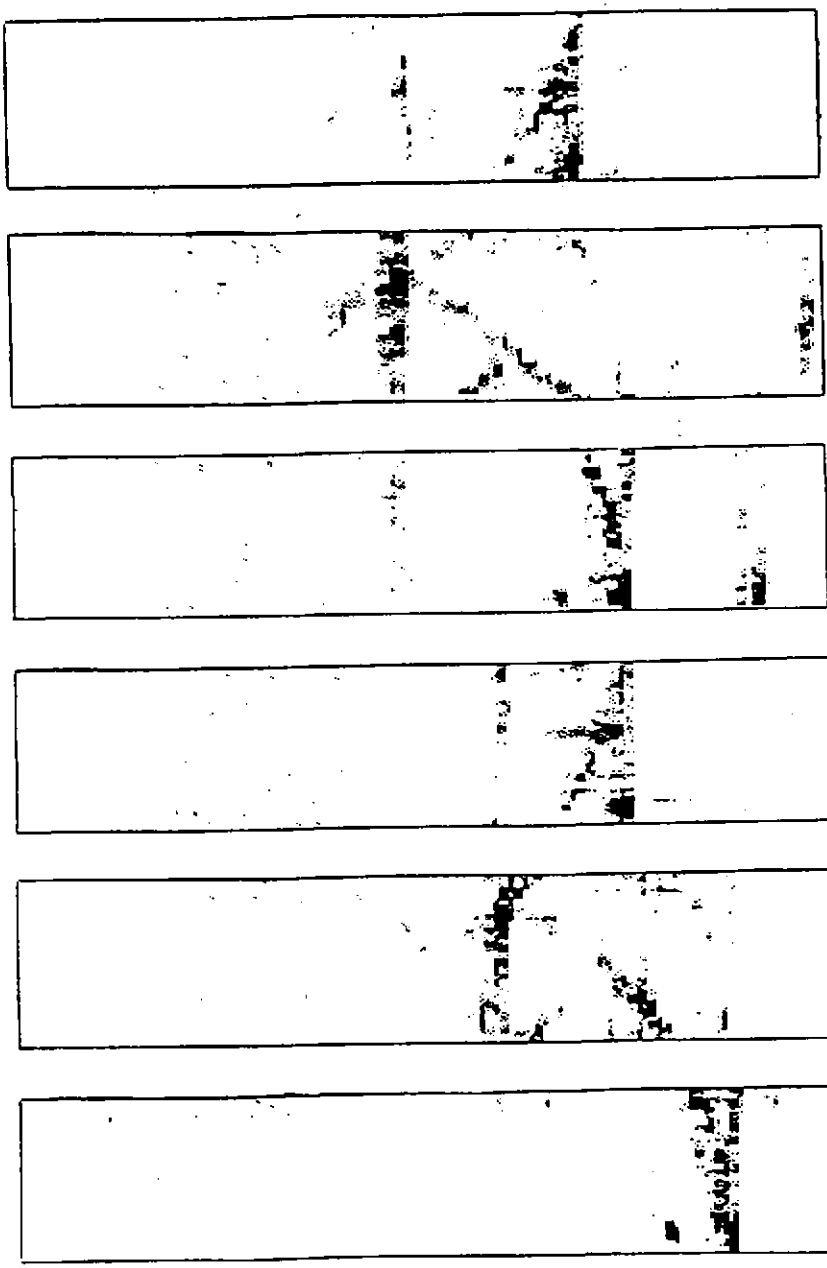

Figure 4. Separate Unprocessed Images

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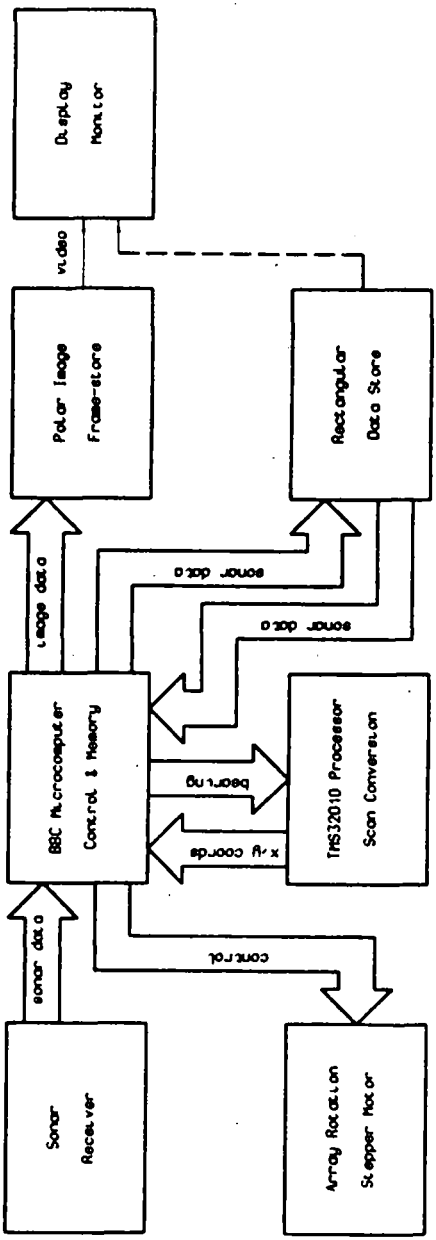

Figure 5. Block Diagram of Scan Conversion System