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SCIENCE AND ENGINEERING RESEARCH COUNCIL
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COMPUTING DIVISION

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Panel Visit to Sullivan & Baker
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Professor K Baker
Dr G Sullivan
Dr D Hogg (Sussex University)

INDUSTRIAL COLLABORATORS:
George Walton BAc
John Fry BAc

Grant Application: GR/C/69320 Knowledge Based Vision: The Use of Multiple Bandpass Filters to Select and Test Perceptual Hypotheses

1. INTRODUCTION

Clive Booth, Deputy Director (Resources) welcomed the Panel and stressed that Plymouth is a highly research oriented Polytechnic and places great importance on close links with industry. They have current grants from SERC, NERC and SSRC. An 'industrial innovation centre' is under discussion: a building built for high technology industry is available and an announcement is expected very soon of its acquisition for the new venture. He stressed that engineering and computing are protected areas when resources are under pressure.

Baker gave a brief summary of relevant projects already supported at Plymouth:

Multiple Band Pass Filters - BAe	
Special purpose h/w for vehicle recognition	- British Robotics Systems
VLSI architectures for Image Processing	- SERC
Knowledge Based Design Tools for Flight Simulator Software Design	- SERC
Knowledge Based Diagnosis of Electronic Systems	- ESPRIT

2. PRESENTATION - G SULLIVAN

Sullivan was not very eloquent but gave a very smooth demonstration of the results of the work of David Hogg and the principles of DOG filters. Hogg's thesis was based on the Walker program that uses a declarative model of a pedestrian in terms of cylinders to track a walking figure. Hogg's program was based on Sobel edge maps and the main point of the demonstration was the value of the top down model based approach when applied to a relatively trivial transformation of the image data.

A DOG filter is the Difference Of two Gaussian filters. If Gi are a set of filters spanning the spatial frequency range of interest then the DOG filters are defined as:

$$Ci = Gi - Gi+1$$

With C0 defined to be the delta function and CN the mean of the image. Then a channel image is defined as the convolution of the image with Ci. Typically a 32x32 matrix is used around each point to calculate the convolution. The basic result of importance is that the set of channel images preserves all the original image data ie. $\sum_i C_i \circledast I = I$. It is an important psychophysical result that human foveal perception can be very well described in terms of a 4 channel system. Earlier work by Baker and Sullivan exploited DOG filters for image enhancement: different thresholds can be applied to the different channels to optimally suppress noise; the image is then reconstructed. The second main point Sullivan made was that developments in special purpose hardware for convolution would mean that the processing cost will soon be very low. Hardware developments already well advanced will achieve a worst case of $\frac{1}{2}$sec for an arbitrary DOG filter using a 32x32 filter over a 128x128 pixel image.

Sullivan went on to give a demonstration of some of the work being done under contract for British Robotics Systems by Hogg at Sussex (CinC). This work is to produce a system that can detect buses approaching junctions. It is fundamentally simpler than the work proposed under the grant (see below) for the following reasons:

(i) The class of objects (buses) is very well constrained
(ii) A fixed camera position is used
(iii) The object can only appear in a very well defined region. A 'trap' is set ie. about 150 templates can test for all presentations across a particular point in the road.
(iv) Sobel edge maps are adequate for the templates.

Given noisy images the system does not perform very well. Sullivan then showed how DOG filters could be used to pick up features such as the high frequency back edge occlusion and low frequency high intensity ridge at the front of a bus. This system performed much better under noisy conditions. It also rejected the bogus hit on a prefab house being carried by a lorry - a good example of a snare for object based systems based on common expectations! The main point of this part of the demonstration was that the description of features in terms of the output of DOG filters was essentially simple. The demo was contrived in the sense that the feature detection had been manually directed rather than driven from an object model. As an aside it was remarked that in Hogg's programme the structured information is coded declaratively and the feature information procedurally. It was also stressed that POP in the POPLOG environment is an ideal tool for this type of development.

The work to be done under the new grant will tackle the substantially more difficult problems posed by less contrained objects in noisy images, vis tanks in infra red images. BAe have reached the limit of what can be achieved (by them) with bottom up processing and are keen to exploit the apparent advantages of a top down model based approach. However, research into features or cues is a component of the programme since effective means have to be found to constrain the search space.

There was discussion as to why they were not attempting to employ an intermediate level of representation such as the $2\frac{1}{2}$D sketch proposed by the vision group in the IKBS Architecture Study. It came down to the fact that they can achieve useful commercial results now by applying the models to the low level cues without tackling the intermediate representation research problem. This is a valid argument since they will gain valuable experience of object modelling from their work. David Hogg can see the need for the intermediate level: in his Walker program he relied on pointwise comparisons between images to pick up the first main regions. He is also keen to participate in the $2\frac{1}{2}$D sketch programme and was only absent from the meetings that framed the proposals because of illness etc.

Summary:

DOG filters are used in the Marr & Hildrith edge detection method; at this level there is therefore no conflict between this work and the expected $2\frac{1}{2}$D sketch proposal.

Sullivan rather overstated his case for top down modelling; Hogg at least understood the value of the intermediate representation work.

Useful results should emerge from the proposed work, but there was virtually no justification given for a significant amount of psychophysical experiments on human cues apart from finding cues of pragmatic value to the automatic system.

3. DISCUSSION

3.1 George Walton explained why they were interested in model based approaches for the next generation of imaging sensors (see above). He stated that BAe policy is to foster collaboration with academic institutions and that in 1980 they placed a contract with Baker (at Sussex) for this development of much of the MBPF equipment which is now in the Plymouth lab. They were very pleased with the working relationship established with Sullivan and Hogg and pointed out that Hogg visits their Hatfield site at least once a month. They consider that on the basic theory they are learning rather than contributing; their contribution comes in having an understanding of real applications and complete systems. They have also contributed a good deal of hardware and built up an experimental facility at Hatfield. The delay in the submission of the RG6 was due to incomplete understanding of all the implications of cooperative grant regulations, which SERC had not been quick to resolve (ie. MJH has not answered their letter).

3.2 It was pointed out that the proposal to employ Hogg as a part-time consultant was unusual. Baker explained that Hogg is employed on a contract at Sussex paid for out of a benefaction to the University. In the medium term he intends to offer him a post on the ESPRIT project. The consultancy is thus a reasonable interim solution.

3.3 The work of the 4 RAs requested was discussed: they had envisaged a split between low and high level processes rather than engineering/psychophysics. The low level work would also be relevant to VLSI developments. They have two or three possible RAs lined up: two of them are currently at MIT.

3.4 Baker pointed out his own experience in managing industrial applications and also that of John Brumfitt who has joined from Logica (formerly in David Stanley's group working on specialised image processing hardware).

3.5 Computing Resources. Since putting in the application they have found they can get a VAX 11/750 cheaper than the price quoted for an 11/730. They also did not think an 11/730 was really up to the job; Sloman agreed with this. Use of the 11/780 at Sussex is a fall back that would be barely satisfactory (NB the 11/780 is not networked anyway). They have a Z8000 system that controls the special purpose hardware. They intend to use BAe support to develop a parallel interface for the VAX. They do not require imaging h/w since they use tapes of images supplied by BAe.

3.6 They had not put down travel in UK because BAe are flexible about funding it. They are willing to cooperate with the Frisby $2\frac{1}{2}$D proposal, there is no antagonism.

3.7 The cost of POPLOG is high because Sussex quoted 50% of the rate for an industrial customer.

3.8 BAe said that their attitude to exploitation is that they want to protect their own right to exploit developments they have fostered, they explicitly are not too concerned about other people using results as well.

3.9 The BAe manpower costs are low. The Z8000 and other h/w contribution looks high but can be justified in terms of existing h/w at Plymouth.

4. RECOMMENDATIONS

After a private Panel session the following comments were made to the investigators:

(1) A good proposal that will be supported when resubmitted.

(2) The proposal should be split in two, an EB proposal and a Science Board proposal for the psychophysical work.

(3) The programme of work for the RAs should be detailed.

(4) The proposed work should be related more carefully to other UK work, particularly the $2\frac{1}{2}$D sketch proposals.

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jg