Reforming our picture of vision

Vision is the most useful advance warning system in the world, a system which can pick up detailed information about the environment at the speed of light. It is an essential part of almost all intelligent, mobile life on earth, and a prerequisite for the development of artificially intelligent flexible robots.

Vision is so much a part of us, a sense we have and use so easily, that twenty years ago it seemed simply a matter of a few years researched research before we would uncover its secrets and be able to put them to use. But our unconscious and effortless use of vision blinded us to its complexity. Researchers quickly found that it was difficult to look at objectively, in order to work out what questions should be asked about it. And 20 years later we are still only scratching the surface.

Two researchers who have helped to reform our view of vision are working at Monash in two entirely different areas. Dr Ray Jarvis is Professor of Electrical Engineering and operates one of the most sophisticated robotic vision laboratories in Australia. Professor Bill Muntz, a zoologist, is the Dean of Science and an expert on comparative vision.

Seeing a flexible future for robots

THE SMALL MACHINE swivels on its joints, opens its gripper and painstakenly lowers itself to pick up a triangular block perched on another. It grabs the thin end of the wedge, and the block slips from its grasp.

At its second attempt, with the gripper coming from a different angle, the robot succeeds and deposits the block in a box by the side of the table on which the blocks are standing. Slowly, in like manner, the robot manages to clear the table of the five irregularly-placed blocks.

That demonstration, given by Professor Ray Jarvis of Electrical Engineering, is pretty close to the state-of-the-art in robotic vision. It took two video cameras, a rotating tray, a complex program, a special image processor and a roomful of other computer equipment in the most sophisticated laboratory of its type in Australia to instruct that robot. And yet a baby less than two years old could accomplish the same thing with ease.

It is hardly the stuff of which Isaac Asimov novels are made. "You won't see R2D2 for another 50 years," says Jarvis, one of Australia's foremost authorities on robot vision.

Yet some are still concerned about the potential even of primitive systems to take away human jobs, and would argue that such research is not good for mankind.

Jarvis said: "My first response would be that most people concede that using robots in harsh environments — for undersea and space exploration, for instance — is beneficial. And then there is great application to prosthetic devices and paramedical aids for the handicapped.

"Then there are certain repetitive tasks which it is below human dignity to do. People in these jobs could be found alternative roles which are much more human — and that's good for mankind. The more hack-work done by mechanical means the more human we can become.

"In the past 10 years, the output from Australian manufacturing industry has dropped 25 percent. If Australia doesn't get involved with robots then we won't survive as an industrial nation. The flexibility of operation using robots is particularly important for countries with very small product runs."

And vision is an important part of making robots more flexible, because it can allow them to become independent and mobile.

Dean looks at Octopus eyes

OUR EYES ARE constantly moving. Hence, relative to them, so is almost everything we look at.

In fact, if you were to sit and gaze at a scene which remains stationary with respect to your eyes — and it can be done using special glasses — you would not see a thing, not even light or darkness.

That is because our eyes are not simply living cameras projecting an image of the world into our brains. The reality is far more complex.

In fact, our eyes process what they see and only send information about change to the brain — about things like movement, where edges are, changes in color. "They're not reproducing the outside world, but selecting biologically important information," says Professor Bill Muntz, the university's Dean of Science and a zoologist who has done much to change the primitive camera notion of how eyes work.

Muntz works in the field of comparative vision and spends his time unravelling such fancy questions as why some fish wear sunglasses, and what a Nautilus sees.

For his pains he has become enough of an authority on vision to have been asked by the US National Aeronautics and Space Administration (NASA) for help in designing the cameras of a space probe to Mars.

"They did not have the power for every picture they wanted, so they had to decide what was relevant. That is what the animal eye does par excellence. They really needed to design a robot along animal lines.

Continued Page 6

Continued Page 7

INSIDE

- Computing could save animals 2
- Procurers can adopt 3
- Antarctic dinosaurs 4,5
- 25 years of Monash 8

MAY 1986
Computer simulation could save animal lives

The modern high-speed digital computer could become the unlikely champion of laboratory animals, a Monash physiologist says.

Dr Brian Chapman says he is convinced that computer simulation will focus research better, leading to more efficient use of animals for experimentation and eventually to their becoming obsolete in some areas of theoretical biomedical research.

Chapman is one of a handful of theoretical physiologists in Australia. He has recently returned from an outside studies program at the National Biomedical Simulation Resource at Duke University in North Carolina, the world's first computer facility dedicated to biomedical simulation.

But lessening the demand for laboratory animals is just a happy-side-effect of a technique which developed as an approach to handle the design and interpretation of experiments in the enormously complex world of biomedical research.

To simulate, mimic or model an experiment on the computer, Chapman says you need two things: a good base of experimental measurements and an interpretation of those results that can be expressed as a mathematical equation or, more likely, as a series of equations which are simultaneously true.

"So you say, 'If this is the way people think it behaves, these are the equations that would need to be true. We'll solve them on the computer and match it to the real world to see if it works.'"

If it fails to match the real world then you have either made a mistake in setting up the simulation or else there is some flaw in your interpretation of the original results, Chapman says.

"The failure of the simulation may suggest how to remedy it, or lead to further experiments with a level of insight not possible without the computer. So it increases the efficiency of experimentation by focusing and disciplining ideas."

But until the development of high-speed computers, effective simulation simply was not possible. "Researchers could conceive the problems, but no one had the time to do the laborious calculations."

For example, in the 50s when Hodgkin and Huxley won the Nobel Prize for their model of how nerves function, Huxley spent three weeks with a hand calculator going through the mathematics necessary to construct a picture of one nerve impulse.

Now the same problem can be handled by a general computer in a few seconds and by a specialized one in milliseconds, the same amount of time it takes for a nerve to fire.

And the prospect which that has opened up for biomedical research is starting to be taken very seriously in the US. In September 1985 the US National Institutes of Health, Division of Research Resources, gave the Department of Physiology at Duke University a four-year grant worth $2.4 million to establish a computer facility to support computer simulation in biomedical research.

Scientists with a National Biomedical Simulation Resource account can plug into its computer free of charge via telephone. A library of programs helpful for simulation also is at the disposal of users. Chapman is negotiating the necessary computer and software so that Monash can participate.

The resource has a specific brief to develop software to help make simulation more accessible, to develop better ways of interpreting computer models and to help in the education and training of biomedical scientists using simulation techniques.

Applied Dynamics, a computer company which supplied the resource with a specialised processor built to solve differential equations, already has become convinced that this is the way of the future and has recently presented the facility with a second processor free of charge. They want to be in on the ground floor when new techniques are developed.

Brian Chapman has had links with the simulation group at Duke University for more than ten years and was not surprised that it was picked to host the resource. "It has the runs on the board. It has even been applying simulation to clinical situations as a tool to evaluate the condition of heart patients."

But the sheer complexity of even seemingly simple biomedical simulations can be staggering. Chapman said he was collaborating with some of the Duke people on a project, trying to simulate an experiment on a single enzyme, where the molecule was tagged radioactively.

"In order to take account of all the different radioactive and non-radioactive forms of the enzyme a system of 69 simultaneous equations had to be constructed and solved."

In many cases this means working right on the fringes of programming too. While at the facility Dr Chapman looked at a problem of extra cellular space with the director, Dr Maiden Koosse. The theoretical mathematical handbooks pattered out at the solution to this problem.

Dr Koosse casually remarked: 'I guess from here on we're on our own', and programmed a solution within a matter of hours.

Chapman thinks it is only a matter of time before computer simulation courses become a standard option in biomedical training.

"Simulation is an invaluable tool for some areas of biology. I would be very surprised if there was any part of physiology that could not be written in terms of differential equations and simulated eventually."

"The computer could be the unlikely champion of laboratory animals."

Dr Brian Chapman of Physiology

Dr Brian Chapman pulls a printout of one of his simulations from a plotter.

MONASH REVIEW

MAY 1986
Procurers may adopt under new Act, researcher says

Recent Victorian legislation could open the way to inter-country and mail-order adoptions by paedophiles and procurers, a Monash researcher says.

Pauline Shiff, who studied the new Victorian Adoption Act for her honors thesis in law, also is concerned that special provisions covering Aboriginal adoptions could be challenged under Federal racial discrimination legislation.

"While in principle the Victorian reform of the laws regarding adoption is laudable, in some aspects it seems to be ill-conceived," she says. And the worry is that the as-yet-unproclaimed Victorian Act could serve as a model for other states and territories.

Under the Australian Constitution, adoption is regarded as a state responsibility. Despite the enactment by each state and territory of uniform adoption legislation during the 1960s, local differences in procedure and legislative changes meant that by the 1980s any semblance of uniformity had disappeared.

So there are now eight different sets of adoption laws in Australia, corresponding to the different states and territories. This is not only inefficient, but can make things very awkward in areas such as inter-country adoption, Shiff says.

"For instance, before they will recognise foreign adoption orders, some states require the prospective parents to have had a period of residency in the overseas country from which the child is to be adopted. Others do not.

All of which makes it very difficult for Australian immigration officials. The perennial newspaper stories about the hardships of Australian families caught in the legal tangles of inter-country adoption can attest to that.

The climate of adoption has changed dramatically in the past 20 years. In the '60s, after the post-war baby boom and in an era of less effective contraception and community intolerance of unmarried mothers, there were many more Australian children available for adoption. At the moment there are waiting lists of up to five years, which puts strong pressure on people to go abroad to find children.

For all these reasons Victoria decided to act unilaterally to update its legislation, but in doing so it has, according to Shiff, made some very questionable decisions.

"The new Victorian act includes no requirement of residency for foreign inter-country adoption. That provides an extraordinary opportunity for people who would find it difficult to adopt locally. I suggest to you that the people most likely to utilise inter-country adoption are either unlikely to be approved here or want to circumvent the waiting period. Their motives might be diverse, from the simple desire to form a family to the possibility that they are paedophiles or procurers."

The Victorian act introduces several new provisions for Aboriginal adoptions, such as recognition of tribal marriage for the purposes of adoption, the right of access to the child granted to the natural parents and their Aboriginal community, and a statutory right for the parents to prefer that the child be adopted by other Aborigines.

Shiff said: "The provisions with respect to Aborigines are exciting — not ideal, but a step in the right direction — but they may well be challenged under the Commonwealth's Racial Discrimination Act, although they are probably meant to be 'special measures' and thus not invalid."

An even more controversial section of the new act seems to open the way to mail-order adoption in Victoria.

"It introduces a new jurisdictional base for the adoption of Victorian-born children about which there was no parliamentary debate whatsoever. The adoptive parents don't have to have any Victorian connection, and neither of the sets of parents nor the child have to be present in the State. Theoretically it can all go through by proxy."

According to Shiff part of the answer to these problems is for adoption to become a Federal responsibility under the jurisdiction of the Family Court. The move would not only increase the efficiency of the administration of adoption, but the Family Court is already staffed already with marriage counsellors and welfare workers, part of whose job it is to look after children.

Until now it has been assumed that the Commonwealth lacked the constitutional power to take responsibility in this area, but Shiff points to specific sections of the constitution which suggest that "all aspects of inter-country and Aboriginal adoption are eminently suited to Commonwealth regulation."

She further argues that action in these specific areas might encourage the States to refer all adoption powers to the Commonwealth or influence voters to do so in a referendum.

Not only was Shiff awarded first class honors for her thesis, but the Law Faculty is also considering it for publication as a monograph, a singular honor for undergraduate work.

It formed the basis of a submission by the Children's Bureau of Australia to the Council of Social Welfare Ministers Joint Committee on Inter-Country Adoption. The committee was impressed enough to send a letter of appreciation.

And all this for a student who entered law school in her thirties, having worked first as a legal secretary and in the travel industry.

For those who are interested in the issues of inter-country adoption, the Children's Bureau of Australia is to hold a lunch on Tuesday, 27 May at which the guest speaker will be Mrs Anne Gordon a specialist in inter-country adoption from International Social Service. The lunch will begin at 1 p.m. sharp at the Air Force Club, 4 Cromwell Road, South Yarra. Further details can be obtained from Mrs Dorothy Wood on 514 6444.

Features

When adoption can go terribly wrong

Baby left behind in Chile: adoption battle continues

Babies for sale in Chinese market
Research team finds Antarctic dinosaurs

A MONASH/MUSEUM of Victoria research team has found fossils in southwestern Victoria which could be important in changing ideas about how dinosaurs became extinct.

The team, led by Dr Pat Rich, a senior lecturer in the Earth Sciences Department and her husband Tom, curator of vertebrate fossils at the Museum of Victoria, found the dinosaurs at Dinosaur Cove, Cape Otway and has been excavating them for three years.

The group has dubbed the specimens "the dinosaurs of darkness," because they almost certainly lived inside the Antarctic Circle in a region which was without sunlight for at least three months each year.

Their existence could modify one of the presently favored theories of dinosaur extinction — that of a collision with a comet or asteroid.

It is thought that such a collision would raise a massive dust cloud blocking sunlight from earth for a period of months. This, in addition to causing freezing temperatures, would result in the death of most plant life and hence, it is argued, the dinosaurs, most of which were plant feeders (Those that were meat eaters depended on the plant feeders for their food anyway).

"But we have now found dinosaurs which were already surviving three months of darkness naturally — unless they migrated out of the area," Pat Rich said. The next stage would be to try to determine how they survived — if indeed they migrated, or hibernated, or were able to operate at a lower level of activity and energy consumption, she said.

The dinosaurs at the cove include at least two completely new species and were found in the company of crocodiles, lungfish, bony fishes, turtles, lizards and flying reptiles (pterosaurs).

Dinosaur Cove (officially named so after the site was discovered) was found by a clever piece of detective work and some hard slogging.

About 100 years ago a dinosaur bone was found near Inverloch and lodged in the Museum of Victoria. In the late 70s two MONASH graduate students went back to the area and found other bones, but the rock in which they occurred petered out at Kilcunda, about 30 km to the west.

The group then pored over a geological map of the State and recognized rocks of the same age and type starting at Eastern View and running west at least 70 km along the coast around Cape Otway.

Pat Rich said "I think we've walked all the way around that coastline except where you cannot get in. The bones were concentrated in certain areas at the bottom of ancient stream channels. Dinosaur Cove was where channels were abundant and bones in greater concentration that anywhere else."

The dig has been made possible only through the help of a diverse collection of talented volunteers, the National Parks Service, the local people, the National Geographic, the Mobile Oil Company and a Swedish mining equipment company, Atlas Copco.

The team hired equipment from Atlas Copco for its first dig in the summer of 1983-84. Because it was expensive the group could afford only two weeks with the equipment and worked 24 hours a day to make the most of the time. One night towards the end of the dig a huge wave washed away almost everything stored on the beach and it became obvious that night work was too dangerous to continue.

By the next year Mr Bill Loads of Atlas Copco had become very interested in the whole project and from that time tens of thousands of dollars worth of mining equipment, maintenance and advice have been supplied free. In gratitude the scientists have created what must be the first mercantile dinosaurs Atlas Copcosaurus Loadsi — in honor of the man and his company.

The Miiini, a small armored plant-eating dinosaur from south-eastern Queensland — from the book, "Kadimakara".

MONASH REVIEW

MAY 1986
Part of the expedition has been supported by Earthwatch, an American-based private research funding organisation through which volunteers pay for the privilege of working on research in the field.

Volunteers also have come through the Friends of the Museum. In particular a housewife, Mrs Lesley Kool, has become an expert in preparing fossil material, teasing the enclosing rock away with a fine needle.

Another volunteer, retired engineer John Herman, has rigged a 300 metre flying fox to carry rock from the site to the top of the overhanging cliff.

And the team has been able to call upon the services of groups with access to helicopters, such as the Victoria Police, the State Emergency Service and the Surf Lifesaving Association of Australia, to help lift material out. Even the local district school children have been involved in the dig.

Already this year more than seven tonnes of fossil-bearing rock has been excavated, which is similar to past years.

For its pains the team is starting to build up a good picture of the backboned animals of the area 110 million years ago. The site has been dated by a Melbourne University group using the fission-track method. And other researchers have been studying the botanical environment in which these animals existed, using pollen to crosscheck the dating.

The only similar site on earth producing “polar” dinosaurs is in Alaska and is not nearly so well described.

But Dinosaur Cove is only one part of an impressive outpouring of information about Australia’s prehistoric fauna that has occurred in the past 25 years, a flow of information that has changed the whole picture of how Australian backboned or vertebrae animals evolved.

The story of how some of those findings came about and what they tell us about our past environment is to be found in the recently released book “Kadimakara: Extinct Vertebrates of Australia,” edited by Pat Rich and Dr Jerry van Tets of the CSIRO and illustrated by the CSIRO’s Frank Knight. It is written specifically for the layperson and is structured around Knight’s impressive color reconstructions of prehistoric Australian animals.

The idea was a joint one and the opportunity to write such a book outside the constraints of a scientific audience was eagerly seized. “There’s a lot of information in it which hasn’t come out yet even in scientific papers. Some of the animals mentioned don’t yet have scientific names. One was only discovered as the book was being written.”

Kadimakara is a South Australian Aboriginal word meaning “animals of the Dreamtime.” The book, which is published by Pioneer Design Studio of Lilydale, is a handsome hardback selling for $45.

Dr Rich’s research is supported by the Australian Research Grants Scheme, the Museum of Victoria, the National Geographic and Atlas Copco.

MONASH REVIEW

OPEN DAY

SUNDAY MAY 25, 1986

MONASH UNIVERSITY

10.30 AM - 4.30 PM

This is the face of Monash today — 25 years and more than 37,000 graduates on. And to celebrate its 25th anniversary, the University will be holding a special Silver Jubilee week culminating in an Open Day on Sunday, May 25 from 10.30 a.m. to 4.30 p.m.

The Silver Jubilee Open Day not only will be a chance for past students and their families to become acquainted with the 1986 campus, but also for prospective students to find out about what courses are offered and the sorts of careers to which they might lead.

In the meantime, Granny can be learning how to dial up information using a microcomputer, while younger brothers and sisters can explode their horizons at the chemistry magic shows.

On the Monday of Jubilee Week (May 19), the Duke of Edinburgh will launch the celebrations at a special graduation where he will receive an honorary Doctor of Laws degree from the University. He will also present medallions to those who have served the University for 25 years. The medallions, designed in bronze by sculptor Matcham Skipper, depict a male and female hand symbolising the equal contributions of the sexes to the University’s growth and development.
Seeing a future for robots

From Page 1

To achieve a robot needs to be able to discriminate between what it has to do and what it has to avoid. Such decisions can only be made on the basis of an appreciation of the surrounding environment — hence the need for vision.

Jarvis said people often speak in terms of three generations of robots. The first generation are the "pick and place" robots which simply move things from one set position to another — for instance, stacking a pallet in a warehouse.

Second generation robots have programs built into them and can be led through a sequence of actions which they can then repeat until they are stopped or break down. "They must operate in a structured environment. They cannot react to or tolerate change. If something is slightly out of place, they will either miss it, pick it up badly or smash into it."

These position robots are only now starting to be joined on the factory floor by primitive third generation robots with some sensory feedback incorporated.

Professor Jarvis said his fascination with robot vision grew out of earlier computer work in pattern recognition and image processing. "With image processing it was hard to tell a good result from a bad one. It was very subjective and depended on the description of images."

"But with robots you are modelling hand-eye co-ordination, and you can't cheat. If you do the job right, the robot should be able to achieve things."

Because of the limited resources in Australia for this kind of research, Jarvis sees himself as in the business of proving the feasibility of new ideas rather than developing them to the full. At the moment, he is involved in five lines of research.

The little robot clearing the tray of blocks is the result of one project.

Multiple views of the piles of blocks were taken, some from the side and one from on top. These were combined in the computer to build up a solid model of which bits of space were filled and which were empty without learning anything about how the space was filled — if, for instance, it is one block or two stacked up on top of one another.

The robot simply was programmed to try to pick up the filled space at the top of each pile, and when that was complete, to repeat the same analysis and action till all the blocks were removed.

Jarvis now is trying to develop a more flexible approach to the same problem. Instead of using multiple fixed cameras independent of the robot, he is going to use one camera in the hand of the robot, which can therefore be moved around taking different viewpoints of the piles from many angles, and making it easier to determine, for instance, how many elements comprise each pile of blocks.

"The way it is, there's no way obviously would lead to a much wider range of applications for any one machine, and is much closer to the ideal of the independent robot."

A third project is to build a computer graphics package to simulate a robot's workspace, so that robot actions could be tested on the computer before they are tried out, to ensure they could be repeated in the real world without banging into things.

Quite clearly such a program would have great application to the factory floor. But to Ray Jarvis it is an important component in his other two lines of research.

One is to develop a mathematical means of using simple vision and range data from a moving robot to calculate the most efficient path between two points avoiding all obstacles.

"There are quite straightforward approaches to this for two-dimensional problems such as a maze on paper. But in three-dimensions it becomes very, very complex. The concepts are well founded but the amount of computation is huge. I think there may be some short cuts, some new approaches."

The second is the practical outcome of the first — to build automated vehicles guided by ranging and vision which could learn about their environment.

"My ultimate goal would be to plonk a device in a completely foreign space and let it come to terms with that, rather like a new student coming to terms with Monash."

In fact, according to Jarvis, despite the fact that the attempts at robot vision so far have turned out nothing like biological vision, the more we know about human vision, the more it will be for those working in robotic vision. Already researchers in the robot area have come up with some fascinating parallels to the biological world.

For instance, a group at the Massachusetts Institute of Technology working in the late '70s on the mathematics of how to determine where edges occur, came up with an answer that correlates almost exactly to biological phenomenon of lateral inhibition, the way that animals accentuate edges.

More recently, another researcher working on how to determine movement using two slightly displaced images (such as happens with our eyes) produced a solution that so closely paralleled the human situation that it even accounted for some optical illusions, where the eye is fooled.

But such work also has confirmed that the problem of robot vision will not be an easy one to crack.

Professor Ray Jarvis of Electrical Engineering observes one of his eye-in-hand robots. "It's extremely complicated, much more complex than anyone ever thought," Jarvis said. "Despite great strides in the development of computational power, we are still orders of magnitude short of what would be needed to solve the problem."

Now we've yet come up with a robust theory of computer vision which could lead to a complete operating system. It's the classic ill-posed problem. Even the problem of definition itself is evolving.

Professor Jarvis' research is supported by money from the Australian Research Grants Scheme, a Monash special research grant and a CSIRO collaborative research grant in information technology.

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MAY 1986
Dean looks at Octopus eyes

From Page 1

"The question I'm really asking is 'Are there any rules in common across animal vision systems? If there are, then those aspects of vision must be especially important.'

Muntz said one such aspect is what is known as lateral inhibition -- it helps animals detect edges. It has been found in every visual system studied. And researchers working independently on computer vision recently came up with a mathematical model that parallels the biological situation closely.

Perhaps surprisingly another common feature is color vision. Despite the old belief that only monkeys and men could see in color, Muntz said that every mammalian eye so far tested (and many eyes from other groups as well) can detect color. The only animals in which color vision is conspicuously absent are those living in the deep, where color is absent anyway.

In fact, even though there might be vast differences in the paths by which they evolved, many of the characteristics of animal visual systems can be correlated with the environment in which they live. The ability of cats to see in the dark and the acuity of hawks' eyes being two obvious examples.

And studying these differences has been an important part of Muntz' work. "My research has been almost entirely on aquatic animals because they are more varied than terrestrial animals, and so is the light environment in which they operate. Migratory fish, for example, go from very clear saltwater to very turbid freshwater within their lifetime."

What Muntz found when he studied such fish, was that their visual pigments, which govern the colors to which the eye is most sensitive, change with environment. Even more extraordinary, the changeover is set in train even before they enter freshwater suggesting it is linked with the hormonal system which signals migration time.

Another group, which includes the toadfishes, slip on sunglasses during the day. Exposure to light stimulates a yellow pigment to cover their eyes. It is a reflex response that can be triggered by a light flash of less than one hundredth of a second, although it takes about 20 minutes for the pigment to flow into position just as with sunglasses, the pigment reduces the sensitivity of the eye to light but also reduces glare and helps the toadfish to see its prey.

The pigment response is one of an interesting set of mechanical movements in the toadfish eye sensitive to light. These photo-mechanical elements form part of Bill Muntz' on-going research.

In the human eye the photoreceptive cells that form the retina at the back of the eye are stationary and light is focused onto them by a lens at the front of the eye. But the toadfish can actually move the retinal cells themselves towards and away from the front of the eye to follow moving black and white stripes, to measure its visual acuity, how well it discriminates things. The Nautilus is placed into a vertical cylinder of sea water and sets of stripes of varying width are rotated around the outside. If the animal can make out separate stripes it will follow them around the cylinder.

"Nautilus can discriminate down to about the width of a 20-cent piece at a distance of just under a quarter of a metre. In comparison, humans can discriminate to about that at a distance of about 250 metres and bowlers at about 600 metres," Muntz said.

To measure sensitivity, the animals are tested on their ability to select a light of carefully controlled brightness at the end of one arm of a Y-maze.

Muntz is running similar tests on Octopuses, an animal on which he started working when he was doing his doctoral research. The eye of the Octopus has a completely different structure from that of the mammal, and yet it can perform almost all the same functions.

"It's a classic example of evolution converging," Muntz said. And it should comfort those working on robot vision to know that it is possible to get similar performance to the human eye without actually reproducing it.

Muntz' measures of sensitivity and acuity quite easily translate into the real world of the ocean. For instance, how long animals can see to feed at the depths at which they live, and how this changes seasonally depends precisely on how sensitive and acute their eyes are. In the deep sea environment that's the kind of information commercial fishermen would not mind knowing.

"Professor Muntz' work is supported by the Australian Research Grants Scheme and a Monash University Special Research Grant.

A myeloid body, concerned with making visual pigments, from the retina of Nautilus. This electron micrograph is 3/1000th mm across.

Professor Bill Muntz, Dean of Science.
Research, graduates: hope for the future

Monash University happened to be born at just the right time. By that I mean that it was opened in 1961, and that period — the '60s and the early '70s — was probably the high-water mark of Federal Government funding of universities.

So the facilities were probably better than had the university been established at any other time and reached 25 years of existence. (That, of course, isn't to say that the facilities can't be improved and shouldn't be improved.)

It means also that Monash attracted good staff in its years of fast growth in the '60s although they were young, but also probably better than the average quality at Australian universities.

It made it possible to achieve a very good international reputation exceptionally quickly in a number of disciplines right across the university.

The other side of the coin is that now, because the staff is not old enough to retire, it's perhaps even more difficult at Monash than most other universities to find places for young academics in the '80s.

In the very first years Monash used to offer scholarships to the three best students they could find in the sciences and the three best in the humanities, based on HSC results. I presume there was a fear that, because Monash was new and didn't have an established reputation, all the very best students would go to Melbourne. The fact that Monash didn't keep the scholarships going for long is an indication that, after a relatively short time, they weren't necessary.

In terms of conventional development, the university really can't go much further. It's extremely unlikely in the foreseeable future that it will get Government funds to expand in any significant student numbers or into totally different academic areas, such as, say, veterinary science or dentistry.

Apart from consolidating, the only way the university can move is in what you might almost call radically new areas, such as the University of the Third Age, using the existing facilities to cater for a group of people who would never have been university students for one reason or another, in this case because of their age.

Money will have to come from new sources, either from tapping in financial terms the intellectual achievements of staff, which is very much in its infancy, or from graduates as they get older and more financially successful.

I think that the university will slowly lose their resistance to commercialisation of their efforts. My view is that, as this occurs more and more frequently, the academic staff will feel their way through sure that anyone knows what the magic formula is, and it probably changes from time to time anyhow. But it is an issue where the senior personnel of the university will have to devote a lot of thinking.

The prospect of closer ties with industry also exacerbates the danger that industry could well offer big salaries to lure clever people away from universities. As far as I can tell that's already happening in a number of areas such as Computer Science.

The only faculty that seems to have grappled with the problem is the Medical Faculty where, of course, people in private practice can normally earn much more than people on university salaries. They gave some of the leading doctors various academic titles and various academic roles within departments in order to attract them, without stopping them working to varying degrees in private practice and earning much more.

There might be a move across the board generally to have more part-time academic staff at the more senior levels. So those people who feel they want to be part of a university department, and have whatever prestige there may be and the benefit of an intellectual environment, won't fall exclusively into one box or the other. For some period of the week they will be able to earn income outside the university, and in addition get a part-time salary for spending part-time hours within the university.

I don't think Australian universities will be as successful at tapping their graduates financially as American universities, but I don't doubt they could be more successful that they are at present. The universities would get a return on their dollar spent, but not necessarily a large multiplier effect.

But graduates have something else they can offer. They're not part of any direct interest group within the university, not being student or academic or non-academic staff. They are therefore unlikely to be pushing barriers for narrow sectional interests; but at the same time they're not ignorant of the important issues.

I would have thought that because graduates can offer an informed but probably more objective view than most within the university, there's great scope to take a sprinkling of them into decision-making forums.

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