"Color Vision for Road Following"

Prof. C. Thorpe

Question *(Prof. Y. Shirai)*:
Before I moved to Osaka University this April, I was at the Electrotechnical Laboratory which belongs to MITI. We have been studied about five years the possibility of launching a project similar to the ALV Project. We made a program as shown in figure (Table 1). Although the 0-th phase started, we are not sure if the following phase may start. The feature of the vision is the use of stereo vision for finding obstacles. My first question is why you do not use stereo vision for your ALV.

Table 1 Performance of SIMUS

No.	Number of Nodes	Scalar CPU* (s)	Vector CPU** (s)	Acc. Ratio	Vect. Ratio (%)
1	425	17.5	2.7	6.5	95.6
2	1825	243.8	17.0	14.4	98.4
3	4961	3077.1	103.6	29.7	99.3
4	10077	3566.3	154.7	23.0	98.8

* CPU Time Not Using Vector Processor
** CPU Time Using Vector Processor

Answer *(Prof. C. Thorpe)*:
Our first experiments with stereo were not successful. We had built a system for indoor use, and it worked very well in the lab where it could track high-contrast features such as books, bicycles and other robots. But outdoors, it was easily confused by trees and grass, which have few sharp edges and which change appearance when the wind blows. Stereo would certainly be useful for tree trunks, and for road signs and road markings. We would like to try new stereo ideas. But for now, our range scanner gives us fairly good data with less time and computation than for stereo.

Question (*Prof. Y. Shirai*) :
As shown in the figure, it may take a long time to make a really useful vehicle. However we expect byproducts in the course of the development, such as cars that transport objects at a restricted environment in a factory without special guides. My second question is what kind of byproducts do you expect.
The last question is your program or expectation of the ALV.

Answer *(Prof. C. Thorpe)*:
I would like to answer to the second and third question together. This figure (Table 2) is made at the NATO ALV Work-shop.
For example, toys are already made by a Japanese toy company "Tomy". The left figure (in Table 2) is my prediction. A watch dog is easy because it just wanders around inside a factory randomly. A factory transport is not easy to predict because the definition is not clear. A street sweeper or a garbage collection vehicle are interesting applications. Since they can move slowly at night, they may be realized much easier than autonomous cars. Graefe in Germany predicted a chauffeur in 7 years. It may be possible only for highways like "autobahn". I can not rely on an autonomous car unless it is able to change a driving strategy depending on a case where a gentleman is driving carefully and where a young guy is driving with a girl friend in a car already damaged. As a whole my prediction agrees with that of Dr. Shirai.

Table 2 Analysis conditions for thermal stress behavior

Items	Conditions
	T-joint pipe 18inch-10inch Material: Type304 stainless steel
Welding	Temperature cycling in the last pass Weld heating time: 4.5 sec
Program	ANINA/ADINAT
Analysis model	Element: 20 Nodes 3D-element Number of elements: 204 Number of nodes : 1258

Question (*Dr. E.A. Metzbower*) :
Are you pursuing the concept of parallel processing for your different sensors?

Answer *(Prof. C. Thorpe)*:
Yes. Our WARP supercomputer consists of 10 boards, each almost a general purpose processor. Each board can do 5 million floating point additions and 5 million floating point multiplication per second, so the whole machine can do 100 MFLOPS. We have tried using half the machine for range data and half for color vision, plus using workstations for path planning and map tasks.
Parallelism helps especially for low-level processing such as finding edges and lines, but we still do not know how to parallelize many higher-level functions.

Question (*Prof. E.R. Wallach*) :
Both you and Prof. Shirai have suggested various kind scales by which applications of autonomous road following might be used and also the limits on road speed of present system. You seem to have the algorithms to handle the data needed, so is it the restriction imposed by

the hardware used to collect the data and by the speed of computers used to process the data that prevents future progress? If so, advances in computing might mean that the Muescales referred to by you could be brought forward considerably and that vehicles might be able to operate at higher speed.

Answer *(Prof. C. Thorpe)*:
Is the main speed limitation the lack of computer power? Yes, mostly. If had much faster computers, we could drive more rapidly. There are still some sensor limitations. For instance, our range scanner takes 1/2 second to scan an image. If the vehicle moves too far during that time, we can get smeared or stretched images. Color cameras are faster, getting an image in 1/30 second, so maybe stereo vision will be better. But even with fast computers, there are still many areas that we do not understand well enough to build reliable systems for all situations.

"The Trends of Supercomputer"

Mr. M. Maruyama

Question
User environment is very important for usage and architecture of supercomputers. How many jobs are processed simultaneously at your supercomputer in typical?

Answer *(Mr. M. Maruyama)*:
Depending on situation, but typically 4 to 5 jobs are executed simultaneously.

Question
How do you think degree of parallelizm in general purpose application software?

Answer *(Mr. M. Maruyama)*:
There are the following four kinds of parallelizm; 1) job level, 2) subprogram level, 3) job step level, and 4) loop level. Job level is taken care by scheduler in the multiprograming environment. Subprogram level and job step level are depending on algorithm of applications. Loop level is similar to vector processing. Combining all parallelizm, degree of parallelizm is very high and multiprocessor architecture is natural for that purpose.

Comment *(Dr. T. Shimizu, S. Sakata)*:

Abstract
An Outline of the structure analysis program SIMUS, which was developed for HITAC S-810, is described. Some examples of computer simulation in structural design are shown. They are oxidation process of semiconductors, thermal stress variation during welding, and large deformation of a solid.

1. Introduction
In engineering and design of machines and devices prediction of their performance and reliability can be carried out by computers. Particularly in the development of new machines and devices a number of computer simulations are carried out to estimate vaious aspects of mechanical engineering such as structural integrity, vibration, fluid- and thermo-dynamics and so on. Recently a remarkable progress in computer simulation technology has been noted because of the introduction of supercomputers as well as advanced numerical analysis methods like the finite element method. In this paper some examples of computer simulation is mechanical engineering and design field are introduced.

2. Structure Analysis Program SIMUS for Supercomputer[1)]
Structure analysis program SIMUS and developed on a supercomputer of HITAC S-810/20. In order to fully utilize the powerful capability of the supercomputer, the following items are very important. (1) The use of D0 loop to get high ratio of vectorization (2) The use of longer vector to get high speed of vector operation (3) Parallel utilization of multi processors. The analysis model shown in Fig. 1 was used to see the capability of SIMUS in terms of computing time. Test results are summarzed in Table 1. The computing time was shortened to 1/30 compared with the conventional scalar operation.

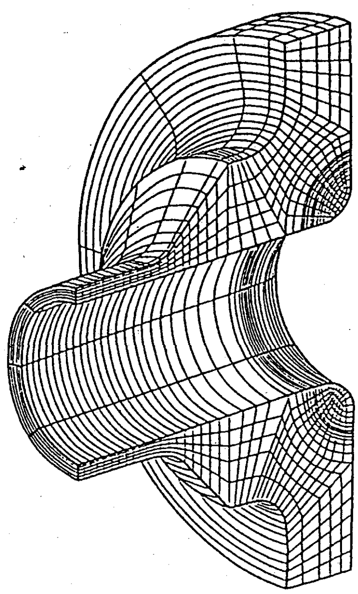

Fig. 1 Analytical model (Ex. No. 4)
No. of Node: 10077
D.O.F: 30231
No. of Element: 1992