Welcome to Pravin Varaiya as new PATH Director

On July 14, Pravin Varaiya, James Fife Professor of Electrical Engineering and Computer Science at the University of California at Berkeley, took the wheel from Acting Director Steve Shladover and became the California PATH Program's third Director. Professor Varaiya, who has served on the PATH Executive Committee since its inception, was also one of PATH's earliest faculty investigators. "I came into PATH in 1989," he says, "when Adib Kanafani in his wisdom thought PATH should look outward beyond traditional transportation management to such other disciplines as mechanical engineering, electrical engineering, and computer science."

Prof. Varaiya's early work was in system theory and urban economics. In recent years he has published extensively in the areas of automatic control and automated highways, including PATH publications Sketch of an IVHS Systems Architecture (with Steve Shladover, 1990), Smart Cars on Smart Roads: Problems of Control (1991), and the forthcoming SmartPath: an Automated Highway System Simulator (with Farokh Eskafi and Delnaz Khorramabadi).

"Although my research involvement has been principally or almost exclusively in AVCS," Varaiya says, "I have a long-standing interest, going back to my work in urban economics in the '70s and '80s, in other areas: transportation planning, land use, ATMIS—virtually all aspects of PATH activity."

"I see the director's job as twofold, because PATH has two clients, Caltrans and the University. Caltrans provides PATH with funding,
Conference Update

Transportation Management

PATH researcher Bret Michael presented a paper titled "Information Requirements for Managing System Safety of Software-Controlled Automated Highways" at the Transportation Management Conference, May 24-26, 1994. The conference was sponsored by the Graduate Program and International Transportation Research Center, State University of New York at Buffalo, located at 30 Schuyler, Throgs Neck, New York.

Dr. Michael's paper examined possible requirements for the collection, maintenance, and dissemination of data from the effect of advanced control system (AVCS) software behavior on the operation of an automated highway system (AHLS), with an eye toward maximizing opportunities to improve highway safety. The data requirements for a highway safety management system are considered from the perspective of a risk-based model of software safety.

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and PATH provides it with research, engineering, and policy analysis expertise. There's substantial autonomy from the University. Many professors work on PATH projects without being paid, because although UC faculty can be paid during the summer, they do PATH work during the other nine months. And graduate students are paid much less than in industry. In return, the University demands first-class research and that the grad students be trained properly. Having a faculty member as director of PATH gives us an opportunity to bring the activity closer to the University's educational functions of supervised research — perhaps teaching can be more closely integrated as well.

I think that Caltrans and the California taxpayers got a very good return for their investment in PATH. The recent budget cut resulted from the overall state budget problem — has forced us to take a very serious look at priorities and see what are the things that we must keep doing and what are the things that we shouldn't do because we will only do them poorly, given the cut.

But the reason I took the director's job was not to handle the budget cuts. It's because PATH is an exciting field for research and development. PATH is a truly multidisciplinary activity, involving most branches of engineering, economics and planning. Aspects of PATH research require legal and institutional analysis and design. PATH researchers (staff, students, faculty) work closely with professionals in transportation management and planning and in industry. Last, but by no means least, PATH brings together academic and other researchers from across the state.

Over its brief history, PATH has succeeded in breaking down disciplinary walls and geographical barriers. This is in part due to the nature of its funding, which is largely due to the vision of the intellectual leadership in PATH and Caltrans that shaped a broad and integrative vision of research and development. In the end, that is why working in PATH is exciting.
Working on Safety in PATH

It is humanly impossible to design a large system that is perfectly reliable, and equally impossible to know exactly how reliable it is. But by good management of specification and good management of design you can improve your chances of creating a system that you are quite sure is quite reliable. The safety of an automated highway system depends on the way the whole system fits together. Safety must be in the specifications as a system requirement, like the requirement that vehicles follow one another in platoons. You cannot fix it on afterwards, like a bumper sticker saying “belt up!”

There will be half a hundred or more researchers and designers involved in design. You can’t know what the system they create meets safety criteria if you do not know what it is that has been designed. So complete specification is the first prerequisite for determining whether a system, an IVHS system or any other, meets the requirement space, including the safety criteria. At the very least, you will know what you will finish up with, in full detail, and in a logically organized way.

Preliminary Hazard and Fault Tree Analysis

Just as the system cannot be perfectly reliable, it cannot be perfectly safe. The safety criteria will specify certain things as hazards — things that you don’t want to have happen, like people being killed, or oil leaking into San Francisco Bay. Hazards are determined by preliminary hazard analysis, which involves looking at the system concept in a systematic way, and deciding what things might go wrong and whether or not to worry about them. The safety criteria will specify either that no faults must occur independently before a particular hazard can take place, or that it cannot take place more often than once every 10 years or every 100 vehicle-miles, or whatever.

My first task at PATH was to do the preliminary hazard analysis for an automated highway system, and then to create a detailed example that would show, in detail, what had to be incorporated into the design to cope with fault conditions. The design had to be modular, for as technology advances modules are going to be replaced, and one should not have to repeat the entire safety analysis every time there is a new design. Also, there had to be a safety-critical subsystem, such that nothing outside it could influence what was inside it. Next, fault tree analysis would have to determine whether the system specified in the example did in fact meet the safety criteria. It did not, for I had made mistakes, as all designers will. They were correctable, but I did not correct them, for it was my objective to demonstrate that the analysis would find errors, rather than to design the complete system.

About this time (1991) Steve Shladover and Pravin Varaiya had proposed their five-layered architecture [1], in which the safety-critical subsystem resides in the lowest three layers. A little later, Varaiya and his students published a partial (normal operation only) specification of a system very different from mine [2]. It was attractive, because it maximized vehicle-borne intelligence, whereas mine had had most of the intelligence at the sides. It provided the basis for an excellent second example for a fault tree analysis. Again, faults were found. I concluded that complete specification and fault tree analysis was a satisfactory method for designing an AHS that met safety criteria, and demonstrating that it did so. All this is reported in my 1992 paper “Methods of Analysis of IVHS Safety” [3].

This work is far from complete, and should be followed up. All that I have done is to specify and do fault trees at the “coordination layer” level. The specification of each subsystem is the specification of the relevant modules, which are part of a whole system that has been shown to meet the criteria. The conformity of each subsystem’s design to its specification should be investigated using the same hazards, and this process should be repeated with the sub-subsystems until eventually the system has been fully designed, and any departures from specification have been identified.

Safety Criteria

The next stage of my PATH work was to develop a method of analyzing the motions of cars resulting from the occurrence of a fault on an automated lane, so as to predict any ensuing deaths or injuries of varying severity. This raises the possibility of using the ultimately desired form of safety criterion — minimum allowable death or injury per vehicle-mile — as a benchmark for verifying the system’s conformity to specification, either by determining whether the system meets the specification or, worse, the problem in reverse, determining what level of system reliability an “acceptable” injury toll requires.

The injury toll per incident for a given kind of failure in an AHS system depends on the system’s layout, design, and operational mode. These factors can make for large differences: factors of ten or more between injury rates for different modes of operation are the norm.

For an AHS system accessed from manual lanes on the same freeway structure there are four principles to ensure the least rates of injury per incident:

- No manual vehicles on high-capacity automated lanes.
- If manual vehicles were permitted on the automated lanes, they would continue to have accidents at present rates, but the consequences of these accidents would be more severe than at present because of high speed and high flow on the automated lanes.
- A high barrier between automated lanes and the other traffic.
- This is to prevent accidents on the manual lanes from spreading onto the automated lanes. Paul Jovanis and Mohammed Anwar have shown that on a 25 km stretch of the Santa Monica freeway, accidents from one lane intruded on others 273 times in two years [4]. Without a barrier this would have meant more deaths per vehicle mile on the automated lane due to this one cause than occur now due to all causes in conventional traffic.

0 Operation in platoons.
- Any other configuration produces many more, and more severe, casualties when longitudinal system fail. Shladover has pointed this out for pairs of vehicles [5].
- No winning of two platoons, or a vehicle and platoon, on the same automated lane at operating speed. Longitudinal control failures have more serious effects when platoons are joining.

The figure below shows the only layout and operational mode I have found that meets these four principles [6]. The high barriers between automated and manual lanes are shown, as are the “gates,” which are gaps with no moving parts that permit entry and exit. The low barriers between automated lanes help to confine a blockage to one lane, but are not vital to safety.
Visitors to PATH

Visitors from China

On July 27, a Chinese Higher Education Delegation visited PATH Headquarters. The delegation, hosted by PATH researcher Wei-bin Zhang, consisted of Presidents and Vice Presidents of five Chinese Universities and officials from the Chinese Ministry of Railways. Dr. Steve Shladover, PATH Deputy Director, gave an overview of the PATH Program, and the visitors were given a demonstration ride in the automated lateral control test vehicle. Before visiting PATH, the delegation met with Chancellor Chang-Iin Tian and Associate Chancellor James Hyatt, toured the Department of Electrical Engineering, and visited with Professor William Garrison at the Berkeley Institute of Transportation Studies.

The visitors were: Mr. Guanmo Chen, Director, Bureau of Education, Ministry of Railways; Zhong Li, Chairman of the Board, Southwestern Jiaotong University; Yongsheng Zhang, Vice President, Northern Jiaotong University; Meng Li, Vice Chancellor, Shanghai Railway Institute of Technology; Shiwen Gu, Chancellor, Changsha Railway Institute of Technology; Baolin Xu, President, Eastern China Jiaotong University; and Xingyou Yu, Deputy Chief, Bureau of Education, Ministry of Railways.

... from Korea

Twelve delegates from Korea, representing universities and major industries, visited PATH shortly after the 1994 IIVHS-America Annual Meeting. Recently, the Korean government established a research organization to develop and implement an IIVHS national program in ATMS. The purpose of the visit to PATH was to learn about the PATH research programs and to explore the possibility of technology transfer. The delegates met with the PATH ATMS group led by Program Manager for ATMS Stein Weisbeinberger. They also met with the AVS group to find out about the automated control devices being developed at PATH. Six of the delegates were from major universities, including Seoul University, and the other six delegates represented major industrial companies including Hyundai, Goldstar and Samsung. Their hosts were PATH researchers Y.K. Yim and Sei-bum Choi.

PATH on Video

In early August, a production crew from IMPACT Films’ Environmental Impact Resorts unit interviewed Deputy Director Steve Shladover, and then filmed the Lateral Control Test Vehicle in action. They produce short segments on environmental subjects and then syndicate them to television stations around the nation to be used in news programs.

Arrivals

PATH Research Staff

Satyajit Patwardhan joined PATH as a Postdoctoral Researcher in May, working on lateral control of vehicles with emphasis on fault tolerant control schemes. He has a Ph.D. in Mechanical Engineering from U.C. Berkeley. He received his M.Tech. degree in Mechanical Engineering from Indian Institute of Technology, Bombay, and B.E. in Mechanical Engineering from the University of Poona, India. His Ph.D. dissertation emphasized the tire burst and sensor fault detection schemes for the PATH program.

Eric Johnson joined PATH as a Development Technician in March. He is an electromechanical technician with experience in naval avionics, manufacturing quality assurance, electronics R&D and auto mechanics. He will assist PATH mechanical engineers. Eric has a degree in industrial technology and administration with an emphasis in methods and materials.

Ching-Yao Chan joined PATH in May as an Assistant Research Engineer. He will be working on advanced vehicle control systems under an FHWA-Caltrans cooperative agreement. He has experience in accident reconstruction and analysis with computer simulation and animation and has done research and design of vehicle occupant restraint systems. He has a Ph.D. and M.S. in Mechanical Engineering from U.C. Berkeley. He has a B.S. in Mechanical Engineering from National Taiwan University.

Benedit Tse joined PATH in February as an Assistant Development Engineer. He has an electrical engineering degree from U.C. Berkeley where he will be returning to study for a Masters. While here at PATH he is designed and constructed printed circuit boards for the lateral control car.

V.K. Ramji Narendran joined PATH as a Visiting Postdoctoral Researcher in July working on topics of automated vehicle control. He has worked with PATH in the past as a graduate student under Professor Karl Hedrick. His Ph.D. and M.Eng. are from U.C. Berkeley in Mechanical Engineering. He also holds an M.S. in Industrial Engineering from the University of Alabama (Tuscaloosa) and a B.S. in Mechanical Engineering from the Regional Engineering College, Rourkela, India.

Visiting Researchers

Christine Weis joined us from the Technische Universität München, where she is a student of Professor Harmut Keller. She is studying European and American approaches to ATMS.

Jean-Luc Ygneux rejoins us from INRETS in France to study the role of private information providers in the Transfino project. He previously spent the 1989-90 academic year at PATH.

PATH Administrative Staff

Nanette M. Woodson joined PATH as a Contract & Grant Assistant in May. She will be preparing and reviewing budgets, MOUs, equipment orders, purchase requisitions and other administrative duties. She has a Master’s in Public Administration and a B.A. in Political Science from California State University, Hayward, and was formerly a hearing assistant with the U.C. Berkeley parking citation office. She also brings experience from the U.S. Department of Energy as a contract specialist and budget analyst.

Barbara Cooper joined PATH in April as a Contract Specialist/Buyer. She will be working on the commercial subcontract awards for all PATH projects. In addition, she will be responsible for procurement of goods and services for the daily operations at PATH. Barbara is a VERIP III retiree with over twenty-five years of experience in procurement at U.C. Berkeley.

Brian Reifste came to PATH in early July and will stay for one year as a research assistant on the Transfino project. He will concentrate on institutional and legal evaluations. This is his third stint at PATH: the first and second were in summers while he was undergraduate Berkeley. He is now on leave of absence from Hastings Law School after one career change year there, and plans to abandon it for art school in Fall 1995 to become an interior designer. Brian Reifste holds a Social Sciences (field major with a concentration on Hofiogian and Austrian) and has studied Aesthetics at a Fulbright Scholar in Vienna.

Departures

Bobby 'eramill-Rao has returned to England after almost three years with PATH as a Visiting Postdoctoral Researcher and Assistant Research Engineer. He is embarking on a major career change: he accepted a position in the London office of McKinsey and Company management consultants.

Nobuyuki Takanaka has returned to Japan to resume his work at the National Research Institute of Police Science after one year as a visiting researcher at PATH.

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Working with Safety

References


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Michael C. Kleiber
Librarian
University of California, Berkeley
ITS Library
409 McLaughlin
Campus