ported that the submissions had received far more than expected. The submissions by the authors from nine different countries were selected as full paper for presentation 11 papers and 25 papers were accepted as poster presentation. In the opening keynote speech given by Dr. David Mizell from Desana System Inc., he had given a presentation on Competing Visions of the Future of Augmented Reality and Wearable Computers. The same day during the evening plenary, not only the participants could enjoy a great dinner, Prof. Masaki Fujihata from Tokyo National University for Fine Arts and Music made a talk about the InteractiveArts and presented many pieces of his very interesting works.

On the second day, the Technical Demonstrations gave very good chances to the participants to experience various applications on MR technologies. The Mixed Reality Systems Laboratory Inc., a co-sponsor of this symposium, had made the Final Report of MR Project and demonstrated the MR Technology Showcase that showed the feasibilities of applying MR technologies to today's technologies. Apart from that the MR System Laboratory Inc. had also delighted the participants by the delightful interactive MR in the Media Art Gallery.

Finally, the Panel Discussion on the topic of the future of Mixed Reality could draw full attention from the audiences. The panelists raised up and discussed on many significant issues about MR technologies especially in the television and movie industries, which would become closer and closer to our every day life. At the end Dr. Hideyuki Tamura, ISMR 2001 Vice-Chair, made the Closing Remarks. As one of the participants of ISMR 2001, I would like to express my thank the organizing committee and staffs on their great efforts for such a valuable symposium.

◆ ISMR 報告 (3)

Keynote Address.
Tools vs. Clothing: Competing Visions of the Future of Augmented Reality and Wearable Computers

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A provocative keynote address was offered by David Mizell, recently moved to Desana Systems (a network router start-up company) after a long stint at Boeing where he initiated several pioneering R&D projects in VR, augmented reality, wearable computers, and pervasive computing. Mizell began by noting that VR and AR share some issues with parallel computing (VR is a "customer of parallel computing"). Parallel computing, when it was at its peak of research activity and public interest, seemed inevitable. Academic and research interest reflect and stimulate general publicity from the press, commercial interest, and, especially in Germany and Japan, government investment. Parallel computers now seem not as inevitable as was once thought. Excepting a few large parallel supercomputers at government labs running nuclear simulations, etc., and companies like Tera notwithstanding, there is little use of general-purpose parallel processor supercomputers. Cray was sold (to aforementioned Tera) by SGI at a 90% discount. Thinking Machines is gone.

"Killer micros" preempted such applications of parallel processors, since a modern 1GHz uniprocessor beats 1000 1MHz processors, regarding simplicity of deployment and actual throughput. The set of problems that require supercomputing got smaller and smaller. The US government ignored open problems and technical issues, played favorites, and misinvested (in projects like the Strategic Computing Initiative). Researchers emphasized the wrong problems- software development (languages, compilers, CASE tools, etc.)- like a drunk looking for his keys under a lamppost instead of where he lost them because the light was better.

The critical problem was hardware-related: interprocessor communication latency. The time to execute a floating-point operation is significantly shorter than the time to move floating-point operands between processors. Parallel processors are not inherently difficult to program, but the basic difficulty lies in overcoming this latency. The Cray 1, released in 1976, was (only) a proof of concept prototype. Parallel computers are fast on medium-sized vector problems of interest to some researchers. Salespeople suppressed interprocessor communication development within computers, opting instead for "Macho-flops," so investors ran out of patience.

VR can be said to be in the same situation of confounding such optimism. Not many VR facilities at large industries and research labs are running expensive CAVE facilities. VPL is gone. SGI is in "free fall." In the US, there is little commercial or government investment. Part of the unreasonably raised expectations were the result of media hype about virtual sex (by people like the Whole-Earth Catalog's and WELL's Howard Rheingold, who coined term "Teledildonics") and virtual drugs (by people like the late Timothy Leary) and virtual everything (by people like VPL's Jaron Lanier), causing massive loss of credibility. Current HMDs (**h**ead-**m**ounted **d**isplays) tend to be like "brain buckets" - large, uncomfortable, and with low-resolution. Game companies like Sega and Nintendo didn't jump in and save the VR community.

In state-of-the-art VR and MR systems, latency rears up again: realistic virtual worlds require at least millions of polygons (at Boeing, a typical aircraft design used billions of polygons), which causes a slow frame rate, which suggests the need for graphics systems with much lower latency, a hardware problem. Computer Scientists are not in a position to prototype new, low-latency graphics hardware, so investors were told that key problem was software (world-building tools, etc.).

Mizell defined the "critical enabling capability" (or CEC) as the hardest problem in a given domain (like interprocess communication latency in parallel computation). Before the problem is solved, nothing else really matters. After the problem is solved, everything is basically refinement. For cellular phones, for instance, the critical enabling capability is not the user interface, but the radio network infrastructure. For the WWW, the design of browser software is not critical, but internet infrastructure is. For parallel computing, the CEC is interprocess communication latency; for VR, rendering latency. The CEC for augmented reality is tracking. We need trackers that are small, lightweight, low-power, fast, accurate, immune to interference, easy to set up and register, and inexpensive. Standard GPS is not accurate enough for most AR applications, since accuracy/precision is at the meter level rather than needed millimeter, and angular accuracy (from triangulation) even worse. A GPS transmitter placed in the corner of a room is more accurate and feasible for indoor applications. For wearables, the CEC is affordable high-resolution color display technology. (As a reference point, an off-the-shelf Cybernaut system costs about $6k.)

Unspoken assumptions about how AR systems and wearables will be used classify applications into two categories: a tool model and a clothing model. A tool model (like most of the prototypes shown in IEEE-VR'01, ISMR'01, and MiRai-01) conceives of an AR system as a specialized tool. One puts it on, does a certain job, and takes it off. A clothing model (as exemplified by the system shown by James Fung under the supervision of Steve Mann) is less focused. One dons such a system upon awakening in the morning, taking it off (maybe) only upon retiring to bed. Such a system does lots of different things for a user, all day long, probably some of them without conscious awareness.

Such different application assumptions lead to different research emphases: a tool model stresses hands-free operation, using technology like speech recognition, eye tracking (no laptop or palmtop), and stressing UI design (maybe we don't need pull-down menus and slider bars any more). A clothing model emphasizes the packaging, like the integration into clothing. Especially applicable technologies for the clothing model include AI, agent technology, image processing (face recognition, etc.) capability, and keyboard (or chorded substitute) design for text input. Ubiquitous tracking is also needed, since a clothing-style AR system will be used all the time.

The tool model is nearer-term, and more likely to attract investor attention in the next few years. The clothing model is longer-term, and must overcome social resistance to wearing a computer all day long. Both may transition eventually into widespread use, but neither may transition any time soon unless we're careful how to explain technology outside our community. "The best is the enemy of the good," quoth Mizell. If perfection is constantly and exclusively sought, adequate compromises might be ignored. In journalism, for instance, thoughtful analysis is too often defeated by sensationalism.

The good news, according to Mizell, is that researchers can't kill technology, only delay it. Parallel processing and VR are probably still inevitable. In the short term, researchers may not have to change research, but just what is said about it. Critical is the choice of spokesperson, and (through reporters) investors. The role of academic research in transitioning new technology is arguably nonexistent. Academic researchers can ignore the near-term, say within 10 years, but Dr. Mizell noted that many scientists have dual employment, working on longer term prospects at university while doing industrial consulting on nearer term projects, moving between the two tracks. Academic researchers are pressured to find something no one else is doing to publish. Mizell encouraged the community to be good salespeople, selling not just one's own work but the VR/AR paradigm in general. When the technology transitions to widespread broad use, everyone will win! He urged selling a general vision for the sake of the whole industry.