

Dr. Susumu Tachi: We now wish to start the panel discussion on Artificial Reality (AR) and tele-existence.

Will Virtual Reality Become Reality?

What kind of technology can realize this?

I would like to discuss this possibility in four aspects:

1) Can VR change future society?

If so, how it will change society and when?

Network society, education.

2) Prospects and potential for AR business.

Even though some of the leading companies already demonstrated this is a very feasible business venture, I think those people do not want to disclose the basis of their future business success in this public forum. But we can at least discuss whether such business looks promising.

3) One of the profound aspects of AR is that up until now there were many different conventional media: books, paintings, motion pictures, TV etc.

Do you think AR will become a new way of expressing human thoughts?

4) Dr. Sheridan of Presence, a new journal from MIT Press coming out this fall, will lead the discussion on whether AR will become a new independent field of science and/or engineering.

1) Future society

Dr. Tachi: I would like to ask Dr. Jacobson who served as the moderator of SCI.Virtual world network whether AR will become a key technology in future society.

Dr. Jacobson: "My feeling is that AR will affect some changes in society. I suspect it has done that already through press accounts and enlivening people's discussions of what some of their fantasy worlds would be if they could have them. People are often deadened to the possibilities by the daily grind of their existence and the routine tasks they go through and VR, even in its fantasy form in the press, has done quite a bit to relieve people from that kind of mental tension.

"As far as specific changes in society, I expect there'll be many like the car or radio or TV technology but it's hard to predict. One thing we'd try to do through our work is to improve the state of education. I think in working with teachers and students, we'll discover quite a bit about the state of education that will change the way we work with the VR technology.

Dr. Krueger: "I think the changes are going to be fairly fundamental. If you think about the world which has existed since Gutenberg and really since the invention of paper, intellectual work has required you to be sedentary. We complain in the U.S. about TV having made our children sedentary, but really paper and the book did that. If you want to consume intellectual material from other people or you want to perform intellectual work, you have to sit down to do it.

"So you have this tension between knowledge and information on the one hand, which is recorded in a static two-dimensional medium, and with action on the other. So it really means two kinds of people: information people and action people.

"The future envisioned here is a rejoining of the mind and body, so that now I can imagine doing intellectual work standing up, I can make it physically strenuous, I can make it something I do as I move around. My computer tools will bring all the world's knowledge with me in a sense, combinations of wearable, environmental and portable technology.

"I think this will be reflected in the arts as well because rather than being a passive consumer of entertainment, you'll be an active agent. We will all be invited to become artists and the art forms of the future will try to lead us all to be participants and I think that will be one of the key elements: our education will teach us to act.

"Education in the past, again because it was sedentary, taught us never to do anything. You were never asked to act, to perform a real project; engineers are lucky in that way but people in other aspects of educational study are really prisoners of the idea that they just write papers etc.

"We'll create new kinds of knowledge that will be based on motion, space and it'll probably take us hundreds of years to really fully explore that. I think the appearance of a new paradigm will energize the intellectual energy of the world in the near future. It's something new, exciting to think about.

"As Bob intimated, the idea works even if the technology does not yet work in its full form."

Dr. Sheridan: "Dr. Tachi asks the question will Virtuality become Reality and I think for most of us the answer is 'yes', to a large extent. We've heard some very exciting and wonderful ways in which this will happen.

"The meeting has been very positive throughout, so let me be a bit negative. I have some real worries and one of them is related to something I've experienced as a professor in an engineering school, and that is many of my students find that when they simulate a job on a computer, at that point they think they're finished with the job. I have a difficult time trying to convince them that is not the end, it still has to be put into the real world and be made to work.

"My second worry, this idea has already been mentioned at the meeting, but let me say it again: when virtuality becomes so close to reality, it's easy to forget which is which. Now we all know that, particularly in the entertainment world, young boys find a great deal of excitement in violence. Our television is full of it, the computer games are full of it. If we bring violence into the virtual world, I'm afraid that can so easily spread into the real world."

Prof. Hirose: "Concerning mechanical engineering, since Dr. Sheridan mentioned the negative side of it, I'd like to mention the positive side that I can see.

"This is something negative, maybe peculiar to Japanese people. When Japanese people use hardware in design, they tend to get carried away about the hardware itself. With the use of VR technology we may be able to re-position an idea over the hardware. Therefore VR may be able to overcome some of the shortcomings of the Japanese people.

Prof. Sato: "What I don't understand is that we call it Artificial Reality but maybe on the technology side there has not been that much improvement. Of course we have to flourish our dreams but if we are talking in the framework of 100 years, we probably have to wait for that to happen.

2) Prospects for AR business

Dr. Robert Jacobson: "Let me express in detail my thought on the change to society. It seems to me that all of us are at the stage when automobiles used to be built by cutting down the pine trees and carving a chassis out of the tree trunks. Then we'd get an expert who'd find a way to build the spokes to the wheel and this was even before there was synthetic rubber so someone would have to tap the rubber plant and find out how to make a tire. Gradually the pieces came together and someone found how to distill petroleum and then we had the automobile. However, it wasn't the automobile even as we know it today, it was something quite special and craftsmanlike.

"If you'd asked those craftsmen at the turn of the century what their opinion would have been about the technology and how it would have affected people, I suppose the main thing they would have said would be that it would have kept the streets a little bit cleaner.

"The truth of the matter is we can't project far enough in advance because in the North American setting, for example, had we had the foresight to find alternatives to the automobile many of us today would have chosen those alternatives. So that's an issue: how do we determine the effect of this technology?

"The second thing which impresses me is an important question but one which we haven't really addressed in these two days. That is: what about the people who actually use the technology?

"The virtuality paradigm says that the person is at the center of the system and that the person's perceptions and understandings and actions are the important results of the technology and yet persons is a big word. Those people, aside from the advertising people, engineers etc., never get represented at these meetings because we don't have room. But we need to find a mechanism to involve those people in the design questions early on, lest we build something which suits our particular likes and needs, but is completely different from what people could use to their best benefit."

Dr. Krueger: "One reason I've chosen to do my work in the setting of the arts is that I've presented my work from the beginning to the public at the same time that I've presented it to the academic and scientific communities."

Dr. Iwata: "Concerning the question: what will happen when VR becomes a real social infrastructure? When the human interacts with the outside world there are two kinds of interfaces: internal interface and external interface. Inner interface technology has greatly improved but we have to pay more attention to the external interface, particularly in the light of increasing environmental awareness."

Prof. Hirose: "What happens when reality and virtuality merge together? What is the definition of Virtual Reality? This

is the core of the discussion and sometimes it creates friction between Reality and Virtual Reality. We have created a head-mounted device and a data glove etc., we've made a great improvement in technology.

"On the other hand, there are people engaged in creating a fantasy world, and what happens when these two worlds merge? Using the earlier metaphor of the automobile, do we need automobile technology? When automobiles first emerged, we wouldn't have thought they would change our living world greatly. The same applies to the aeroplane created by the Wright Brothers. So we should separate the implementation side from the technology itself. If we are only concerned with implementation we might have some problems.

Dr. Tachi: "In order for VR to become the basic technology, taking the example of automobiles, road infrastructure was very important in its development. In terms of AR, in order to transmit high speed and large volumes of information, we need a network. In the future, the ISDN is a possible technology for which we foresee a bright future. Unless we have the information network, infrastructure, we won't be able to operate the technology smoothly.

"Another point is that in the case of automobiles there were all kinds of prototypes. T-type model of Ford came up ultimately as the prototype and after that we saw great development. The same applies to the hardware. In the future, as Dr. Jacobson

mentioned, we'll see a more standardized model and more compatibility.

"The second issue is related to the prospects for the business of AR applications."

Dr. Jacobson: "Dr. Tachi said telecommunications was the means by which VR would grow. I'd put it the other way and say that one of the things that will drive the VR development is the possibility of using it for telecommunications.

Telecommunications will be the number one industry for the VR applications and that many services will develop on the table of telecommunications.

"Other areas that we've been approached about would be in the pharmaceutical field for chemical synthesis and fabrication; in the health field for various kinds of medical and surgical processes as well as biomedical research. In the field of design and manufacturing, we already have several projects in our laboratory. Graphics design, including design of objects, for industry and marketing, is another big area.

"The area that's most neglected is education and the reason is that educational money, in our country at least, is diffused among many authorities who all have their own way of spending it. Consolidating the money to create the educational application is quite difficult.

"Another area is datavisualization: anyone who can take computer data and find a way to make it humanly accessible certainly is on the right track."

Dr. Sheridan: "I think datavisualization presents a tremendous opportunity which we haven't begun to really break through yet. One of the big challenges is when we have more than three dimensions we're trying to visualize.

"Clearly you can represent three physical dimensions on a computer screen by some perspective tricks, and you can use color, text or some other way of representing other variables. But if you've ever tried to arrange physical objects that differ by more than three dimensions e.g. shoes or cars, if you try to arrange them in four dimensions and then shift your computer view from one 3-dimensional set to a different 3-dimensional set, you find it's very difficult to comprehend. So we're still looking for a breakthrough in that realm.

"I disagree with Dr. Jacobson's earlier reference to standardization. It seems to me, particularly from a business standpoint, this field is much too early for standardization. A number of years ago we did an exercise with the American Bureau of Standards, with regard to robotics. They were asking if we should standardize certain things about robotics. The result of a two-day discussion was that it's too early but we should standardize the terminology we use to talk about robotics. We

found that words like 'friction', 'linearity' and other common engineering terms were being used by different people to mean different things. The same kind of thing may happen here, so I think it's important to standardize our language before we standardize computer codes, interfaces etc."

Prof. Sato: "Dr. Jacobson, I don't agree that education is a business because we're talking about human interface here but education is the most difficult human interface field. It will be another 100 years before we can use this technology in the field of education. Perhaps we're overexaggerating this technology's capability. A while ago CAD-aided education was very popular but the application of that technology was used in a completely different field of education. So I think we'd be wrong to have too high hopes for the educational field."

Dr. Krueger: "I think you're right that education won't be a technology driver because it doesn't have any money. One problem this technology would have in education is that it would change what we teach as well as how we teach and that is a political issue. I don't think the feasibility is that much of a problem, I'm sure there are useful ways that the technology could be used to teach. On the other hand I don't expect education to lead at all, it hasn't in the past, it's the last thing to climb on the band wagon."

Dr. Jacobson: "My comments shouldn't be taken to mean that education is going to be taken over entirely by VR and that tomorrow or 10 years from now you'll walk into the virtual classroom where there's no teacher and teach yourself. I don't believe that.

"But I do believe that the tools that are used for teaching can be enhanced through the VR experience e.g. we've talked about creating a virtual encyclopedia that one would access using technology. That technology would not be so different from what W Industries is doing with a CD-ROM, perhaps hooked up to some sort of 3-dimensional data set so that a person could prowl through the data and then go to CD-ROM to pull up important data. I do see education as a large market like the textbook market.

"I agree with Dr. Sheridan on standardization, that it's too early. Yet every time a computer manufacturer gives us a new piece of equipment and says can you plug this into the system, I want to say yes but I know the answer is no because the systems we're working with are so peculiar that we as a laboratory have to deny them access to the field of work in which we are conducting research. So the resources of an entire company are written off because they can't be made compatible in some way with the work that's going on in our laboratory. That's a tremendous catastrophe because we have so few resources to begin with. I wish someone would try to help us make more of this energy available to us through compatibility."

Dr. Krueger: That standardization issue though is not part of AR, it's part of technology in general at the moment. We have chaos in the marketplace. Everybody is screaming for help: even compatibility between machines of the same manufacturer from one month to the next is hopeless practically."

Dr. Sheridan: "About education, it's easy to say that technology in traditional education has been a failure, many companies have invested money in this and gone out of business. But the funny thing is that traditional schools are not the only way to educate and there are companies making money out of selling tapes to teach languages or other very simple virtual environment techniques. So I think there will be some very successful educational techniques. They may not be in the context of traditional schools."

Prof. Hirose: "I can't agree more with Dr. Sheridan. I think there are at least two kinds of education: one is formal, the other is informal. In Japan there is a preparatory school system to put students through university and college entrance examinations. So maybe VR-type technology could find an informal supplementary role first, and then gradually penetrate the formal education system. I think both formal and informal education should compliment each other."

Dr. Iwata: "My experience at the campus is that PCs are increasing and the best use is that after establishing an educational curriculum, some of the academic results are not achieved. But if you provide students with a PC and a very simple program, they can experiment so the course can achieve higher results.

"The biggest issue here is the cost. We have to successfully reduce the cost of VR technology so that we can give at least one computer to several students."

Prof. Hirose: "Referring to Dr. Jacobson's suggestion about standardization of terminology. In Japan we have the Japanese Industrial Standard for industrial goods which could be helpful."

Dr. Jacobson: "One question is how do we make the connection between the business application and the state of the research today? Most of the research does not have an immediate application and may not have for several years. However we need to develop means to keep the research alive and to make it progress to where it meets the applications.

"We don't have as much time as we'd like because there are other technologies which are vying for people's attention like computer automations that are doing tele-robotics, or people using HDTV instead of the virtual inclusive environment. Those are issues we have to come to grips with."

Dr. Krueger: "That's something I try to emphasize in what I do. There's a tendency in the U.S. that when we have something that works, to say that we should be doing long-term research in it rather than delivering it to the marketplace. It's important to think about things that could be delivered quite quickly. What this technology needs is a good demo, a delivery to the public in the next year or two where people can see the promise being realized.

"Computer graphics has had a wonderful momentum because it had promise but at the same time each year it provided something new that people could use. If this field looks too far out into the horizon and doesn't deliver something soon, and it's at least 22/24 years old now, then the people who invest in it, e.g. in the form of research, will get discouraged and there'll be a collapse, as there currently is with Artificial Intelligence."

Dr. Tachi: "To finish the discussion on the business side, I'd like to add some comments. The first-generation robot was introduced in the 1960s, the first product was introduced by the Unimate company and was made by Dr. Engelberger. It was the first robot as a product.

"Since then the application technology of robotics has been developed. In the 1980s companies generated profits by using industrial robots which have also developed into second- and

third-generation robots. In terms of VR I think we are at the 1960s stage of robotics. So I think we'll be able to find more business opportunities in the new generation products."

3) Could AR become a new media?

Dr. Krueger: "In my new book I have a few pictures of work that I find exciting, done by Alan Gevens in San Francisco. He has a helmet that you wear and there are 128 channels with EEG information. He has visualization of the brain thinking: different parts of the brain are illuminated, based on their activity during the thought process.

"What you might be able to do is take a person's inner state, their brain and physiological states and make more of that part of their external appearance. If you could watch the other person thinking all over the body in some sense, and get their reaction to what you were saying, you might realize much more quickly the emotional response, you might see things like confusion as they spoke. Whether it would really work we don't know but it's fun to conjecture about."

Dr. Sheridan: "With regard to the media question and AR, which we haven't really talked about, when we normally think of media we think of TV, newspapers or books where one person or a very small number of people create something and then it's observed by a very large number of people.

"VR permits a kind of media where two people, or a very small number of people, can interact. Of course the telephone is also a medium in this sense. A kind of media that we haven't dealt with very much is where many people interact with many people at the same time. In a meeting like this it's one person talking to you but with VR one of you could control an image here on the stage so that you could express your feelings to me, or to a whole group, without revealing your identity."

Dr. Jacobson: "When printing was first introduced in Europe, suddenly people could read people's feelings about one another and the result was not very beautiful. It was the beginning of the Wars of Religion and dispute on every intellectual point you can imagine. That spread to the U.S.

"So I don't know if harmony is necessarily the result of change in the media."

Prof. Hirose: "One of the advantages of VR is that it allows for a wide range e.g. informal information can be sent in mass volume to many destinations."

Dr. Iwata: "What we have not considered so far is tactile visualization. Soon there will be a museum where you can touch objects and there have been experimental museums like this. If we develop this tactile technology we will be able to enrich more of our active interaction.

Prof. Sato: "If we are to bring in the religious aspect as well, like Gutenberg, this would add another menu to our technology. If we want to talk about the media it is so vast but we haven't been able to utilize the television or telephone yet and I don't know when this will be feasible in the future. I don't know if this information volume would enhance people's imagination e.g. the radio was a greater stimulus to my imagination than the television."

Dr. Sheridan: "I find it very curious that AR is going in the opposite direction of evolution. In primitive animals smell and touch are the first to be developed and then hearing, and the newest part of the brain is the part to do with vision.

"In VR we've gone very far in developing vision but not in the other senses."

Prof. Hirose: "I wonder if we can develop any VR technology in terms of taste. One person in the museum says he's introducing food from all over the world and is wondering what will happen if we eat food in the VR world. It will be interesting in terms of multi-cultural understanding."

Dr. Sheridan: "Actually, we're doing that already because half of the food we eat nowadays is artificial!"

4) Is it possible for VR to become a field of science?

Prof. Sheridan: "In English the word 'doctrine' is a very frightening term because it suggests dictatorship or the military etc. Clearly there is a challenge to understand reality much better than we do and understand "presence". A few years ago Alan Newall first pointed out to me that to have a theory of artificial or virtual or tele-presence somehow suggests that we ought to understand actual or physical presence better than we do and we don't really have a theory of physical presence. I think these philosophical questions will take on a new meaning now we have the technology."

Dr. Krueger: "It's a psychological experiment in the sense that to do it well the first time requires us to understand how we work. It's a head-mounted display, you've got the outputs from a human and the inputs all captured for study and you can make an input/output model of what the human organism does and what it requires. What it does is it's right in the path of lots of science that's already under way, it's a new tool for science. It's a new problem for science and I think it is the scientific part of engineering, the science of invention. I think AR will be a feast of this kind of invention for some time."

Dr. Jacobson: "In my opinion it is already a new science, although not necessarily recognized as such. This is a political

consideration. Our peers may choose to acknowledge that the field we are now defining is not valid and I feel that at some point we may have to declare it for ourselves.

Prof. Hirose: "I am from the Faculty of Engineering at Tokyo University. The conventional engineering system is to produce some man-made objects and is therefore not specialized in human studies. However these gadgets have no meaning unless they're operated by humans."

Prof. Sato: "This is so esoteric that I can't keep up but I thought academic study was my field. VR technology has to know the knowledge and understanding of human behaviors and the right-hand brain-type of knowledge has to be promoted. This is not fully exploited in AR studies yet. At the moment AR research is just interested in the left-hand side functions of the human brain but my dream is to integrate AI and AR.

"Robotics is where AI meets the physical world. Therefore AR can provide what AI missed in the past i.e. some of the physical and human understanding, this is my personal view."

"On this we now wish to adjourn and close the two-day symposium on VR and tele-existence. Thank you very much."