Memory of the Early Days and a View toward the Future

Editors' Note: To celebrate Presence's *25th year of publication, we have invited selected members of the journal's original editorial board and authors of several early articles to contribute essays looking back on the field of virtual reality, from its very earliest days to the current time. This essay comes from founding editorial board member Susumu Tachi, who focuses on the idea of a "telexistence society" and outlines ways in which that can help us address an aging society and ever-greater needs for us to communicate globally.*

1 It All Started at a Conference in Santa Barbara in 1990

In 1990, from March 4 to March 9, virtual reality (VR) researchers (the name "VR researchers" was yet to be coined at that time) from all over the world gathered in Santa Barbara, California, to attend the Human Machine Interfaces for Teleoperators and Virtual Environments Conference. Professor John Hollerbach, then a member of the Engineering Conferences Advisory Committee of The Engineering Foundation, consulted Mr. Nat Durlach and Professor Thomas B. Sheridan of MIT, and with cooperation from Dr. Steve Ellis of NASA, organized the first historic world conference that can be considered as having given birth to the field of VR.

Professor Sheridan, Steering Committee Co-Chair, invited me to join the committee during the planning phase. In addition to collaboration in planning the conference, I presented a paper titled "Tele-existence and/or Cybernetic Interface Studies in Japan." This presentation introduced a robot avatar system of telexistence, which was conceptualized in 1980 (Scoică, 2015).

Figure 1 shows the cover page of the conference proposal. Researchers, not just from the U.S.A., but also from Japan, Europe, and other parts of the world, gathered and stayed at the Sheraton Hotel in Santa Barbara where everyone presented their own research; the discussions continued throughout the day.

Joining me from Japan was Professor Michitaka Hirose, a visiting scientist in the U.S. at that time. Participants from other countries who were considered VR pioneers included Professor Dick Held, Professor Larry Stark, Professor Blake Hannaford, Professor Tom Furness, Dr. David Zelter, Professor Fred Brooks, Mr. Jaron Lanier, Mr. Scott Fisher, Dr. Elizabeth Wenzel, Dr. Michael McGreevy, Professor S. K. Ganapathy, Professor Bob Stone, Mr. Myron Krueger, and Professor Tony Bejczy (see Figure 2).

In fact, at that time similar research was being conducted in various fields around the world. Even though studies were being conducted in various engineering fields, research was also being carried out in completely different fields, such as arts and philosophy, psychology, and medicine. Although the fields were different, the aim was the same. Expressing it in one sentence would be, "employing self-projection in life-size three-dimensional space and using it interactively." Prior to the Santa Barbara conference, various terms such as *artificial reality, telepresence, telexistence, cyberspace,* and *virtual environments* were being used in different fields for VR. However, as the conference progressed, an implicit agreement was reached that all of these terms could be collectively called "virtual reality."

In that sense, I think that 1990 is the year when the VR Big Bang occurred. Thereafter, the participants in the conference went back to their respective fields and

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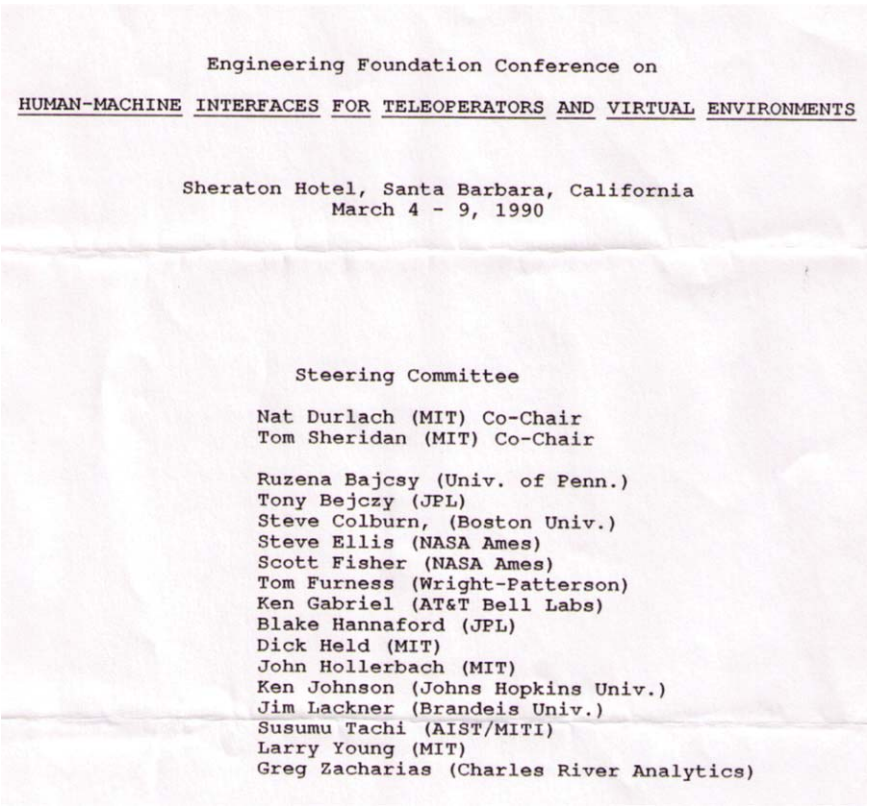

Engineering Foundation Conference on

HUMAN-MACHINE INTERFACES FOR TELEOPERATORS AND VIRTUAL ENVIRONMENTS

Sheraton Hotel, Santa Barbara, California
March 4 - 9, 1990

Steering Committee

Nat Durlach (MIT) Co-Chair
Tom Sheridan (MIT) Co-Chair

Ruzena Bajcsy (Univ. of Penn.)
Tony Bejczy (JPL)
Steve Colburn, (Boston Univ.)
Steve Ellis (NASA Ames)
Scott Fisher (NASA Ames)
Tom Furness (Wright-Patterson)
Ken Gabriel (AT&T Bell Labs)
Blake Hannaford (JPL)
Dick Held (MIT)
John Hollerbach (MIT)
Ken Johnson (Johns Hopkins Univ.)
Jim Lackner (Brandeis Univ.)
Susumu Tachi (AIST/MITI)
Larry Young (MIT)
Greg Zacharias (Charles River Analytics)

Figure 1. *Cover page of conference proposal.*

Figure 2. *March 9, 1990, before departure, after the Santa Barbara conference.*

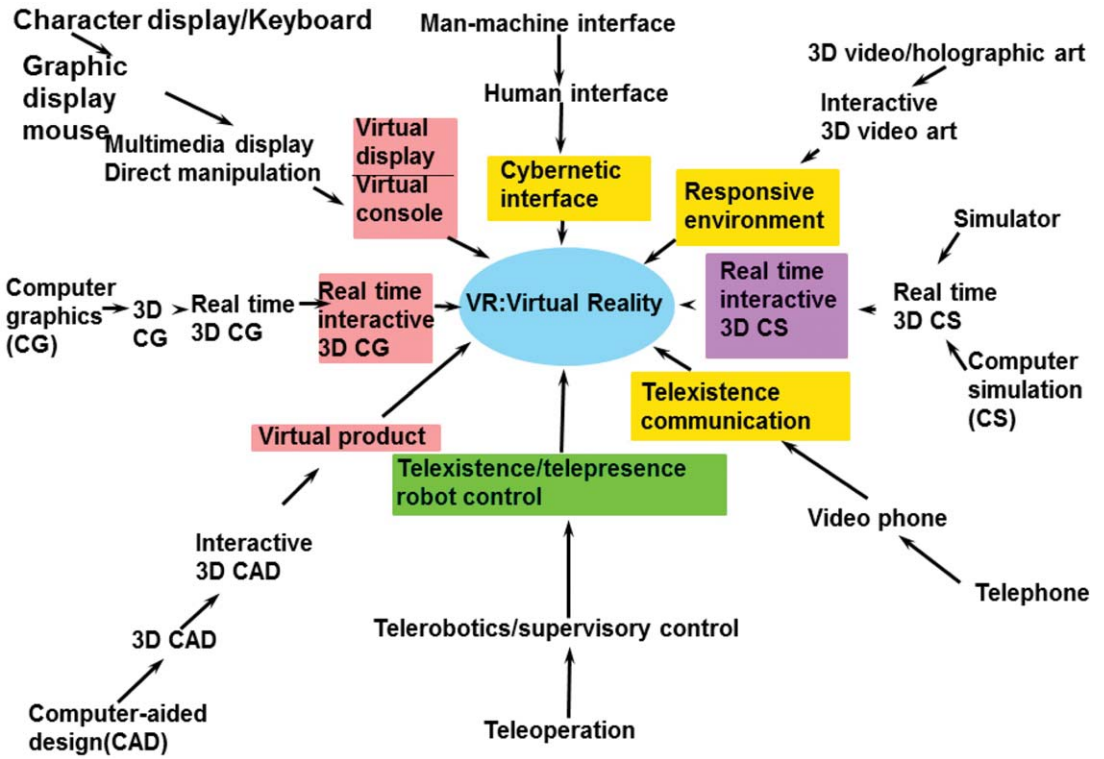

Figure 3. *Evolution and development of virtual reality.*

carried on with not only conducting further research but also promoting VR as pioneers. I described the aspect of various fields converging to VR (Tachi, 1992; Tachi, 2015) in 1992, as depicted in Figure 3. Moreover, I also discussed that VR and telexistence essentially represent the same concept (Tachi, 1992; 2015). Telexistence in real space is telexistence in a narrow sense, whereas telexistence in computer-generated environments is VR. Moreover, using the depiction in Figure 4, I also explained that augmented telexistence is actually telexistence in a real environment through a virtual environment.

A science writer, Mr. Howard Rheingold, also attended this conference and afterwards came to Japan to interview me about research on telexistence. In July 1991, he published a book titled *Virtual Reality: The Revolutionary Technology of Computer-Generated Artificial Worlds—And How It Promises and Threatens to Transform Businesses and Society*, that vividly depicted the dawn of VR.

Incidentally, the academic journal, *Presence: Teleoperators and Virtual Environments*, was also conceptualized from ad hoc discussions in the conference. It was first published by the MIT Press in 1992, and celebrates its 25th anniversary this year. I participated in the discussions and remember that after long discussion, Dr. McGreevy proposed the name *Presence* and it was accepted with everyone agreeing.

2 What Happened in Japan after the VR Big Bang

The following describes the VR activities that occurred in Japan just after the VR Big Bang.

2.1 Research Committee on Artificial Reality and Telexistence (from 1990 to 1997)

It must be noted that the VR Research Committee was formed in Japan at approximately the same

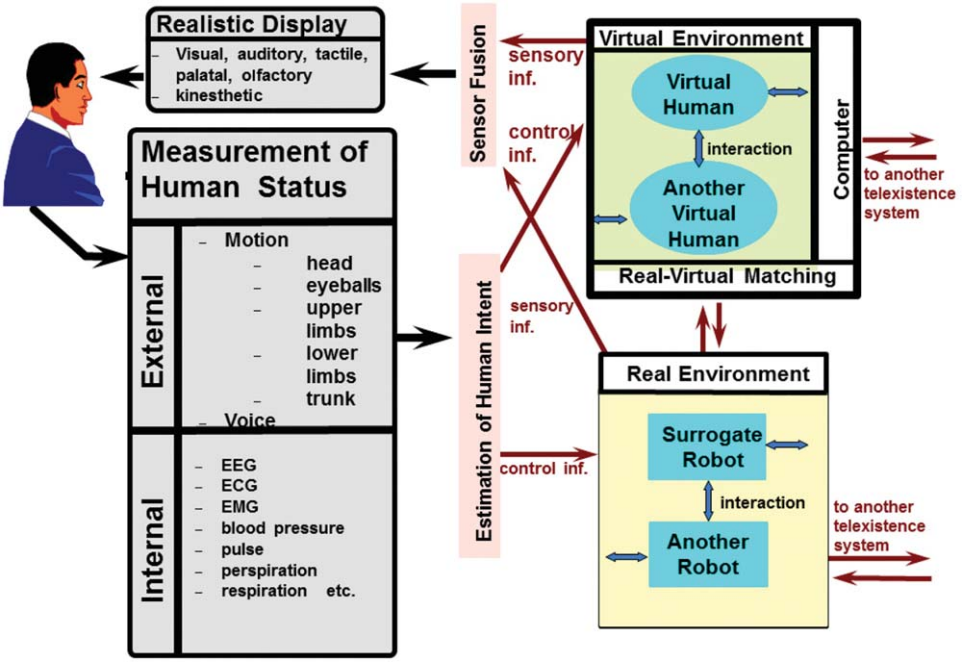

Figure 4. *Telexistence in real environment, virtual environment, and real environment through virtual space.*

time. This indicates that the number of VR researchers in Japan was already comparable to the number in the U.S. It was on May 15, 1990, immediately after my return to Japan from the Santa Barbara conference, that Mr. Shinji Ishikawa from Japan Technology Transfer Association (JTTA) came to me to discuss establishing the committee. He was very much interested in my research on telexistence and wanted to establish a research committee on it as the theme.

On June 23, on the way back from the ISMCR (International Symposium on Measurement and Control of Robotics) held in Houston, TX, I went to San Francisco and met with Professor Michitaka Hirose to discuss the Research Committee plan. As a result, the inaugural Symposium on Artificial Reality and Telexistence was held on October 19 at the Ruby Hall of Tokyo Station in the Ariake room on the 12th floor. On that day, there was a large audience and the lectures and discussions were marked by intense deliberations. It was a start wherein there was an auspice that the field would develop robustly. As the source, this committee led to the birth of international conferences and contests, such as ICAT and IVRC, that are still growing today.

2.2 ICAT: International Conference on Artificial Reality and Telexistence (from 1991 to Present)

ICAT (http://www.ic-at.org/) started when Nikkei Inc. began supporting the activities of the Research Committee on Artificial Reality and Telexistence of JTTA and embarked on planning a VR international conference. Three people were involved in the planning for the first-ever international conference in Japan—with me as the committee chairman, Mr. Ishikawa from JTTA, and Mr. Kenichi Kaeriyama from Nikkei Inc. Many other researchers, including Professor Hirose, also collaborated in organizing the conference. The first conference was held successfully on July 9–10, 1991, at the Tokyo Ryutsu Center.

Following the success of the first conference, ICAT was held every year with support from Nikkei Inc. until 1996. The VRSJ (Virtual Reality Society of Japan) was

formed in 1996, and by 1997 the foundation had been laid for VRSJ to bear the responsibility for organizing an international conference, replacing Nikkei Inc. VRSJ took over the responsibility for organizing a truly academic conference, deepening the academic aspect that continues today.

Starting in 2015, ICAT merged with EGVE (Eurographics Symposium on Virtual Environments) and the conference began being jointly organized by ICAT–EGVE. In 2016, the 26th ICAT and the 21st EGVE was jointly convened under the ICAT–EGVE banner and held in Little Rock, Arkansas, U.S.A. on December 7–9. Since its inception with the VR Big Bang, ICAT is now the oldest international conference on VR in the world.

2.3 IVRC: International-Collegiate Virtual Reality Contest (from 1993 to Present)

On July 6–7, 1993, ICAT'93 (3rd International Conference on Artificial Reality and Telexistence) was held at the newly built Tennozu Isle, commemorating its opening. Starting that year, in tandem with ICAT, the first International-collegiate Virtual Reality Contest (IVRC, http://ivrc.net/2016/en/), a VR contest for students, was held successfully.

In 1991 and 1992, in association with ICAT, an exhibition of VR products was held and was widely acclaimed. However, in 1993, in collaboration with Reed Exhibitions Japan Ltd., it was expanded to a large-scale exhibition as the IVR (Industrial Virtual Reality Show and Conference). This led to planning for new activities in place of product exhibition.

ICAT was beginning to grow as an international conference where the emphasis was on the academic aspects of VR and robotics. Initiatives that would be appropriate in this context and yet be more valuable than product exhibitions were painstakingly contemplated. As a result, nurturing young talented individuals, who will be responsible for the next generation of our society, was believed to be the best initiative. At that time in 1992, it was intuitively clear that VR is an important key technology of the future in the 21st century. However, in order to objectively demonstrate that, more than anything else it should be acceptable to the younger generation who will be responsible for the next generation of our society. It was felt that a new technology cannot be rooted unless it inculcates interest in the young generation and makes them passionate about it.

Based on that perspective, a virtual reality contest between students was the most suitable plan. As a substitute for the exhibition, I proposed to the committee that the student contest would be planned, executed, and contested by the students themselves; the proposal won strong approval. This was followed by intense discussions. In this way the original purpose of "the contest of the students, by the students, and for the students" was achieved.

In accordance with its establishment in 1996, VRSJ assumed the responsibility for organizing ICAT and IVRC, and this continues to be an important organizing activity for VRSJ even today. The students who were in their 20s back then as participants in the contest are now in their 40s after about 23 years, and are actively engaged in academia, industry, and the art world, leading and exploring the new frontiers in VR, AR, haptics, embodied media, human interaction, and telexistence.

2.4 Japanese National Project, Fundamental Study on Virtual Reality—Generation of Virtual Space and Human Interfaces for Virtual Environments (from 1995 to 1998)

The *American Heritage Dictionary* defines "virtual" as "existing or resulting in essence or effect though not in actual fact, form, or name." This definition also applies to virtual reality (VR) per se. For VR users, "virtual reality" exists "in effect or in essence" although "not in actual fact or form."

The Japanese national project of "Fundamental Study on Virtual Reality—Generation of Virtual Space and Human Interfaces for Virtual Environments," was launched in 1995 and supported by the Ministry of Education, Science, Sports and Culture (Monbusho) as a Priority Scientific Research Area. The project is led by me (from the University of Tokyo), and joined by more

than 200 professors and researchers of the universities in Japan. The project tries to clarify how the human-made environment can be made "virtual" for human beings in the sense just defined (Tachi, 1997).

In this study, fundamental research on virtual reality was conducted in the following groups:

1. Elucidation of perceptual and behavioral human characteristics in virtual environments (Group Leader: S. Tachi).
2. Optimal design of interface devices between human and virtual environments (Group Leader: M. Sato).
3. Establishment of virtual world construction and/or representation methods (Group Leader: M. Hirose).
4. Assessment of the influence of virtual reality technology on human society and/or human health and welfare (Group Leader: T. Ifukube).

The course, until this Priority Research Area was approved, is described briefly. Since 1990, when the Research Committee on Artificial Reality and Telexistence was formed, among the members of the committee there was strong intent to establish VR as an academic field. For the healthy development of such new technology, the existence of virtual reality science was deemed vital, and the members were convinced that the creation of a new academic field that brings together the knowledge in Japan would be essential in that respect. As a first step, an application for Grants-in-Aid for Scientific Research for a research study was submitted. After it was approved, the first meeting was held on October 4, 1991. In that research study, preparations were underway toward the creation of a new academic field. As a result, the aforementioned Japanese National Project, "Fundamental Study on Virtual Reality—Generation of Virtual Space and Human Interfaces for Virtual Environments" was approved by Monbusho, leading to the establishment of a new academic field.

2.5 Virtual Reality Society of Japan (VRSJ) (from 1996 until present)

A new academic field was thus created. However, in order to continuously develop such an academic field, it was deemed essential not only to publish the knowledge structure in the form of papers and books, but also to disseminate new ideas and to return the achievements to society along with educating the personnel involved in a sustained manner. Based on this background, on the occasion of the first Executive Committee Meeting and the first General Assembly of the Priority Research Area, held on July 11, 1995, I (as the project leader), presented the proposal for founding an academic society; it was strongly endorsed by the participating researchers.

In response to the decision to establish a society taken in the Executive Committee Meeting of the Priority Research Area, the first establishment preparatory meeting was held on September 22, 1995. I gathered with professors Hiroshi Harashima, Michitaka Hirose, Hiroo Iwata, and Toshio Fukuda to discuss a society journal/transactions newsletter, website creation, and the goal of publishing *IEEE Transactions on VR* in the future.

Thereafter, eight more meetings of the preparatory committee and the assemblies of founding members were held. On March 13, 1996, a Founders Summit was organized with 278 renowned virtual reality scholars as the founders. Four more executive meetings were held, and on May 27, 1996, the general assembly for establishment was convened, whereby the Virtual Reality Society of Japan (VRSJ) was established (http://www.vrsj.org/english/about/).

Currently, VRSJ, with more than 1,000 members, organizes one annual conference every year, and publishes the transaction and the journal four times each year. It must be noted that for about ten years, starting in 1997, VRSJ and *Presence* maintained a collaborative relationship.

3 Toward a "Telexistence Society"

At present, in Japan, people are faced with many difficult problems, such as an increasing concentration of population in the metropolitan areas, an increase in the number of elderly persons and decrease in the number of workers due to the trend toward smaller families, cultural frictions and worsening of public safety due to immigration, dilemmas posed by concurrent child-rearing and work, and the fact that a great deal of time is

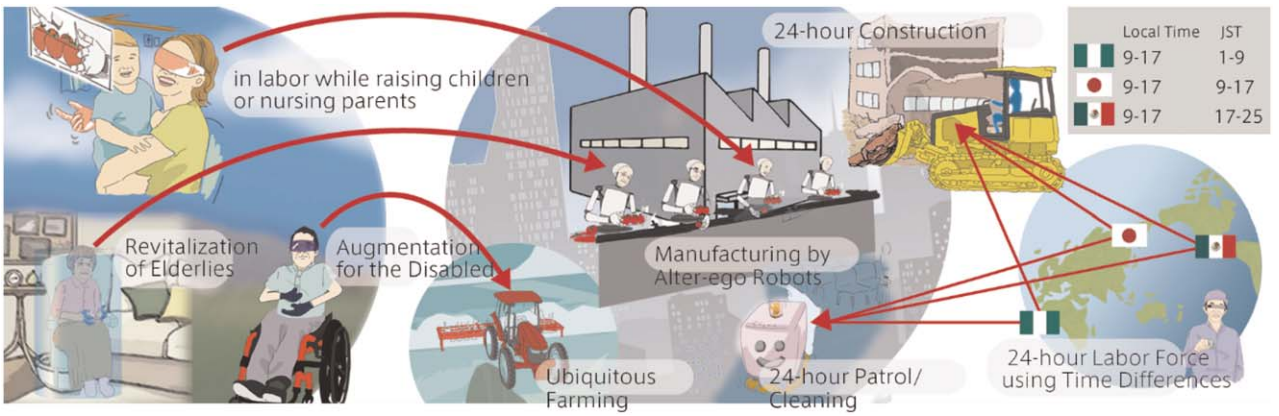

Figure 5. *Telexistence society.*

required for commuting to and from work and the resulting lack of personal time. If it were possible to create innovative technology that changes the conventional conceptualization of movement by transferring physical functions without this being accompanied by actual travel, these difficulties could be overcome.

Working at home remotely to date has been limited to communications and/or paperwork that transmit audio-visual information and data, as well as conversations. It was impossible to carry out the physical work at factories or operations at places such as construction sites, healthcare facilities, or hospitals; that cannot be accomplished unless the person in question is actually on site. Telexistence is a technology that departs from the conventional range of remote communications that transmit only the five senses, and it realizes an innovative method that transmits all the physical functions of human beings and enables the engagement of remote work accompanying labor and operations that was impossible until now.

If a telexistence society that can delegate physical functions were realized, the relationship between people and industry and the nature of society would be fundamentally changed. The problems of the working environment would be resolved, and it would no longer be necessary to work in adverse environments. No matter where a factory is located, workers would be assembled from the entire country or the entire world, so the conditions for locating factories will see revolutionary changes compared to the past, and population concentration in the metropolitan area can be avoided. Since foreign workers would also be able to attend work remotely, the myriad problems accompanying immigration as a mere labor force, separate from humanitarian immigration, can be eliminated. Moreover, it will be possible to ensure a 24-hour labor force at multiple overseas hubs by making use of time differences, rendering the night shift unnecessary. Both men and women will be able to participate in labor while raising children, and this will help to create a society in which it is easier to raise children (see Figure 5).

The time-related costs due to travel in global business will be reduced. Commuting-related travel will become unnecessary, and transportation problems can be alleviated. It is predicted that it will no longer be necessary to have a home near one's workplace, the concentration of population in the metropolis will be alleviated, the work-life balance will be improved, and the people concerned will be able to live where they wish and lead fulfilling lives.

In addition, owing to additional functions of an avatar robot, which is the body of the virtual self, even the elderly and handicapped will not be at a disadvantage physically compared to young people, since they can augment and enhance their physical functions to surpass their original bodies, and thus they can participate in work that gives full play to the abundant experience amassed over a lifetime. The quality of labor will rise greatly, thereby reinvigorating Japan. The hiring of such specialists as technicians and physicians with world-class skills will also be facilitated, and optimal placement of

human resources according to competence can also be achieved.

With a view to the future, it will be possible to respond instantly from a safe place during disasters and emergencies, and this technology can also be used routinely to dispatch medical services, caregivers, physicians, and other experts to remote areas. In addition, owing to the creation of new industries such as tourism, travel, shopping, and leisure, it will greatly improve convenience and motivation in the lives of citizens, and it is anticipated that a healthy and pleasant lifestyle will be realized in a clean and energy-conserving society.

In this manner, it goes without saying that the realization of a "telexistence society" that makes it possible for human beings to virtually exist in remote places is an extremely high-impact challenge technologically. One can even conclude it that it is a noncontinuous innovation that differs from novel improvements involving progress of existing work equipment and environments insofar as it radically alters both the nature of labor per se and people's lifestyles.

4 VR Moves in 30-Year Cycles

Needless to say, VR is an activity that pursues the "virtual," or in other words, "the essence of things." It is "a design theory that puts the human being itself and not the artifacts at the center of all events, an idea, an art, and an academic field."

It is often said that history repeats itself and it has been analyzed that 3D and VR moves are in 30-year cycles (Tachi, 2013). Now that VR has again regained the excitement of its early days, I hope that it will encourage further growth, which in turn will greatly change society and keep on contributing to humankind.

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