DISRUPTION FROM THE VIRTUAL WORLD
The word "virtual" shares its root with "virtue," a word whose original meaning denoted "strength." More recently, "virtual" has come to describe something that possesses essence and effect without possessing form, something not quite physical, but with a measurable impact on the real. That's certainly true of virtual worlds.

Decades ago, text-based games like Dungeons and Dragons created virtual worlds in which players, usually sitting around a table, chose personas and had to overcome virtual obstacles and opponents. The games were a kind of cooperative play that encouraged camaraderie and offered a socially acceptable channel for expressing rowdiness.

Later, the Internet moved these kinds of games online. As technology advanced, so did the worlds, and their usefulness grew.

Today, the widespread availability of powerful processors and of broadband Internet connections has introduced large numbers of people to virtual worlds animated in 3-D and delivering advantages of communication and idea exchange not possible in the real world.

Current virtual worlds are computer-based simulated environments accessed by numerous users through an online interface. Users are represented by animated characters, and can interact with each other, as well as with virtual objects in the space. They can conduct various activities in the virtual world and experience fully immersive alternative lives.

Virtual world applications cover a broad spectrum of activities. They range from learning to social networks.

Globally distributed engineering teams can use virtual worlds as immersive and interactive platforms for concurrent product design, for virtual prototyping and manufacturing, and for workforce training. Advances in computing resources, visualization facilities, and communication bandwidth now permit real-time data analysis, visual simulation, multimodal interaction and presence in synthetic environments, and collaborative decision making. The challenges associated with distributed value chains, product customization, increasing product complexity and functionality, and accelerated time-to-market of new products can be addressed in virtual worlds.

Virtual worlds are gaining popularity and their academic, business, military, and government applications are multiplying rapidly. It is estimated that the combined annual revenues from virtual worlds in 2009 will reach $19.3 billion. These include membership fees, fees to content providers, advertising sales, and sales of virtual goods such as items to differentiate users' avatars, or virtual accessories for games. Virtual worlds may rival the movie industry in the next five to ten years.

Virtual worlds provide us with a panorama of possibilities, and are likely to influence many facets of our lives. Virtual worlds can provide a creative work environment with new modes of working and with far greater collaboration than is currently practical. They can help enhance innovation, and accelerate technology development and product creation. For example, a seamless virtual product life cycle and supply chain environment can be generated, incorporating a high-fidelity virtual representation of the entire value chain from raw materials to product and production planning to lifetime maintenance and remote service. Also, virtual worlds can reduce the ramp-up time...
Virtual worlds provide a highly compelling distance-learning environment connecting experts, instructors, and learners anywhere in the world. They enable interactive, engaging, and collaborative learning by simulating physical environments and real-life experiences. Over 300 colleges and universities in various countries have created virtual campuses, complete courses, or learning modules on Second Life and other virtual world platforms. Student avatars learn from an instructor’s avatar in virtual learning spaces.

Being in the same space, at the same time, in a 3-D immersive environment improves the learner’s sense of presence and the sensory engagement with multi-modal interaction of the advantages of learning in virtual environments. They are effective platforms for immersive learning, and for integrating formal and informal learning. They help learners connect to groups of other learners around the world and foster truly collaborative project learning.

The environments help shift engineering and science education from being fact-based to inquiry-based and help learners to think analytically. They also make it possible to reach learners in difficult-to-reach areas.

The Campus Project of the New Media Consortium is a large experimental educational project in Second Life. It has several facilities, including a library with more than 7,000 periodicals and research databases, a fine arts museum, a conference center, an orientation island, and an open-content object repository. The consortium is a non-profit association of 300 colleges, universities, museums, and research centers. Its overall goal is exploring emerging technologies for learning, research, and creative expression.

Ohio University has a complete virtual campus in Second Life, where learning experiences range from entire college courses to one-hour learning modules. Learning kiosks house course content in a variety of media forms. Spaces are provided for an art and music center, virtual trade shows, and conference exhibits. Engineering, computer science, and other courses are taught in parallel with the real-life campus counterparts.

The Imperial College in London used Second Life as a platform for medical service design, immersive clinical training, and scenario-based simulation. Participants are able to learn, practice, and perfect procedural innovations in realistic scenarios.

Virtual worlds with visually rich environments are being used for conducting specific job-site training and simulation. Examples include emergency services and industrial training, which has traditionally been on-the-job, but is now becoming richer and less costly in virtual worlds.

Over 20 science- and technology-related organizations have set up a cross-disciplinary, mini-continent “SciLands” in Second Life, with 34 islands. One of the islands is created by Britain’s National Physics Laboratory as a hub for nanoscience and nanotechnology research and services. Residents, through their avatars, can run nano-instruments, and experiment with building molecular models, and with atom-by-atom assembly of chemical compounds. They can also attend state-of-the-art lectures by experts in nanoscience. The services provided on the nanotechnology island include free space for exhibits and free assistance for organizing events.

Other activities in Second Life incorporating interactive molecules and prototype nanoscale technologies include the Textile Nanotechnology Laboratory of Cornell University, and the open-source Useful Chemistry project, led by the Bradley Lab of Drexel University, where results of experiments are presented to the public as open notebook science.
for engineering products that are not mass produced, like locomotives and windmill turbines.

A U.S. federal consortium for virtual worlds was formed in 2007 to support individuals and organizations and to expand the role of virtual worlds in government. It consists of members from government, academia, and corporate sectors. It provides a venue to share lessons learned, best practices, and policies for the collaborative use of virtual worlds, and creates structures to share resources.

The U.S. Air Force launched in December 2008 a virtual exploratory and interactive environment, MyBase, to support both continuous and precision learning. Designed as a virtual Air Force base, its main objective is to enhance training, education, operations, and recruiting. It enables users to make effective decisions, perform assigned tasks, and conduct operational rehearsals. In the current public version, a user can enter MyBase in Second Life, take a virtual tour of the base, take a virtual flight in a P-51 Mustang, interact with other visitors, and learn about the Air Force and available jobs. A secure site will be established for education and training, including certification and degree programs. Future secure versions will recreate operational environments, such as an air base in Iraq where Air Force members would train and meet others with whom they would deploy.

A virtual world called U.S. Nexus is being developed to support training, education, and collaboration across the U.S. government. An initial operational capability is planned for this month. It includes several classrooms, conference rooms, auditoriums, and operations centers for supporting the simultaneous training of geographically dispersed groups. The Defense Acquisition University, with more than 320,000 students worldwide, plans to use the system for avatar-to-avatar synchronous classroom delivery.

The U.S. Army used the America's Army Web site as a recruitment tool. It has also commissioned one virtual world company to build a model of the entire real world where thousands of virtual soldiers can rehearse conflict anywhere on the globe.

China, with the help of a Swedish company, MindArk, developer of an online game called Entropia Universe, has created a virtual economic district, where millions can communicate and work. It will host a set of animations, game development, and virtual world development companies, and provide a platform for traditional enterprises, Internet companies, and individuals to work together. It will provide a new model to aid the transformation of traditional enterprises into virtual ones. An estimated 7 million local Chinese are using virtual worlds, and are reaching out to 150 million Chinese overseas.

The number of virtual worlds online and under develop-
World Platforms

Although Second Life is currently the best known virtual world platform, a number of open-source and commercial virtual world platforms and servers have been developed in recent years for building a variety of applications, and for delivering real-time 3-D content over the Web.

ActiveWorlds is geared towards games and social applications requiring a firewall, such as secure communications and private experiments. OLIVE serves as a simulator for real-world, secure environments with accurate physics. It supports application sharing, business process rehearsal, advanced training, and collaborative work.

Protosphere incorporates Web 2.0 technologies, and focuses on learning, knowledge management, and training.

Teleplace (formerly Owaq Forums) is built around the core concept of document collaboration. It has a built-in whiteboard and facilities for creating virtual spaces, for importing files from outside sources, and for sharing and editing office documents. Applications include secure small meetings, virtual operations centers, and corporate training.

Web.Alive is a fully immersive business environment that can be used for browser-based 3-D applications, virtual meetings, training, consumer-focused 3-D commerce, and sales tools.

Multiverse is a platform for building custom virtual world applications, including secure applications. OpenSimulator, a free open-source 3-D application server, can be used for Second Life-like applications, for meetings, and for data organization.

A number of virtual world platforms are currently under development, including Project Wonderland, 3Dxplorer, and Vastpark. The first two are Java-based and can be used for developing private virtual worlds, or intravessels, hosted inside the enterprise firewall. The same is true for multiverse and open simulator.

THE REAL IN THE VIRTUAL

Virtual worlds are making a paradigm shift in new product development and are becoming an integral part of computer aided engineering. They are enabling the convergence of analysis, visual simulation, and design in the creation of virtual products, as well as facilitating the participation of all stakeholders in the product creation. Autodesk has an island in Second Life.

Among the many engineering applications of virtual worlds are virtual product development services, and getting input from customers during product creation. Toyota, for example, developed a virtual model of its Scion XB in Second Life for people to test drive online.

Virtual worlds provide an opportunity for businesses to reduce production cycle time and increase user input earlier in the development process, as in the Toyota test drive. Current products and those under development can be presented to customers in engaging and interactive ways, and the company can ask for people’s comments.

NASA is using simulations of remote landscapes in virtual worlds to evaluate extraterrestrial transportation options and operators. It has a number of displays in Second Life showing rockets, shuttle, moon lander, production rovers, and outer space probes. The International Spaceflight Museum in Second Life provides a virtual ride into the cosmos, including taking part in a Space Shuttle flight—blasting off, and watching the Earth below, as well as seeing the International Space Station and the Hubble telescope go past.

A number of robotics applications have been deployed in virtual worlds. IEEE’s Robotics and Automation Society is using a five-floor building in second life as a platform to spread robotics culture; to present information about how to design, build, and control a robot, and to investigate possible paradigms of social interaction in heterogeneous communities of robots and humans.

Mirror worlds, which are high fidelity virtual recreations of real-world environments, such as offshore platforms, or chemical and manufacturing plants, are used by a number of enterprises to evaluate safety procedures and check the adequacy of escape routes.

IBM created a virtual business center in Second Life, which includes a sales center, technical support library, client briefing center, and conference center. Users are able to buy hardware, software, and services, or ask an IBM sales avatar for help regarding business problems. Users can browse 3-D bookshelves, view a 3-D book, or talk to a librarian.

Siemens PLM software offers a way for customers and partners to experiment with new collaboration and visualization technologies in Second Life.
Some companies have created virtual scenarios for sales training, where participants interact with virtual receptionists and sales prospects to learn how to behave effectively. Cisco, Intel, Dell, Microsoft, and others are holding global events, meetings, and training sessions in virtual worlds. IBM uses virtual worlds in company events such as conferences and town halls. In these applications virtual worlds were found to enrich interactions by offering visual, aural, and spatial dimensions lacking in commonly used online interactions of today. A new tool, Sametime 3D, will enable business colleagues to exchange instant messages, speak, and share presentations and ideas in private, prefabricated, reusable meeting spaces located in a variety of virtual worlds.

Healthcare applications are steadily increasing in virtual worlds. These include training and skill building programs for physicians, nurses, and medical students; disease-specific support and discussion groups; and facilities for individual consultation. The two key design attributes for successful applications are anonymity (through the use of an avatar) and interactivity.

FUTURE WORLDS

Virtual worlds have the potential of transforming the 2-D Internet into a 360-degree multi-sensory 3-D immersive experience, with all the richness, depth, and extensibility that it implies.

Engineers will be able to create proof-of-concept 3-D models, view multidimensional representations of their design spaces, and change models quickly and inexpensively to satisfy customer requirements. They will view their products in high-fidelity simulations of the physical environment, and will be able to walk around and fly through, as if they were actually there.

Far greater collaboration within globally distributed teams, and new modes of working will become possible.

The developers of the virtual worlds have limitless opportunities to shape the scale and appearance of the world, the capabilities of its avatars, the methods of communication, and even the laws of physics (e.g., space exploration over galactic distances). It is possible to explore new experiences that are not possible in any other medium. Also, novel concepts of smart worlds, limited only by our
imagination, can be tested in the virtual world before implementing some of their features in the real world. The richness of experience in virtual worlds can be significantly enhanced, and their potential realized, through the integration of a number of technologies and facilities, some of which are currently under development.

Virtual 3-D factories facilitate experimentation with manufacturing processes and can expedite the training of workers.

These include:

- **Increased sense of presence and multifaceted forms of immersion in settings that include sound and visual cues, rich textures, and realistic perspective.**

- **Extending user interfaces, providing natural communication and direct manipulation of 3-D virtual content.** This includes seamless flexible 3-D interfaces; automatic, real-time conveyance of gestures and other non-verbal expressions.

- **Emotionally responsive and interactive life-like avatars** which convey emotional expressions and body language automatically (e.g., interpreted by webcam).

- **Expanding the role of intelligent agents, bots, and robotars.** It will be possible, for instance, to assign tasks to autonomous software agents such as an animated avatar giving a scripted presentation and answering questions, using more advanced systems than the ones currently available on the Web, without human control.

The fusion of virtual and physical worlds will lead to future Digital Ecosystems—the next generation 3-D immersive socio-technical-business cyber environments for education, research, commerce, and entertainment. These will be distributed, adaptive systems, inspired by the natural ecosystem, and will link academic institutions, research labs, industry, and other stakeholders. Users benefit from each other’s participation.

The ecosystems will help in pushing the boundaries of human value and enable humans to perform increasingly complex and imaginative tasks of synthesis and creativity. New patterns of organized culture and new models for virtual organizations, including extensions to those in the real world, will emerge within these ecosystems.

Some people envision the emergence of 3-D “learnscapes”—that is, technology-rich networked platforms for learning. A lesson on particle physics, for instance, could include an Einstein-looking avatar giving an introduction, followed by 3-D simulations of phenomena at the nanoscale. Then the learners from across the globe might be invited to manipulate the parameters in the simulations, observe the behavior of photons, and compare the results with mathematical predictions.

Product innovation ecosystems can be developed by mashing up virtual worlds with lifecycle engineering, management, supply chain, and related technologies. Intelligent digital factories may some day automatically select production processes and factory layout, based on the designers’ specifications of the product's characteristics, and test them in a virtual world. A high-fidelity model of the product would be provided to the customer to test in the virtual world.

The 3-D virtual worlds of today, and the advanced worlds of the near future, have the potential of making more significant impact on engineering practice than that made by the 2-D Internet.

They can link engineers with an ever-broader range of meaningful information, enabling multi-site interactive visualization of simulation data and 3-D models, and making insights more intuitive.

They already offer real-time presence and immersion, and promise to become even more lifelike, for synchronous communication and interaction. They can enhance co-creativity and the power of collective intelligence via rapid brainstorming and by supporting globally distributed teams in collaborative inquiry and problem solving.

A virtual world is like a blend, after all, of play and work. It offers a rich range of features, as well as an engaging and exciting environment for collaborative invention of new products.

For More Information

Readers interested in pursuing the subject covered in this article will find links to more information at http://www.aee.edu/virtualworlds/

The Web site, created as a companion to Mechanical Engineering magazine’s Feature Focus, contains links to material on virtual worlds and their applications, and has continuously updated information feeds. There are also links to other online services and features of the Center for Advanced Engineering Environments at Old Dominion University.