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Associate Professor Masaki Takahashi tackles the effective use of model base control technology to develop systems design that benefits people and society at large.

Making the Most of High-Precision Control Technology to Design Systems Useful for People and Society

Model base control technology meets the needs of people and society

Automobiles as a convenient means to transport people and cargo, high-rise condominiums providing ample residential space in the center of metropolitan areas . . . the development of technology has benefited people's lifestyles and prosperity of society in modern times. But when we look at such amenities brought by technological advances from a human viewpoint, there are still people who suffer from carsickness and high-rise buildings that shake due to earthquakes or strong winds, causing us discomfort. A new attempt is now being made to take a new look at the relationship between technology and humans from the perspective of "Safety and Comfort for Humans." In this issue, we listened to Associate Professor Masaki Takahashi who is contributing to the development of model base control systems to create products and systems useful for people and society.

Realizing a better relationship between people, society and machines

"Model Base Control" is a method to realize effective control by modeling a target system and developing an optimal control technology for the target. An advantage of this method is that it allows you to develop a desired control technology while conducting simulations. On the other hand, there are cases where the system developed cannot work as simulated if the model precision is poor or the simulated operating environment differs significantly from reality. This makes it important to develop highly accurate modeling as well as to design a control system that can properly respond to changes in the environment and modeling errors.

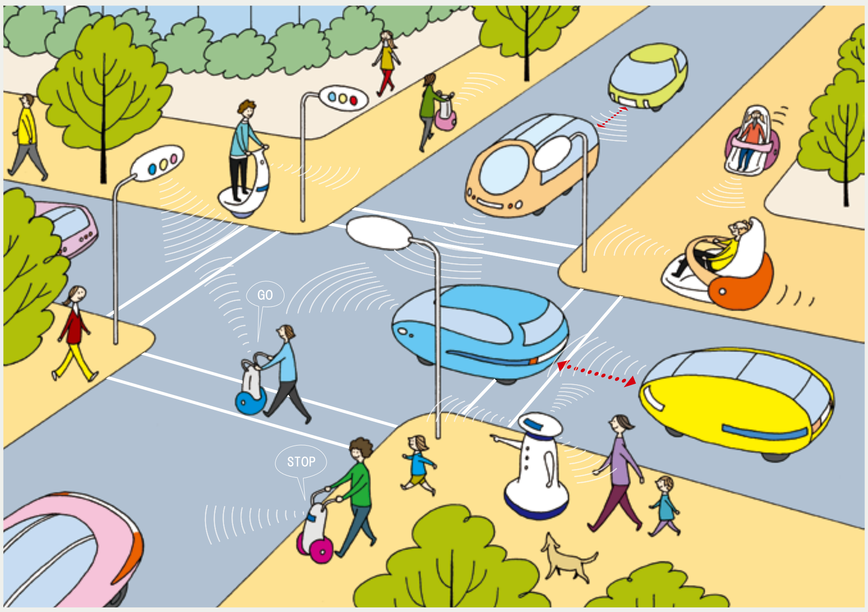
"Modeling including that of the operating environment is indispensable to perform highly precise model base control. Of various factors involved, the most difficult is to assume users. Modeling of users is difficult because we humans conduct ourselves based on our own judgment. But modeling including that of users is inevitable to create systems that can be practically used in actual society," remarks Associate Professor Takahashi.

As research themes, Dr. Takahashi has chosen robotics, automobiles and buildings – realms that have much to do with people and society. This is because by making use of model base control he aims to contribute to the development of products and systems useful for people and society.

Controlling robots' autonomic movement

An application of model base control can be found in robots for automated guidance and transport of expendables and other articles in hospitals.

Dr. Takahashi adds, "We aim to make such guidance/transport robots autonomic to act and move around inside a hospital. Therefore, we are developing a control technology with a focus on how robots should conduct themselves in human society. The key point here is how humans will react when they encounter a robot. Some may be surprised and leave the place, while other will be interested and come closer. We are currently making improvements to the robot so that it can predict and judge the behavior the person in front of it will take and respond to the person properly, taking the past behavioral history and the current situation into account. I feel that people's recognition of robots today is still at a low level, which is a major barrier to full introduction of robots to society. For



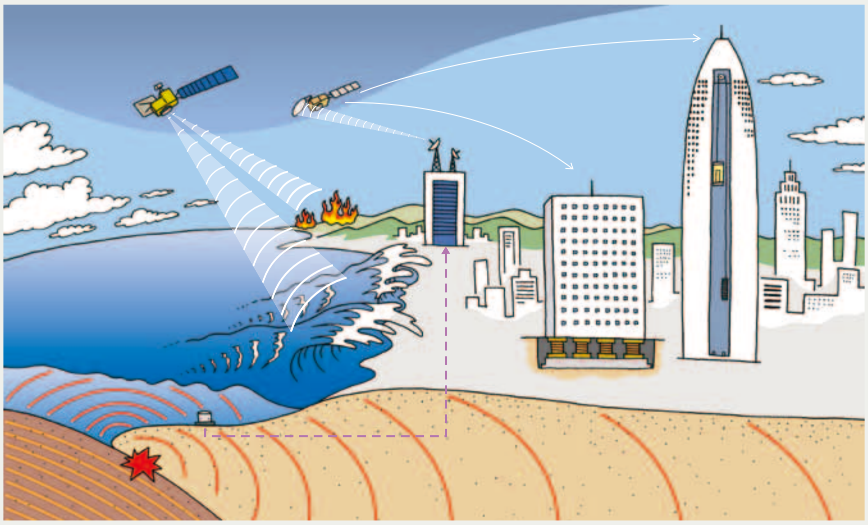
Safe and more comfortable society with control technology

Control technology finds its applications in virtually every aspect of our modern society – from daily lives to industry and to space development. If this technology advances further, it will become possible to use automobiles and guidance/transport robots, etc. more safely and comfortably as shown in this illustration.

robots to be widely accepted by society, therefore, it is important to provide people with more opportunities allowing them to see and better understand robots."

The key to achieving this goal lies in on-site experiments and observations. In other words, we need to visit hospitals and observe, as a robot's eyes would do, nurses carrying medical supplies and the like and how patients and visitors will look at them, as well as how patients on wheelchairs or crutches will act and move.

He continues, "We conduct experiments and observations together with many, such as representatives from robot manufacturers and students. Then all of us have a meeting to discuss the experiment and observation results. We extract characteristic elements from the behavior of nurses and people around them, which form the foundation for the development of component technologies needed. In fact, on-site studies are a rich source of discovery. For example, desk researchers tend to create advanced high-performance robots by introducing the latest in technology. However, the technology actually needed to transport goods in hospitals is not the technology needed to create fast-moving robots. On the other hand, if the robot design places too much emphasis on safety, the robot may cease moving, incapable of responding to constant changes occurring in the environment. This means that we need to develop technologies such as those enabling the robot to recognize obstacles peculiar to a place in question and evade them at a speed suitable for the place."



Control technologies active on various technological forefronts

Control technology can control quake-absorption of high-rise buildings, dealing with individual earthquakes based on information from emergency earthquake reports. The control technology for satellites and other spacecrafts can also be applied to terrestrial issues like shaking control of elevator ropes.

Protecting buildings from earthquakes and wind, while enhancing comfort

There are types of model base control that contribute to society in relation to social infrastructure. A typical example is the control technology for quake-absorbing base-isolated structures. Heretofore, architects assumed the magnitude of earthquakes beforehand and built structures that could withstand the assumed magnitude. Dr. Takahashi's approach is different. He is thinking of an active quake-absorbing control based on positive utilization of the latest seismic ground motion forecast/warning system.

"I'm now proposing a quake-absorbing control system based on the utilization of information from emergency earthquake reports. If the hypocenter location of an earthquake and its magnitude can be predicted in advance, the control system can enhance the quake-absorbing performance of buildings accordingly. Just as a strongly rocking swing can be controlled simply by changing the timing of its rocking, we can effectively control quaking and realize highly safe quake-absorption by controlling the quake-absorbing device in a way to alleviate the structure's shaking caused by seismic ground motion propagated from the hypocenter."

Dr. Takahashi's approach is based on a combination of knowledge obtained from preceding studies on the way the ground quakes (propagation routes of seismic ground motion and ground structures taken into consideration) and information available from emergency earthquake reports. This approach is attracting attention as a new method of quake-absorbing control as expansion and improvement of social infrastructure rapidly advance today.

Dr. Takahashi reveals his view saying, "This active shake control applies not only to earthquakes but also to shaking of buildings due to strong winds. I predict an ever-increasing need to control the shaking of buildings, which is interlocked with new forecast/warning systems."

Use of satellite-controlling know how to control elevator ropes

Control technologies are also being developed to control a variety of equipment operating in the space environment. One example is the attitude control technology for small-size satellites. In recent times, compact satellites are equipped with large-size, flexible and lightweight solar panels to meet their increasing power demand. If the satellite main body, heavily loaded with cameras and other equipment, changes its direction toward an observation target, that motion shakes the flexible solar panel, causing photo image distortion just as we experience with our digital camera shake.

Dr. Takahashi says, "Depending on orbit, it can take several days for a satellite to return to the position for photographing the same observation target point on the Earth. Meanwhile, there are increasing demands for photographing multiple observation points at one time – such as places suffering from serious environmental disruption and places of large-scale natural disasters. In such cases, the satellite needs to change its attitude promptly. Such attitude change involves the shaking of flexible structures like the solar panel. But it becomes possible to change the satellite attitude promptly without shaking if we apply a control technology."

The phenomenon, in which the whole of a flexible structure shakes, is not limited to artificial satellites. Similar phenomenon can be seen in elevator ropes, for example.

"Elevator ropes are becoming longer and longer as buildings rise higher and higher, causing the problem of shaking elevator ropes. The control technology enabling rapid change in attitude of satellites without shaking can be applied to elevator ropes on the ground surface – this is a merit of the model base control technology based on mathematics and dynamics."

Endorsed by a rich track record, "Model Base Control" technology is sure to enhance our quality of life and contribute to the betterment of society.

(Reporter & text writer: Kaoru Watanabe)