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'Young Robot Engineer' (42) Dr. Kyu-Nam Kim, Hyundai Motor Company

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The'Young Robot Engineer' section is a series jointly planned by the Korean Society of Robotics and the Robot Newspaper to discover and introduce young robot engineers who will lead the future Korean robotics industry.

The 42nd interview is Dr. Kim Gyu-nam of Hyundai Motor Company. Dr. Kim graduated from Gyeonggi Science High School and Seoul National University Department of Mechanical and Aerospace Engineering and received a Master's degree in Mechanical Engineering from the University of California, Berkeley, USA, and a Ph.D. in December 2016. Designed to respond to failures of urban aeronautical mobility (UAM), high-speed and lightweight autonomous drones, and multi-rotor aircraft while working as postdoctoral scholars at the California Institute of Technology (Caltech) from February 2017 to April 2020 after graduation. And control, bipedal walking on the ground, and dual walking mode robots capable of flying in the air. Currently, since last July, he has been working as a lead researcher in the aircraft development team of the Urban Aviation Mobility (UAM) Division of Hyundai Motors Uiwang Research Center.

His main interests are the development of a unique autonomous robot system for future applications that can innovatively improve the quality of human life, mainly urban aeronautical mobility (UAM), robotics, dynamics, control and estimation theory, motion planning, and vision-based navigation. , Design optimization, etc. He was selected as a National Science and Technology Scholarship from 2004 to 2009 and a Scholarship from the Samsung Scholarship from 2010 to 2015.

Q. Please introduce the aircraft development team of Hyundai Motors Urban Aviation Mobility (UAM).

Hyundai Motor Company's UAM Division is an organization dedicated to developing core UAM technologies and promoting business in order to preoccupy the UAM market, which is expected to grow rapidly in the near future. Within the division, the UAM gas development team is a team of experts in related fields for the development of UAM finished gas, and among them, I belong to the group in charge of control aviation.

Q. I know you have joined Hyundai Motor Company since last July. Please introduce any research you are currently doing.

At Hyundai Motor Company, our division is in charge of R&D for the controller design and autonomous flight algorithm of the UAM aircraft, which is aimed at development, but it hasn't been long since I joined the company, so I cannot tell you much. Instead, I would like to introduce you to two research studies currently being completed at the California Institute of Technology (Caltech).

The first study is conducting a study on the design of a controller that can sustain flight while maintaining maneuverability without falling in case of failure of one or more propellers in a multi-rotor aircraft. Many multi-rotor aircraft, including a number of UAM aircraft currently being developed, are designed to use multiple propellers to prepare for such a failure situation. Even in this case, a general controller is used depending on which propellers fail. There are cases where it is difficult to maintain flight controllability.

However, safety is a particularly important part in the operation of the aircraft, so a special controller is required that can prevent the aircraft from falling even in such difficult situations. It needs to be designed in depth.

In the research I am working on, I analyzed the motion characteristics of the aircraft closely to define the motion that can be implemented using only limited control input when a propeller failure occurs, and devised a method to design a controller that follows it. I think that it can contribute particularly important to ensuring the safety of the aircraft.

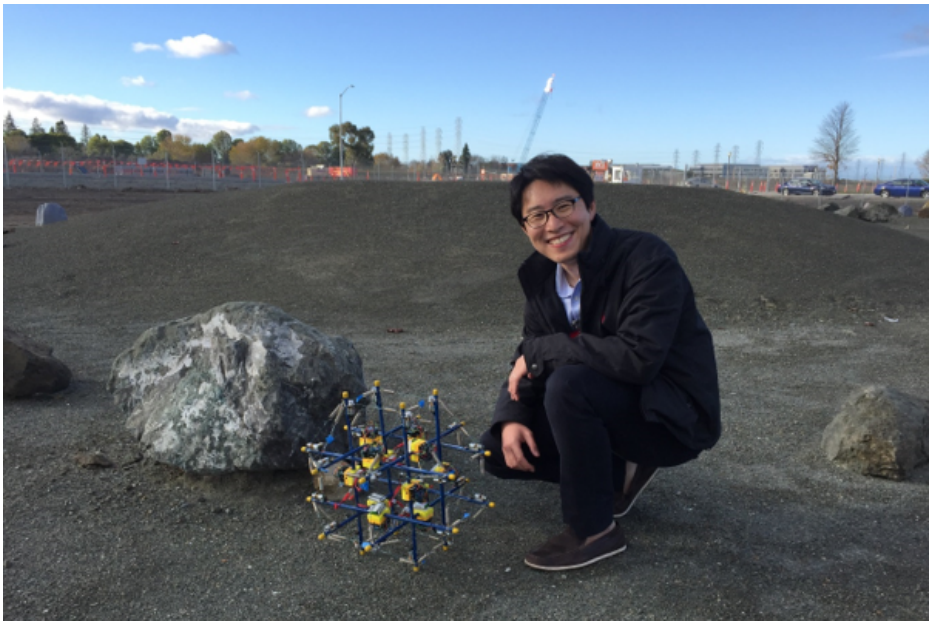
For the second study, we are developing a dual walking mode robot that combines a leg a nd a propeller to enable bipedal walking on the ground and flying in the air. Most of the e xisting robots have been developed and manufactured specialized in one movement meth od of walking on the ground or flying in the air.In general, it is known that the terrain gre atly affects the walking performance and there are difficulties in walking over large or hig h obstacles. In addition, flying robots have the disadvantage of relatively high energy con sumption and difficult to load heavy mission equipment.

In this study, in order to overcome the problems of these single walking mode robots, a n ew type of dual walking mode robot was developed. This robot needs to overcome difficult terrain or obstacles, or when it is necessary to overcome difficult terrain or obstacles, it us es a propeller to fly. The advantage is that you can reduce energy consumption by using t wo legs when you need to travel on flat terrain or perform a mission while staying in one place for a long time. Based on these advantages, it is expected that the existing robots w ill be able to perform tasks that were difficult to accomplish, such as inspection and replac ement of oil refinery pipes.

▲ Caltech's dual walking mode robot LEONARDO

Q. You received your Ph.D. from UC Berkeley under the theme of "On the Locomo tion of Spherical Tensegrity Robots". Please tell us what it is about.

Tensegrity structure refers to a structure in which rigid rods are connected by elastic bodi es without direct contact with each other to maintain their shape. Among these structure s, the polyhedral tensegrity, which is approximate to the sphere, is often referred to as sp herical tensegrity. During my doctoral course, I conducted research on the development o f a robot based on the spherical tensegrity structure. Among them, we focused on develop ing methods to implement the two walking methods of the old Tensegrity robot, the cloud and the leap movement, and this was actually applied to two types of Tensegrity robots w ith different shapes and verified. Tensegrity robots are not only lightweight, but also have structural elasticity, so they have the advantage of being resistant to external shocks, so t hey are expected to be used in a variety of applications from human assistance robots to space exploration robots.



▲ UC Berkeley and Berkeley Emergent Space Tensegrities Lab's Tensegrities Robot

Q. I know that you have done a lot of research on aircraft such as urban air mobility (UAM) and autonomous drones. What is the scope and importance of the application in the related field?

Autonomous flying drones have already been expected to be widely used in missions such as reconnaissance, real-time surveillance, search and rescue activities, delivery, and remote sensing from several years ago. Recently emerging UAM aircraft are passengers such as airport shuttles and air taxis. In addition to transportation services, the scope of its use is expected to increase more and more widely, such as transporting cargo between cities and providing emergency medical services such as flying ambulances. The introduction of these new means of transportation is expected to bring innovative changes throughout our lives, including economy, society, and culture, in the near future. To respond proactively to these changes and lead the field internationally, I think it is most important to preoccupy core related technologies through R&D activities.

▲Caltech, with autonomous flying drones from Aerospace Robotics and Control Lab

Q. I am curious about what is the biggest challenge technology in UAM research, represented by flying cars.

As you generally know, an aircraft contains so many technical elements that it can be see n as an integral part of engineering. Moreover, UAM aircraft are a new type of aircraft that requires differentiated requirements and functions from other aircraft that exist so far, an d therefore, in their development, it is necessary to combine advanced technologies from various engineering fields. I can dare say that all of the technologies are difficult technolo gies.

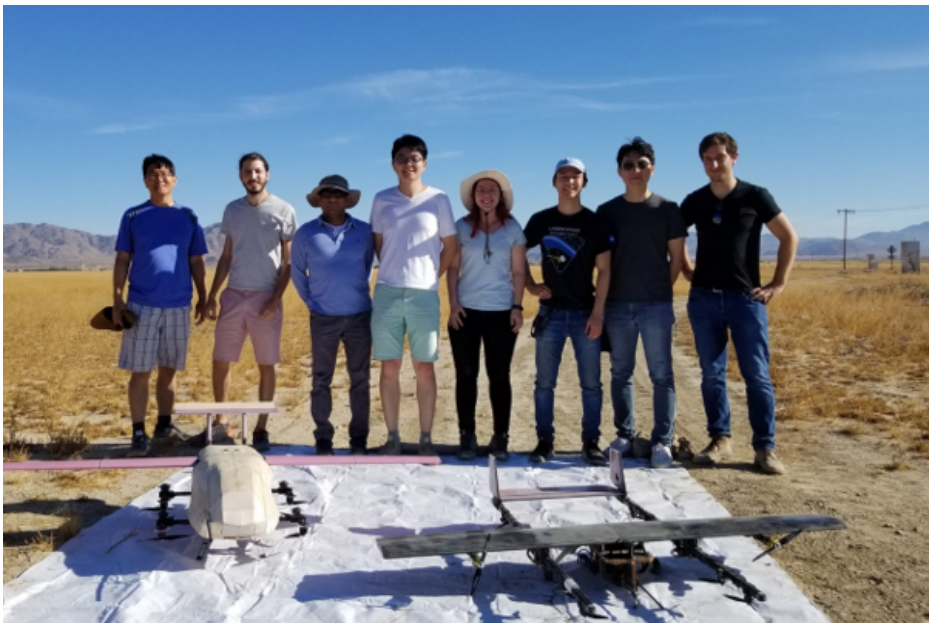
Among them, I think that the technologies related to the safety of the aircraft are the mos t difficult and important technologies due to the characteristics of UAM operating in urban areas, and flight control and autonomous flight technologies that can ensure the safety of the aircraft are also very difficult technologies in this context. One example would be rese arch on safe flight control, such as designing an emergency safety controller in case of pr opeller failure mentioned earlier.

In addition, if UAM is commercialized in earnest, multiple UAM aircraft will be operated si multaneously.In this case, it would be impossible to board skilled pilots on all aircraft, and if possible, it would be disadvantageous in terms of economy and safety. Is expected. For this reason, autonomous flying technology that can secure a high level of safety will be es sential for the commercialization of UAM in the future, but as seen in the case of autonom ous vehicles, the development of such autonomous driving technology requires a lot of ti me and cost. From this moment, I think it is necessary to make full-fledged efforts to sec ure UAM autonomous flight technology.

Q. UAM, a flying aircraft, has been attracting attention recently. What are the lat est market trends or technology trends in your field?

I first started my research in this area about three years ago when I was involved in Calte ch's Autonomous Flying Ambulance (AFA) project. At the beginning of the project, our tea m had the goal of creating a'city-moving vehicle capable of driving on the road', a literally flying vehicle. These aircraft were attractive as an end-to-end means of transportation be cause they utilize the existing road infrastructure and can operate not only in flight but als o on the ground. We have found that it is quite difficult to overcome the disadvantages of flying, as the limitations limit the wing area of the aircraft. In addition, it was expected to be a realistic problem to be solved, such as the establishment of relevant laws and safety rules, and the reorganization of the road traffic system, which must be in place to operate with other existing ground vehicles.

Even now, there are companies that aim to commercialize such a flying vehicle, and I also expect such a transportation method to be born someday, but many other companies are electric propulsion direct take-off and landing aircraft, which are likely to be commercializ ed in the near future. (eVTOL: electric Vertical Take-Off and Landing) is being developed. This aircraft has an operating concept that connects with take-off and landing and ground transportation systems in places called vertiports installed throughout the city with a drivi ng distance of several tens to hundreds of kilometers. I focused on eVTOL. For the develo pment and commercialization of eVTOL, not only the performance improvement of the exi sting traditional aircraft technologies, but also several new technology elements are being researched and developed. Representatively, fields such as distributed electric propulsion, batteries, noise reduction, autonomous flight, and air traffic control are I can hear it. In p articular, autonomous flight can be said to be a field that is deeply related to robotics.



▲After completing Caltech's Autonomous Flying Ambulance flight test,

Q. What motivates you to study unmanned aerial vehicles or aircraft?

When I was very young, I followed my father and participated in a comet observation eve nt, and I became interested in the aerospace field, and through high school and college ed ucation courses, I became deeply immersed in related disciplines. Then I learned that my doctoral advisor, Professor Alice M. Agogino of UC Berkeley, is working on a space explora tion robot research in the lab with NASA researchers, and ask the professor to participate. I have been awarded a doctorate for related research. The research conducted at this tim e was very enjoyable, but on the one hand, there was a regret that the sense of reality w as somewhat inferior because the target site was the universe. As a result, I got the oppo

rtunity to work as a podak at Caltech's Professor Jeong Soon-jo, who is researching robot s in the aviation and space fields, and participated in research related to UAVs, including AFA, which can affect our lives more closely. Was able to expand. At the same time, the i dea that UAM will revolutionize people's lives in the near future became more and more in tense, and with the desire to participate in making such a change based on the experienc e accumulated so far, I participated in the current UAM gas development work.

Q. You received your master's and doctorate degrees in mechanical engineering at UC Berkeley, a prestigious US state university. I am curious to see how well th e UAM technology in the US is and when will it be commercialized.

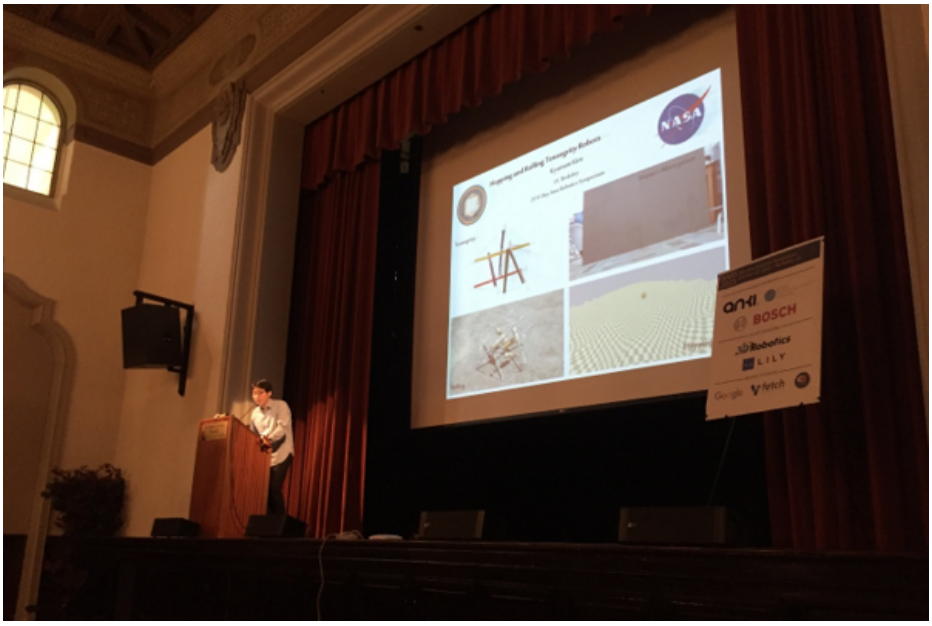
The United States is moving quickly to lead the market pioneering, leading the technologi es required to realize UAM by joining established solid aviation companies, challenging sta rtups, government agencies, national research institutes and academia. Representatively, NASA is carrying out the'Advanced Air Mobility National Campaign' step by step for the ne xt several years in cooperation with each organization to build the UAM ecosystem. Throu gh this, we are promoting the formation of a collaborative body for UAM technology devel opment, discussing future UAM operation forms and related laws, while preparing an oppo rtunity for the public to become familiar with UAM and persuading the safety of UAM to be trusted. . In line with this trend, Korea also announced a roadmap for Korean Urban Air Tr ansportation (K-UAM) recently, clarifying its vision to achieve transportation innovation th rough UAM and leap to a leading UAM country.Starting commercialization in 2025, in 203 0 We have set a goal to achieve full-scale commercialization. These plans are not lagging behind in time even compared to other countries that are responding quickly to UAM, and if we focus our national capabilities, we believe that Korea will be able to rise to the ranks of leading UAM countries.

Q. After graduating from UC Berkeley, you have been a postdoctoral researcher a t Caltech for 3 years. What are the strengths of the US research field or what can we learn?

With my short insights, I don't think I can discern the strengths of the numerous fields of research that are being conducted in the United States, so I would like to replace the ans wer with the envy of my research in the United States. My dream as a child was to work a t NASA, and fortunately, when I was at UC Berkeley graduate school, I had the opportunit y to intern at the NASA Ames Center, and while working as a podak at Caltech, I was at t he Jet Propulsion Lab. There were opportunities to collaborate and exchange with researc hers at. At the same time, I was able to hear information about the various space explora tion programs being conducted in the United States, and I used to envy their experience, technology, and economic power to make such research possible. For example, NASA has an Early Stage Innovations (ESI) support program that supports groundbreaking space te chnology ideas even if they are not highly skilled, and this support was quite special in the conservative space sector. The Tensegrity-based space exploration robot development pro ject I participated in during my doctoral course was also a rather challenging project with a strong character to confirm the possibility of new technologies, so I was able to receive research funding from this program.

In addition, the Americans had a chance to feel vividly that the general public is also very interested and proud of the space exploration programs in their country. In 2018, when I was working at Caltech, NASA launched the first probe called Insight to Mars for the geolo gic exploration of Mars, and an event to commemorate and announce the launch of the pr obe was held in Caltech's main hall. Has been opened in. Even though it was daytime on weekdays, the spacious auditorium was crowded with people of all ages, men and women,

and at the podium in the auditorium, experts related to exploration programs delivered sci entific knowledge to the general public in an easy-to-understand manner. NASA's broadca sting station vividly relayed the entire process from the probe launch preparation to the s uccessful landing on Mars.In particular, people who watched the last few minutes of the p robe's full-fledged landing attempted a successful landing signal from the probe. It was ve ry impressive to see everyone cheering and rejoicing upon arrival. This landscape, which c annot be easily seen in Korea, came to me differently, and space exploration research has been conducted more actively in Korea. .



▲At the 2015 Bay Area Robotics Symposium

Q. What are your future dreams and goals as a researcher?

I want to become a researcher doing research that can help people a little bit and help ch ange people's lives in a positive way. And now, through UAM, I want to realize my dream. I want to contribute to the development of a safe and convenient UAM that can improve p eople's quality of life.

Q. Recently, as interest in drones and flying aircraft has increased, more and mo re students are studying it. As a senior, could you give advice on what kind of pr eparation and effort are needed to your junior?

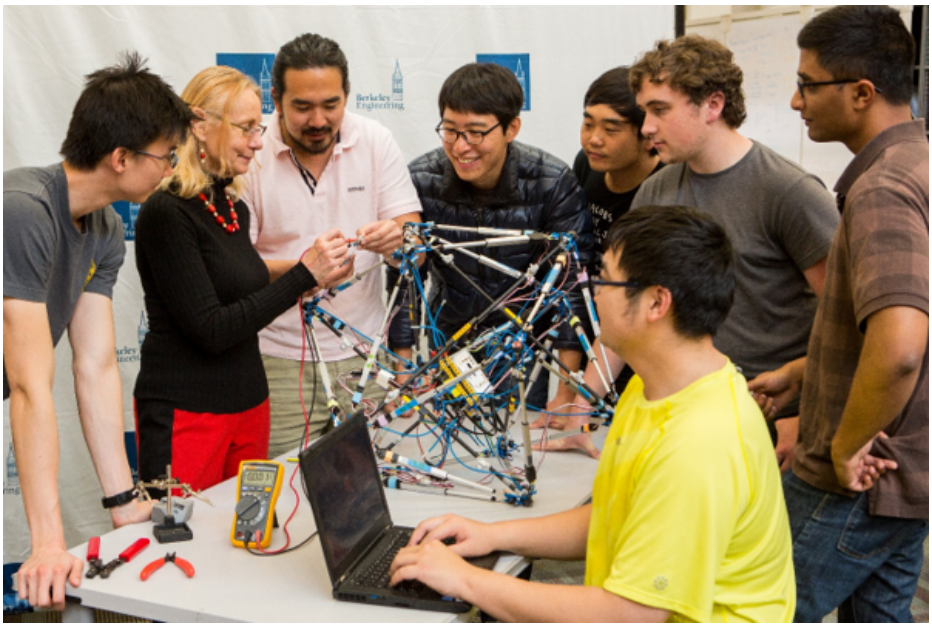
In interviews with others earlier, many people mentioned that robotics is a comprehensive discipline that encompasses various fields, but I also agree with this. And I think this is th e same for drones and UAMs as well as aircraft. Therefore, research and development of a ircraft requires those who have knowledge and experience from various fields. In other wo rds, there is a part where each researcher's current research field and experience can be usefully combined in aircraft research. It would mean to do it. From that point on, if you a cquire additional knowledge and expand your research area, I think you will be able to do great research that fits your interests.

And, of course, there may be research conducted by myself in these research activities, b ut in many cases I have collaborated with other researchers, and I used to realize that wo rking together as a team is more difficult than I thought. Therefore, consider the elements necessary for collaboration, such as how to set common goals and plans, how to communi

cate effectively, how to distribute and manage tasks, etc., and not only participate well in collaboration, but also leadership that can lead collaboration. How about growing it?

Q. As a researcher, would you give me any advice to advance the Korean UAV or UAM industry one step further...

I don't yet have the insights I dare to give any advice. However, if there is one hope for t he development of the UAM industry, I hope that many people will be interested in UAM a nd give their opinions. It is said that an important factor in the development of the UAM in dustry is public acceptance. No matter how well-made UAM gas, it will be difficult to succe ssfully commercialize it if people do not trust it, but it will not be easy to get rid of the sus picion and rejection of the new gas. So, if we build a social consensus on UAM from now o n and actively discuss the direction of the UAM industry in our society, it will serve as an i mportant driving force for Korea to leap forward as a leading UAM country.



▲With Professor Alice M. Agogino and lab colleagues

Q. If there is a professor or researcher who was primarily influenced by the rese arch...

Despite my not so long research experience, I have been grateful for the help and support from many people. Among them, Professor Alice M. Agogino of UC Berkeley, who guided my doctorate course, gave me excellent research guidance as well, but he taught me the basic attitude to have as a researcher and the attitude to work on research, and that teac hing still forms the basis of my research as a researcher. There is. Prof. Soon-Jo Jeong of Caltech, who guided my podak research, cultivated an eye for discovering creative and ch allenging research topics, and greatly expanded my experience and knowledge by particip ating in various aerospace robotics projects. Lastly, Dr. Dong-jin Hyun of Hyundai Motors Robotics Lab was the first person to enter robotics while studying in the United States, an d he continues to be my mentor by presenting an endless passion and vision for robotics. In addition to that, I am always grateful to all those who helped me to grow up to this ext ent as a researcher, and I, too, would like to constantly try to become a researcher who c an be an example for someone.

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