



The Royal Academy  
of Engineering

# Research Exchanges with China and India

## Case Study

# Development of Remote Control for a Lunar Rover

## Major Award



### UK Researcher:

#### Dr Yang Gao

Lecturer in Space Autonomy  
Surrey Space Centre  
University of Surrey



### Chinese Researcher:

#### Professor Ju Hehua

Director of the Deep Space Robotics Centre  
Beijing University of Technology  
China



## Reasons for the exchange

Dr Yang Gao at the Surrey Space Centre of the University of Surrey started to work with the researchers at the Deep Space Robotics Centre of the Beijing University of Technology in mid 2006. Jointly they have been working towards fully autonomous rovers for future robotic explorations to the Moon, such as the proposed UK Moonraker mission and the Chinese Chang'E lander mission. The Royal Academy of Engineering's Research Exchanges with China and India Award provided them with an opportunity to take this collaboration to the next level. This exchange involved two groups who have common research interests as well as individual strengths. The Surrey group specialized in artificial intelligence theories and small-satellite technologies, and the Beijing group had a strong background in hardware. This exchange enabled them to join forces in order to address a challenging problem which required expertise and research facilities from both groups. In the long term, this collaboration will lead to the development of key enabling technologies for future space missions using rovers.

## Match of institutions and researchers

The Surrey Space Centre and Beijing University of Technology groups are both very active in space robotics and autonomy research in their home countries. The Surrey Artificial Intelligence and Autonomy Research Group, led by Dr Yang Gao, has been involved in various projects in space robotic technologies, funded by the European

## Statement from the Host

*Dr Gao said at the time of receiving the award: "This award is prestigious and valuable to us. It provides an excellent opportunity for researchers from the UK and China to exchange expertise and build up long-term relationships. The collaboration can help to generate key robotic technologies for future lunar explorations, which are of major interest to both parties." She also suggested that the award was timely and would better position the UK researchers in seizing opportunities in the Chinese Chang'E program. Both Dr Gao and Prof Ju found the visits to each other's institutes an invaluable experience. Dr Gao said "the visits help us to bring our research expertise together in developing and testing autonomous operation systems for lunar rovers. I will also greatly benefit from this exchange in terms of understanding the different research culture in Chinese universities and the latest developments of the Chang'E program".*

Dr Yang Gao, Lecturer in Space Autonomy,  
The Surrey Space Centre of the University of Surrey

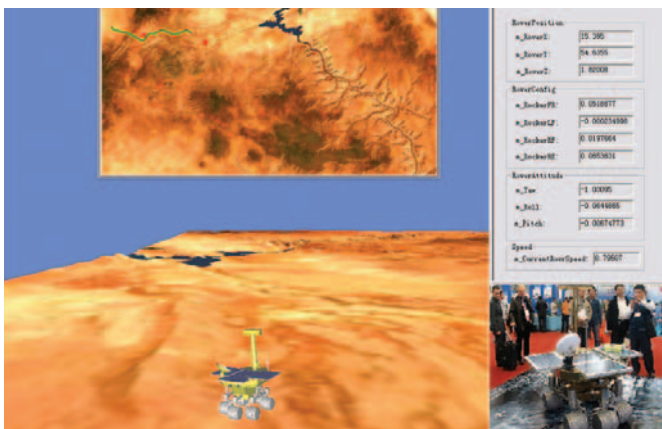


Dr Gao (left) worked on a lunar rover platform with students from Beijing

Space Agency, European Commission, UK Research Councils and industrial companies such as EADS Astrium and Surrey Satellite Technology Ltd. Dr Gao is also actively involved in the UK-led lunar mission studies MoonLITE and Moonraker. Her group consists of 3 Postdoctoral Fellows, 5 PhD students, 3 visiting scholars and a number of masters and undergraduate project students each year. Prof Hehua Ju is a member of the Chinese Deep Space Exploration Committee, an expert on China's Hi-Tech Research and Development Program (863 program), and director of the Deep Space Robotics Centre at Beijing University of Technology. He has supervised 18 masters students and 4 PhD students.

## Objectives of visit

The Academy sponsored visits between Dr Gao and Prof Ju aimed to strengthen the existing collaboration between the two institutions on autonomous lunar rover research. During these visits, they developed automated operation software for lunar rovers and tested it using the rover prototype in Beijing. This included new algorithms for localization and path planning as well as a rover operation software simulator.



Lunar rover software simulator based on the Beijing rover prototype

## Visit outcomes

Rover operation software has been produced as a result of the research exchange between Surrey and Beijing. It has been tested in both institutes and validated via remote control of the rover in Beijing from a Surrey station. The software can also simulate the rover operation in 3D vision which can be used to test and validate various onboard navigation algorithms of a rover (see figure below). Two conference papers and one journal paper have been written and published jointly based on this work. This exchange also served as a channel for Surrey to establish research networks with other Chinese institutions. For example, Surrey attended the 4th UK-China Joint Workshop on Space Science and Technology in Changsha, China, where Dr Gao and Prof Ju presented their collaborative research and results. This was regarded by all as setting a good example for future UK and China collaboration in space engineering research. By the end of the workshop, Surrey had signed 6 Memoranda of Understanding with Chinese space research institutions such as China Academy of Space Technology and Beihang University on space technology R&D as well as Beijing University of Technology to continue the existing activities on rover technologies research. Dr Gao was also invited to lecture at the Committee on Space Research (COSPAR) summer school on lunar and planetary science at Harbin Institute of Technology, China in September 2009 (see figure below).

## Future links and collaboration

Dr Gao and Prof Ju are very keen to extend their collaboration in the future to include other international partners such as the Austrian Academy of Science and Warsaw Space Centre. Together they will develop a useful rover instrument that can drill deep into the lunar regolith and take thermal conductivity measurement.



Dr Gao (2nd from right) was an invited lecturer of the COSPAR summer school at Harbin Institute of Technology

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Further information regarding the scheme  
is available from The Academy's website:

<http://www.raeng.org.uk/research/researcher/reci/scheme.htm>