Royal Academy of Engineering

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PROFILE
Distinguished International Associate

Thematic area: Photonic sensors

Project title: Uncrewed aerial vehicle (UAV)-based laser spectroscopic monitoring of greenhouse gas emissions in urban and rural India

Strategic goals: To develop a compact and lightweight laser-based trace-gas-sensing system to measure ambient carbon dioxide, translating laboratory research to local industrial bases and providing reliable emissions measurements.

Background: Having already achieved a First Class Bachelor of Technology degree in electronics and communications, and a Graduation Certificate of Merit from the Department of Atomic Energy in India, I obtained my PhD in 2010 from the University of Strathclyde's Department of Electronic and Electrical Engineering. Since then, I have focused my research on tunable diode laser spectroscopy for precision gas parameter measurement, as well as fibre-optic physical and biomedical sensing.

I am nationally recognised as one of the few Indian researchers with expertise in engineering applications of tunable diode laser-based precision spectroscopy, and I have a flourishing Photonic Sensor Lab at IITGN with state-of-the-art research facilities.

Previous Academy involvement: This is the third time I have been awarded funding by the Royal Academy of Engineering and my growth as a researcher has received a significant boost as a result. I was the Indian lead in a previous Industry–Academia Partnership Programme (IAPP) project titled 'Development of a fibre-optic sensor network to monitor hazardous gas leaks in industrial plants', in partnership with a professor at City, University of London.

About my project

Objectives: Air pollution is a leading cause of severe and chronic health issues, and industrial emissions are dominated by carbon dioxide, carbon monoxide and oxides of nitrogen. The problem is especially acute in the state of Gujarat where I am based, which is home to a thriving chemical and pharmaceutical industry. Vast agricultural activity is also a major contributor to emissions, with unregulated use of fertilisers on crops contributing to the emission of ammonia and nitrous oxide, which is 300 times worse as a greenhouse gas than carbon dioxide.

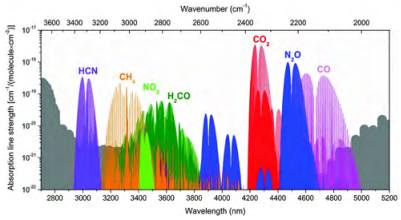
There is an urgent need to adopt advanced technologies for the reliable measurement of emissions, which must be precise, robust and easy to deploy. I propose developing and using UAVs for ambient air quality measurement, combined with laser spectroscopic systems using tunable diodes and embedded electronics. We envision partnering with Indian industries that could take up the technology for widespread use.

On the UK side... Building on an existing relationship with City, University of London, I am drawing on colleagues with complementary skills and facilities. My own background is highly international and interdisciplinary, which enables me to carry out impactful collaborative research with greater impact than would be possible by working solely with colleagues at my home university.

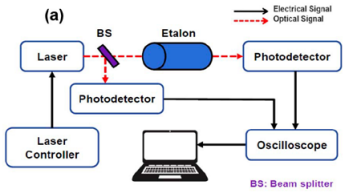
Project output: The first step involved designing a lightweight electronic system to drive the tunable laser. Future activities will include procuring a suitable UAV and mounting the laser-detector

UAV-based laser spectroscopic monitoring of greenhouse gas emissions in urban and rural India

1. A gas absorbs infrared light of wavelength specific to the molecule

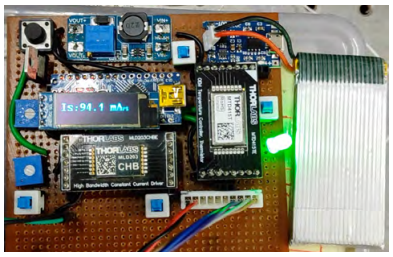


2. Use a tunable diode laser and a photodetector to make a sensor system

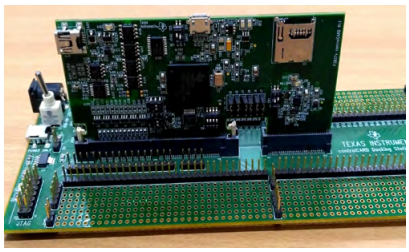


3. Mount the system on a drone for airborne measurement

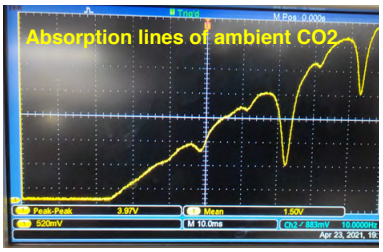
4. Design custom electronics to control the laser



5. Design custom electronics for data acquisition and signal processing



6. Make vertically resolved airborne measurements of trace gases



pair on it before testing for total flight time per battery charge. We will develop a Python-based post-processing algorithm for trace gas measurement and create a Raspberry Pi system for data acquisition and wireless data logging, again using Python.

A working prototype is ready and has been tested in various parts of Ahmedabad and Gandhinagar. The system is being upgraded for many more measurement campaigns. Discussions are ongoing with a leading Indian company, which is keen to develop the laser-based sensing technology.

An online workshop titled 'Photonics for Health, Atmosphere, Safety, and Education' was held in January 2022, delivered in a hybrid format with invited talks by experts on optical sensors and optical imaging. The event saw significant participation from undergraduate and postgraduate students at IITGN, the University of Calcutta and the University of Strathclyde.

Anticipated outcomes and impact: Any advanced technologies for reliably measuring emissions must be precise, robust and easy to deploy. They will be mounted on UAVs for vertically resolved measurements that are currently not carried out because there are no such UAV-mounted systems. Once the technology has been developed and tested, planned demonstrations of UAV-mountable robust greenhouse gas measurement systems would inspire confidence among local industries to take up the technology for widespread indigenous production.

Final thoughts on the Distinguished International Associates programme: I thank the Academy for this excellent opportunity. The DIA programme has allowed me to strengthen my links with my current collaborators and to develop new relationships. I feel more connected to other parts of the world through this project, which will have a trickle-down effect on the quality of teaching and the development of graduate students working on this project.

About the Distinguished International Associates Programme

The Distinguished International Associates Programme is an award scheme for international engineers working across all sectors, who are at the cutting edge of engineering research or innovation.

Awardees are offered a grant to amplify the impact of an existing collaboration with the UK in an area that aligns with the Academy's new strategic priority themes.

The programme aims to develop a broad international network of excellent diverse engineers across countries and disciplines, with research and innovation links to the UK, to work alongside the Academy to enhance progress towards achieving its goals for an inclusive economy and sustainable society.

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