Dr Santosh Bhattarai
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Education

University College London, UK (2010 – 2015)
Doctor of Philosophy in **Global Navigation Satellite Systems**
Thesis: "*Satellite Clock Time Offset Prediction in Global Navigation Satellite Systems*"
UK EPSRC studentship (2010 – 2013)

University of York, UK (2006 – 2009)
Bachelor of Science in **Mathematics and Physics, first class honours**
Final year project: "*Hydrogen and Nanotubes*", awarded top 5 in year group

Professional Qualifications

Associate Fellow of the Higher Education Academy (2013)
Teaching and Learning in Higher Education
Certificate no. PR057169

Professional Experience

University College London, CEGE (2017 – Present)
Lecturer
- Research collaboration with UCL Atmospheric Physics Laboratory on atmospheric drag modelling for low-Earth orbiter satellites (since March 2019)
- Module Coordinator for Advanced Mathematical Modelling and Analysis (BARC0130), Year 2 module on the M.Eng in Engineering and Architectural Design programme
- Programme Lead for Mathematical Modelling and Analysis I (ENGS103P) for students on the M.Eng. in Engineering and Architectural Design programme
- Coordinator of CEGE Scenario D: Environmental Building Design
- Tutor for Engineering Surveying (CEGE0098) delivering lecture and practical session on GNSS for Surveying
- Research student supervision at postgraduate and undergraduate level

University College London, CEGE (2013 – 2017)
Research Associate
research focus: high-fidelity modelling of spacecraft dynamics, spacecraft force modelling, precise orbit determination

- Developed force models for various missions (including GNSS missions: GPS, Galileo and Beidou; the altimetry satellite Jason-2 and ESA's satellite-based InSAR mission Sentinel-1) that account for the effects of radiation pressure, the geomagnetic field and thermal emissions on spacecraft motion.
- Designed and developed tools for automated testing of the performance of new force models using time series analysis, statistical analysis and visualisation methods.

- Co-author on a winning bid for an ongoing European Space Agency project worth €83,000 to UCL for applying newly developed force modelling techniques on the Galileo GNSS mission.
- Produced papers, reports, presentations and documentation enabling external partners (ESA, NASA Goddard Space Flight Centre) to introduce the UCL force models into their orbit determination processes.
- Managed the development of UCL's Orbit Dynamics Library – a spacecraft orbit simulation software package written primarily in C++ with a set of analysis tools in Python. Set up a Git repository for the Orbit Prediction Software to enable effective collaboration with other group members. The project has been active now for over 5 years with 5 contributors and about 900 total commits. This software has now contributed to several research projects including consultancy work for the Defence Science and Technology Laboratory (DSTL) and ESA.

University College London, CEGE (2010 – 2015)
PhD Student, Space Geodesy and Navigation Laboratory;
research focus: multi-constellation GNSS, GNSS satellite clock behaviour modelling, satellite clock prediction algorithms

- Analysed satellite clock time series data spanning across several years (2010 – 2013), corresponding to multiple satellite navigation constellations (GPS, GLONASS, Galileo) and derived from real measurements, to characterize the in-orbit behaviour of GNSS satellite clocks. Performed data cleaning and used a combination of time series analysis, statistical analysis and visualisation methods to aid the development of improved satellite clock models.
- Analysed the performance of existing GNSS satellite clock prediction algorithms, identifying their limitations. Proposed a new GNSS satellite clock modelling and prediction strategy based on an enhanced deterministic and stochastic model of clock behaviour set up to operate in a Kalman filter estimation framework.
- Worked on several side-projects – consultancy, research and teaching – that gave me knowledge and experience of a wide range of techniques in GNSS, as well as positioning, navigation and geodesy more generally. As an example, I was involved in a project to model the deformation of Mount Erebus volcano in Antarctica using GPS data from a network of geodetic receivers on the continent. This was a large data processing campaign using over 10 years of data, and required me to understand the precise point positioning (PPP) data processing strategy in some depth. I developed methods to be used by UCL's PPP software to process this data, and also used JPL's GIPSY software for this.

Teaching Experience

- GNSS for Surveying (2016-2017) – developed content and delivered a lecture on the use of GNSS for Surveying at UCL as part of the Mapping Science course for MSc students enrolled in various Geomatics programmes
- Space Systems: Astrodynamics Minor (2016) – assisted in problems classes
- Engineering Principles: Electricity and Magnetism for MSc in Rail Integrated Design Management (2012 – 2013) – developed and delivered course materials and assessment
- MSc course in Numerical Data Analysis (2011 – 2014) – ran problem classes and marked coursework on statistical analysis, least squares analysis, geospatial data analysis and Kalman filtering

- Mathematics for 1st and 2nd year undergraduate students (2011 – 2016) – helped in problem classes on differential equations, linear algebra and vector calculus
- Supervision of 1st year civil engineering students during the Lampeter field course (2011 – 2015) as part of the GPS team

Other Projects

- Contributed to a series of investigations for DSTL (2013, 2015) on the use of high-fidelity non-conservative force models for the identification of countermeasures used by ballistic missiles to avoid detection. The UCL Orbit Dynamics Library was used for the simulations for the 2015 study.
- Commercial software development for Spirent Communications (2013) with the UCL SGNL team. My contribution was in software testing, in comparing computer simulations of an inertial measurement unit (IMU) with real-world IMU data. For this, I created a data analysis tool in Matlab for producing Allan variance curves to study the noise characteristics of both the real and simulated data.
- Developed data processing tools for the EGNOS in Urban Environments (EGURE) project, which was a consultancy project that the SGNL group did for ESA (2011).
- Surveying: Carried out GPS surveying with the Leica GPS 500 and Leica Viva GNSS receivers for various projects, and for teaching. Part of the surveying team for an archaeological conservation project on Wanstead Park for English Heritage (2013).
- Management training: Participated in several professional development courses including an MBA elective course in Negotiation and Bargaining at London Business School; the Engineering Young Entrepreneur's Scheme where my team placed second (out of six) in a business development exercise; UCL graduate school residential courses organised by the UCL Centre for Advanced Learning and Teaching (CALT) in leadership and management, and personal and professional management.

Upcoming peer-reviewed publications

- Li, Z., Ziebart, M. & Bhattarai, S. (2019). DREMT: A new physics-based empirical representation of solar radiation pressure for Galileo satellites – in review.

Publications

- Bhattarai, S., Ziebart, M., Allgeier, S., Grey, S., Springer T., Harrison, D., Li, Z. (2019). Demonstrating developments in high fidelity analytical radiation force modelling methods for spacecraft with a new model for GPS IIR/IIR-M, *Journal of Geodesy*, published online: 10 June 2019, doi:10.1007/s00190-019-01265-7.
- Momoh, J. A., Bhattarai, S., & Ziebart M. (2019). Receiver clock jump and cycle slip correction algorithm for single-frequency GNSS receiver. *GPS Solutions* – accepted for publication.
- Li, Z., Ziebart, M., Bhattarai, S. & Harrison, D. (2018). A shadow function model based on perspective projection and atmospheric effect for satellites in eclipse. *Advances in Space Research*.
- Li, Z., Ziebart, M., Bhattarai, S., Harrison, D. & Grey, S. (2018). Fast solar radiation pressure modelling with ray tracing and multiple reflections. *Advances in Space Research*. doi:10.1016/j.asr.2018.02.019
- Li, Z., Ziebart, M., Grey, S., & Bhattarai, S. (2017). Earth Radiation Pressure Modelling for Beidou IGSO Satellites. *China Satellite Navigation Conference 2017 Proceedings*.

- Bhattarai, S. (2015). *Satellite clock time offset prediction in global navigation satellite systems* (Doctoral dissertation). University College London.
- Bhattarai, S., Virdee, H., Grey, S., & Ziebart, M. K. (2014). Geomagnetic Lorentz Force Modeling for Orbit Prediction: Methods and Initial Results. *Proceedings of the AIAA/AAS Astrodynamics Specialist Conference 2014*. doi:10.2514/6.2014-4137
- Grey, S., Ziebart, M., & Bhattarai, S. (2014). *High Fidelity Modelling of Space Resident Object Surface Charging due to the Photoelectric Effect*.
- Virdee, H., Bhattarai, S., Grey, S., & Ziebart, M. (2014). Non-conservative torque and attitude modeling for enhanced space situational awareness. *Proceedings of the AIAA/AAS Astrodynamics Specialist Conference 2014*. doi:10.2514/6.2014-4136
- Davis, J. A., Bhattarai, S., & Ziebart, M. K. (2012). Development of a Kalman filter based GPS satellite clock time-offset prediction algorithm. *European Frequency and Time Forum (EFTF), 2012*, 152-156. doi:10.1109/EFTF.2012.6502355

Technical Notes

- Devlin, L., Harrison, D., Bhattarai, S., Ziebart, M. & Maskell, S. Final report for the 'Integrators' project, contract ref. DSTLX-1000110640
- Bhattarai, S., Ziebart M. K. (2016). Guidelines for implementing UCL Jason-2 conservations force models: radiation pressure and thermal re-radiation models, technical note delivered to NASA and ESA
- Ziebart, M. K., Grey S. & Bhattarai, S. (2016) Technical Note 1: Galileo Orbit / Solar Radiation Pressure Modelling for Long Term Prediction, delivered to the European Space Agency as part of an ongoing project

Presentations

- *The vulnerabilities of GNSS to Space Weather*, Workshop on the cascading impacts on GNSS failure at The Royal Society, London, November 2018 (invited talk)
- *An overview of radiation force model development work at UCL – progress towards Sentinel-1 orbit determination,* COMET Science Meeting (2016), Manchester
- *Force modelling for Sentinel-1 orbit determination at UCL – A first look at Sentinel-1 precise orbits,* COMET InSAR workshop, University of Newcastle, November 2015
- *Modelling of radiation force on Sentinel-1 for orbit determination,* COMET Annual Meeting (2015), Shropshire (invited talk)
- *Geomagnetic Lorentz force modelling for orbit prediction: methods and initial results,* AIAA Space and Astronautics Forum, San Diego, August 2014
- *A performance analysis of the IGS predictions of the GPS satellite clocks*. Presented at: International GNSS Service Workshop 2014: Celebrating 20 years of service,
- *Enhanced modelling and prediction of GNSS space clocks.* ICT KTN Workshop on multi-constellation GNSS (2012), National Physical Laboratory, UK.

Research project supervision

Ph.D.
- Mr Taylor Knuth (PhD student, as subsidiary supervisor), January 2019 - present
- Mr Michail Spyridis (PhD student, as subsidiary supervisor), October 2018 - present
- Mr Saleh Abdel Vetah (PhD student, as subsidiary supervisor), October 2017- present
- Dr Zhen Li (PhD student, as subsidiary supervisor), March 2019

M.Sc.

- Yannik Garcia, *Thermospheric Density Observations using QB50 Cubesat measurements,* MSc Project in the Department of Physics & Astronomy, 2019 (2nd supervisor)
- Heidi Hurst, *Impact on resolution on car detection accuracy in satellite imagery using convolutional neural networks*, MSc Thesis, September 2018
- Maria Kainz, *Monitoring air pollution using satellite imagery*, MSc Thesis, September 2018
- Allyce Beaumont, *Measuring the impact of the T-charge (pollution charge) using satellite imagery at a high temporal resolution*, MSc Thesis, September 2018
- Alex Bridger, *An exploratory analysis of the PlanetScope Satellite Imagery Dataset*, MSc Thesis, September 2018

B.Sc.

- Lammy Ogboye and Calum Lockhart, *Analysis of two-line element data sets to represent the orbit of space debris*, B.Sc. Project, March 2018

Professional appointments and affiliations

- Member of the CEGE departmental extenuating circumstances panel (since 2019)
- Member of departmental scholarships shortlisting panel (2019)
- Journal reviewer for:
    - Advances in Space Research (2019)
    - IEEE Transactions on Aerospace and Electronic Systems (2018, 2019)
    - GPS Solutions (2018, 2019)
    - Frontiers of Information Technology and Electronic Engineering (2016)

- Member of the American Institute of Aeronautics and Astronautics (since 2018)
- Associate of the International GNSS Service (2012 – Present)
- Associate Fellow of the Advance Higher Education (2013 – Present)
- Associate of the Royal Astronomical Society (2014 – 2015)
- Student member of American Institute of Aeronautics and Astronautics (2014 – 2015)

Awards and other honours

- Excellent Personal Tutoring Award, Student Choice Awards, UCL (nominated: 2018, 2019)
- National Research Council Research Associateship Award at the National Oceanic and Atmospheric Administration in Silver Spring, MD, July 2017 (declined)
- UK EPSRC PhD studentship, 2010 – 2013

Skills

- **Programming languages** C/C++, Python, Matlab, bash, Fortran 90
- **Technical** astrodynamics, orbit determination, time and frequency analysis, geodesy, differential equations, mathematical modelling, prediction algorithms, GNSS positioning algorithms, precise point positioning with GPS, space vehicle force modelling, high performance computing, time series analysis, statistical analysis,

visualisation, least squares analysis, Kalman filter estimation, grant/proposal
writing