2023_37_ESE_Mason: Developing time-series InSAR for understanding changes to the ground surface, subsurface, biosphere and environment

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Interferometric Synthetic Aperture Radar (InSAR) is a technique with proven value for detecting and measuring changes to infrastructure, ground and environment. Time-series InSAR technology has progressed very rapidly and now allows global monitoring and measurement at mm-scale accuracies. Such developments are of great value in geohazards, infrastructure and agronomy. Earth Observation and InSAR are now standard tools for monitoring a wide range of natural and anthropogenic processes.

One such technique is Persistent Scatterer InSAR (PSI), which tracks small motions of scattering ground objects through a stack of SAR images. Regular global coverage and improving spatial resolution has led to thousands of publications but there are few open source tools offering PSI, and none with GUI or Windows PC support; which prohibits ease of use by researchers and industry. This lack prompted the development of our own Imperial College Synthetic Aperture Radar (ICSAR) toolset, which includes standard data processing, and several novel features for extraction of quantitative information about land cover, crops and physical environment.

Seasonally variable scattering patterns caused by natural and cultivated vegetation, soils, and regolith produce spatiotemporally complex phase changes in InSAR data. These patterns store valuable information relating to plant phenology, soil moisture, freeze-thaw and other behaviour. The lengthening global Sentinel-1 SAR archives (and new SAR satellites coming online soon), enable monitoring and retrospective analysis of such patterns to reveal some longer-term trends linked to groundwater, weather and climate. Hence, time-series InSAR analysis has potential to improve understanding of plant development and response to stress over time, to develop biomass analysis, and to better understand the physical landscape responses to environmental change.

This project will develop ICSAR's library of scripts and tools, and will incorporate Deep Learning techniques to exploit the InSAR phase variations – aiming to extract quantitative information about ground behaviour, land-cover and biomass changes, and/or soil moisture variations; analysing these to identify change, in relation to weather patterns and longer-term climate patterns. The broad research objectives are:

1.	Evaluate & develop ICSAR's capabilities

2.	Assess DL approaches

3.	Integrate & develop DL capabilities, & testing

This project outline has very broad scope and allows room for the candidate to pursue any one of several potential directions but all demand strong coding skills (e.g. Matlab, Python), a mathematics, physics or geophysics background, some familiarity with Earth Observation, SAR and/or InSAR, and with an interest DL techniques, and in geo/environmental science.

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