IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Land-use mapping from new-generation Earth Observation satellites with weak supervision**	
Project Number	**IMURA0824**	
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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

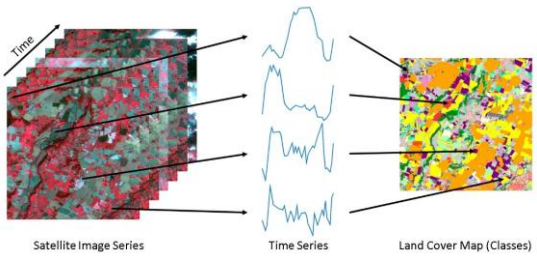
X	1.	Advanced computational engineering, simulation and manufacture
	2.	Infrastructure Engineering
	3.	Clean Energy
	4.	Water
	5.	Nanotechnology
	6.	Biotechnology and Stem Cell Research

The research problem

Define the problem

On March 23rd 2017, the European Space Agency successfully launched the final satellite of the Sentinel-2 mission into orbit. This mission now provides provide frequent images of the surface of our planet at no charge to users. This revolutionary program opens up an incredible opportunity to monitor the surface's evolution of the planet at a high spatial resolution of 10 to 60 meters and with 16 spectral bands. Combined with NASA's Landsat-8 mission, all land and coastal areas are now systematically imaged at weekly. These satellites produce vast streams of unprecedentedly rich data in the form of time series, enabling the creation of nuanced, temporal land-cover maps that describe the evolution of an area over

time (see Figure on the right). The standard to producing land-cover /land-use maps from this data is now to use Machine Learning (ML) methods to map each (x,y) area (ie GPS coordinate) with a temporal class. Current state-of-the-art ML systems such as Random Forest, XGBoost, Convolutional Neural Networks require millions of examples to be provided, generally each year, so that accurate maps can be constructed. This is usually a very costly process that can often not be performed, especially in low-density countries (such as Australia) or in developing ones, because it usually involves having humans drive to all the regions of the country, usually during a specific time of the year (eg just before harvest).



On the bright side, new-generation satellites such as Sentinel-2 are provided vast quantities of unlabelled data at no cost to the end-user. This represents an exciting opportunity for research: How can we reduce the number of examples to be given to an ML system, while maintaining a high-level accuracy for land-cover/land-use maps?

Project aims

Define the aims of the project

This project will seek to deliver so-called unsupervised methods that can help ML system to learn a supervised model of land-cover/land-use. The student will review study weakly-supervised systems that have been developed in computer vision and adapt and refine them for the particular problem of designing a land-cover/land-use mapping system for parts of the world where large amounts of data cannot be reasonably expected. Note that Earth Observation data have exciting characteristics that will make the adaptation of computer systems non-obvious, including missing values (when clouds are present), irregular temporal sampling, generally sub-sampled observation and multimodality when combined with RADAR or hyperspectral imaging.

Expected outcomes

Highlight the expected outcomes of the project

The project will seek to deliver methods and open-source software that can make the most of the available unlabelled data from new-generation Earth Observation satellites, in order to provide accurate maps of the world without the need for large number of training examples.

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

This project will primarily address the goal of “Advanced Computational Engineering, Simulation and Manufacture” by providing new methods for:

- computer science and data mining: this research will seek to develop novel Machine Learning systems and architectures for the accurate mapping from satellite image series.
- The target data being satellite images, some of these new techniques will directly apply to the fields of computer vision and signal processing.

Secondarily, this project will have potential to support the “Water” goal, by making it possible to provide accurate, high-resolution land-cover maps. These maps are an essential input to many applications including flood modelling (the water behaving differently depending on the type of surface it is flooding, its capacity for absorption, etc).

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

- excellent organisational skills

- good discrete and continuous math
- willingness to learn and get out of your comfort zone
- good programming skills
- familiarity with machine learning

If your mathematics or coding is exceptional then you don't need all the above. We also do understand that each person brings their own story to the PhD and can accommodate some lacking skills for an extremely motivated student.

Degree required: B-Tech/M-Tech in CSE/ECE

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Christoph Rüdiger (Monash)
Charlotte Pelletier (Monash)
Subhasis Chaudhuri ((IITB)

Please provide a few key words relating to this project to make it easier for the students to apply.

Machine Learning, data science for social good, earth observation, remote sensing, satellite image, time series analysis, computer vision