CDI FY18 Request for Proposals

Mapping land-use, hazard vulnerability and habitat suitability using deep neural networks

Submission Title: Mapping land-use, hazard vulnerability and habitat suitability using deep neural networks

Lead PI: Jonathan Warrick

Mission Area: Natural Hazards

Region: Pacific Region

Organization: Pacific Coastal and Marine Science Center

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Type: Collaborator

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Region: Southwest Region

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Type: Collaborator

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Region: Northeast Region

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Type: Collaborator

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Mission Area: Not Applicable

Region: Southwest Region

Organization: Northern Arizona University

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Type: Collaborator

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Region: Southeast Region

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Science Support Framework Element 1: Science Data Lifecycle - Analysis

Science Support Framework Element 2: Science Data Lifecycle - Processing

Science Support Framework Element 3: Communities of Practice

In-Kind Match: $42,110.00

List of anticipated deliverables from the project: (i) A user-friendly/configurable/scalable open-source (Python and TensorFlow) toolbox for automating advanced pixel-level classification of satellite, manned and unmanned aerial imagery, orthomosaics and digital elevation maps, utilizing state-of-the-art DNN architectures, (ii) Example data sets of imagery, from coasts and rivers in MA, CA, FL and AZ, with associated trained DNNs (e.g., https://goo.gl/KY5bZn), (iii) Two multi-day software training workshops held at the USGS in Santa Cruz, CA, and the USGS in Flagstaff, AZ, (iv) A detailed user manual, GitHub repository and website, (v) A report and/or journal article detailing the methods behind the software.

Lead Cost Center: Pacific Coastal and Marine Science Center

Project Description: Deliver a user-configurable image-classification and mapping tool based on state-of-the-art deep neural networks (DNNs) for assessing hazard vulnerability and habitat sustainability in coastal and fluvial environments from imagery, orthomosaics, and digital elevation maps.

Total Budget: $49,917.00

Title: "**Mapping land-use, hazard vulnerability and habitat suitability using deep neural networks**."

USGS Lead-PI: *Jonathan Warrick*, Natural Hazards Mission Area, Coastal and Marine Geology Program, Pacific Region, Pacific Coastal and Marine Science Center, orcid.org/0000-0002-0205-3814/, jwarrick@usgs.gov, Santa Cruz, CA.

Project Narrative: Coastal and fluvial landscapes are a nexus of human activity and natural change, where hazards threaten commercial, residential, and recreational infrastructure and natural resources. Quantifying landscape characteristics, such as hazard vulnerability and habitat suitability, requires accurate, fast and objective methods to classify large spatio-temporal datasets like the dense point clouds generated by lidar and photogrammetry. Machine-learning classification algorithms allow automatic mapping of land use/cover, vulnerability, and habitat suitability from diverse remote sensing datasets.

There have been huge advancements in artificial neural network models in just the past few years. **Deep neural networks (DNNs)** mimic the mammalian visual cortex, employing several layers of artificial neural networks to learn and subsequently recognize patterns in data, forming the basis of many state-of-the-art applications from self-driving cars to cancer detection. Pixel-level image classification algorithms using DNNs can pick out features based on barely perceptible differences in color and texture. However, much of the computer science research into these methods focuses on the identification of common objects (people, animals, man-made objects) in oblique photographic images with small spatial footprints, rather than real-world applications with digital datasets at the landscape scale. Thus, the advantages offered by deep (multi-layered), convolutional (capable of higher-order abstraction) neural networks has not been exploited for analysis of hazards and habitats in coastal and fluvial environments. Open-source software frameworks (e.g., TensorFlow) now make this technology accessible, but the wide range of choices involved in DNN are daunting for inexperienced users, especially with the challenges posed by natural landscapes.

Our preliminary work has shown these methods, with some novel modifications, can be powerful tools for automatically identifying and mapping natural features, textures and objects at the landscape scale (see our gallery of examples: https://goo.gl/KY5bZn). Recent examples include success at reliably distinguishing sand, rocks, water, surf, riparian vegetation, large woody debris, roads, and buildings, at different scales and using a variety of image types and quality. This could easily be extended to a multitude of additional types of land use, land cover, landforms, geological formations, wet versus dry land, rough versus smooth water, etc. – almost anything that is classifiable and distinguishable by the human eye.

The objective of this CDI project is to develop a flexible and easy-to-use DNN classification framework in open-source software that is well documented, and comes with several example datasets and associated trained neural networks from rivers, lakes and coastal settings of the United States. This will be accomplished by providing: ***(i)*** A user-friendly/configurable/scalable open-source (Python and TensorFlow) toolbox for automating advanced pixel-level classification of satellite, manned and unmanned aerial imagery, orthomosaics, digital elevation maps, and other data sets, utilizing state-of-the-art DNN architectures, ***(ii)*** Example data sets of imagery, from coasts and rivers throughout the U.S. with associated trained DNNs, ***(iii)*** Two multi-day software training workshops held at USGS offices and attended by USGS scientists across all Mission Areas, ***(iv)*** A detailed user manual, GitHub repository and website, and ***(v)*** A report and/or journal article detailing the methods behind the software. These tools will allow USGS scientists to apply the most successful machine-learning technologies available to natural hazards and habitats along the Nation's coasts and rivers.

Community For Data Integration (CDI) RFP BUDGET FORM

Budget Category	Federal Funding "Requested"	Matching Funds "Proposed"
GRAND TOTAL:	**$49,917**	**$42,110**
Do not edit the rows above this line.		
1. PERSONNEL (SALARIES including benefits):		
Personnel:		
Sherwood, 1 pp, at $9066.30 per pp (incl. overhead)	$	$ 9,066.30
Warrick, 2 pp, at $9349.44 per pp (incl. overhead)	$	$ 18,698.88
Grams, 1 pp, at $6922.66 per pp (incl. overhead)	$	$ 6,922.66
Brown,1 pp, at $4821.71 per pp (incl. overhead)	$	$ 4,821.71
Contract Personnel :		
Buscombe, 3 months at $9950/month	$29,850	$
Total Salaries:	**$29,850**	**$39,510**
2. TRAVEL EXPENSES:		
Trip 1 (5 days, 1 traveler: Buscombe)	ESIP Tucson July 2018	
Per Diem:	$300.00	$
Transportation (Airfare + Mileage/Shuttle):	$200.00	$
Other expenses (hotel, registration fees):	$750.00	$
Trips 2 & 3 (5 days, 4 travelers)	Training workshops, Aug -Sept 2018	
Per Diem:		$1,550
Transportation (Airfare + Mileage/Shuttle):	$2,600.00	
Other expenses (hotel):	$3,200.00	
Total Travel Expenses:	**$7,050**	**$1,550**
3. OTHER DIRECT COSTS: (itemize)		
Equipment (inc. software, hardware, purchases/rentals):	$	$
Publication Costs:		$1,000.00
Office supplies:	$	$50.00
Training:	$	$
Other expenses (specify):	$	$
Total Other Direct Costs:	**$0**	**$1,050**
Total Direct Costs:	**$36,900**	**$42,110**
Indirect Cost: NAU-CPCESU @ 17.5% for Buscombe salary	**$5,224**	**$**
Indirect Cost: USGS PCMSC @ 18.5% for total	**$7,793**	**$**