JPL SIRI INTERNSHIP ANNOUNCEMENTS OF OPPORTUNITY
Fall 2020
(subject to change without notice)

AO# **10886**
Project: **3D printing model of miniature spectrometers**

Background
Water is important for us! We drink water but also, in general life, as we know it, depends on water. Studying the creation of water and its transfer in the Solar System contains information about the evolution of Solar System and how did water end up on the Earth. One of the approaches to study where the water on Earth came from is by studying OD/OH ration on various objects in the Solar System. However, the OD/OH emission in 308nm is very faint and a very difficult measurement to make, often required in situ mass spectrometers to be sent to the astronomical bodies with spacecraft. In my lab at JPL, we have developed a new technology that has can potentially make these measurements remotely using small aperture telescopes.

Description
The student will be involved in a project to develop 3D printing models of various Miniaturized Spectrometer designs for Lunar robots, electronics, mechanics and integration. The main criteria for this position for the student to know about 3D printers and how to work with them and fix them. Also depending on the background of the student/she would be involved in reviewing the system requirements and design.

Background, Skills, Courses
hands-on electronics

Major(s): Electrical Engineering, Mechanical Engineering, Physics

AO# **11283**
Project: **Mars Data Analysis**

Background
The Jet Propulsion Laboratory is seeking highly motivated undergraduate students to participate in Mars data analysis focused on information returned by the Mars Global Surveyor, Mars Odyssey, the Mars Reconnaissance Orbiter spacecraft, the Mars Exploration Rovers, and InSight lander. Data to be studied will be from the Mars Orbiter Camera (MOC), Mars Orbiter Laser Altimeter (MOLA), Thermal Emission Spectrometer (TES), Thermal Emission Imaging System (THEMIS), High Resolution Imaging Science Experiment (HiRISE), the Context Imager (CTX), and instruments of the Mars Exploration Rover Athena Science Payload and the InSight lander.

Description
Work will be directed at characterizing the geology and safety of candidate landing sites for future Mars missions, including the Mars 2020 Rover. Safety issues focus on quantification of slopes of concern for landing safely in potential landing sites using MOLA data and digital elevation models from stereo images. Work will also be related to measuring rocks on the surface of Mars from orbit and on the surface and understanding their context. This will include analyzing rocks visible in high-resolution HiRISE images and quantifying their size-frequency distribution to better understand landing safety. InSight work will involve mapping geological features observed in the images such as craters, eolian bedforms, rocks, and soils. The maps will help define the geological processes responsible for creating and modifying the surface. HiRISE and CTX images will also be georeferenced to lower resolution images (CTX, THEMIS) and topographic maps (MOLA). Additional work may include analyzing craters on Mars to investigate rock distributions in their ejecta, how they change with time and their morphologic state as well as the geomorphology as a clue to the subsurface geology.

Background, Skills, Courses
Most of the work will be done on personal computers utilizing mixed operating systems (Windows and Macintosh), so experience with them is important. The ability to measure and tabulate rocks, place the data into standard spreadsheets, and plot the results is required for the work on rock distributions. Experience with ArcGIS mapping software (10.x), especially georeferencing imagery, is preferred as our landing site data is specifically formatted to work with this GIS package. Additional knowledge of Integrated Software for Imagers and Spectrometers (ISIS 3.x), SOCET SET, or Matlab software would be a plus. Preference will be given to students with backgrounds in geology or planetary science and other related disciplines such as geographic information science, physics, chemistry, astronomy, engineering, and computer sciences. The students will spend most or all of their time at JPL. They may be supervised by one or two research scientists and may also work alongside other researchers and students.

Major(s): Planetary Science, Earth Science

AO# **11286**

Project: **Combining unsupervised and supervised deep learning algorithms for improved semantic segmentation of satellite images**

Background

It is important to segment different objects from satellite images in various earth science applications, including wildfire propagation predictions and groundwater estimation. Manually segmenting a large set of high-resolution satellite images requires significant manpower. Therefore, we need an automated solution to semantic segmentation of satellite images. There have been attempts at automatic semantic segmentation of satellite images using machine learning, but the disadvantage is that training machine learning requires a large set of labeled training data sets that require a lot of human resources.

Description

We aim to develop a hybrid machine learning framework that tracks smoke plumes from multi-sensor images with unprecedented training speed and accuracy with minimal human labeling in multi-modal image processing. We will build an agile on-board processing and analysis system to support future field campaigns. First, we will apply an unsupervised deep learning algorithm for semantic segmentation of satellite images. The semantic segmentation will then be refined using a supervised machine learning model with minimal number of labels.

Background, Skills, Courses

Suggested: Tensorflow and/or PyTorch Data science and machine learning https://www.coursera.org/specializations/deep-learning Required: Python, linear algebra, basic calculus

Major(s): Computer Science, Earth Science

AO# **11287**
Project: **Efficient swarm path planning by transforming a mathematical model into a numerical model**

Background

State-of-the-art motion planners cannot scale to a large number of systems. Motion planning for multiple agents is an NP (non-deterministic polynomial-time) hard problem, so the computation time increases exponentially with each addition of agents. This computational demand is a major stumbling block to the motion planner's application to future NASA missions involving the swarm of space vehicles.

Description

We aim to pioneer new methodologies, leveraging recent advances in optimization and deep learning, which can transform computationally demanding mathematical motion planning problems into deep learning-based numerical problems. We will construct a deep learning architecture that can handle multiple agents (~ 100) and obstacles (~ 100) of various sizes and speeds. We will combine convolutional and recurrent neural networks to solve spatial and temporal optimization problems.

Background, Skills, Courses

Suggested background/skills/courses: Tensorflow and/or PyTorch Data science and machine learning https://www.coursera.org/specializations/deep-learning Required background/skills/courses: Python, linear algebra, basic calculus

Major(s): Computer Science, Aerospace Engineering

AO# **11297**
Project: **Holographic Examination for Life-like Motility**

Background
Imagine you fly to Europa, melt some ice, and stare at the liquid under a microscope. Or thick, salty Martian brines. Or the plumes shot out from Enceladus. How would you know what you see in that liquid is alive? You can test for DNA or proteins that mean life on Earth, and there are instruments for that. But what if, instead, you just looked at the movies of particles in the liquid and asked, "Is it moving like life?" Any human could watch and tell you what that meant, but try to write a program to measure it. Instead, we will use humans to provide labels like "This object here is moving like life" and "This object is not." Then we will train a machine learning program to take measurements of the particles and learn, statistically, what the human labelers are talking about. This is HELM, an algorithm that will fly to Europa, Mars, and other worlds looking for signs of life wiggling in the water. It also will be used extensively on Earth, rapidly identifying potentially dangerous organisms in our beach ocean water, lakes, streams, and even within our own blood.

Description
We are developing the above algorithms in Python while keeping our memory and compute requirements very small so that we can fit on rad-hardened space hardware in future missions. But to train our algorithm, we need a LOT of labels. Those are made by humans staring in detail at real data movies taken of known living and non-living things, so that the ML methods can figure out how to determine life from un-life. This position will require helping us label a lot of such images, some each day. You will be embedded in our development team and watch the growth of a real ML system designed for space use, be exposed to real-world ML considerations, challenges, and solutions, and get real science-data analysis experience. But don't be fooled...it takes a lot of work to provide these labels in an accurate, careful manner. You will work at JPL in the Machine Learning & Instrument Autonomy group with flexible hours, meet the group, and make connections across JPL.

Background, Skills, Courses
Required: Computer familiarity, and some programming experience. Nice to have: Microbiology

Major(s): Computer Science, Mathematics, Biology

AO **11301**

Project: **AI for Mars (AI4Mars) - Image labeling and crowdsourcing project management**

Background

We are a group at NASA Jet Propulsion Laboratory that works on machine learning algorithms for Mars rover missions. Ours is one of the first labs to implement deep learning tools for exploring the Red Planet, in part because we have access to the rovers, raw data, and experts. This project is motivated by the lack of labeled datasets required to train the majority of deep neural network-based approaches. On Earth, researchers across the globe managed to curate many different datasets for things we encounter in day-to-day life, such as house numbers, cityscapes, random stuff, and maybe most importantly, puppies and kittens! Sadly, all of this data is of little use for mission-critical, autonomous exploration of other celestial bodies. Creating a high-quality, large-scale dataset is of central importance to create an AI for Mars exploration.

Description

The intern students will help create a training dataset for future Mars rover algorithms in one or more of the following ways: i) Label images from Mars rovers and/or from analog sites on Earth, ii) help managing a crowdsourcing project for collecting labels from the internet (https://www.nasa.gov/solve/AI4Mars/), iii) develop data analysis/management tools with Python, Javascript, or C/C++ Students will be also exposed to an opportunity about getting experience in the latest machine learning technologies with JPL mentors. We expect highly motivated students with a genuine interest in exploring the red planet!

Background, Skills, Courses

Programming in Python, Javascript, or C/C++ (desired but not required.)

Major(s): Computer Engineering, Aerospace Engineering

AO# **11304**

Project: **Analysis and Archiving of Near- and Mid-Infrared Observations of Jupiter and Saturn**

Background

Images and spectra of Jupiter and Saturn from visible, near- and mid-infrared instruments are sensitive to temperatures, abundances of a major condensate (ammonia) opacity of clouds and the variability of the molecular para vs. ortho-H2 ratio. These define the fundamental state of the atmosphere and constrain its dynamics. This research will focus on observations obtained from a variety of instruments used at large professional telescopes: NASA's Infrared Telescope Facility, Gemini North and South Telescopes, ESO's Very Large Telescope, and the Subaru Telescope, and the Juno mission images of Jupiter in reflected sunlight from the JunoCam instrument. The general objective of the specific tasks below will be to create fully reduced data from unreduced or partially reduced sets. In some cases, our objective is to format the data for input into an atmospheric retrieval code from which atmospheric properties will be derived.

Description

Several specific topics are available: (1) A major challenge working with the Juno mission's JunoCam images is to assign accurate geometry to them for comparison with other data sets. Our objective is first to create this geometry with a code supplied by the US Geological Survey ("ISIS3"). An immediate second objective is to re-map the images into standard Mercator or polar projections, with high priority on images that can address the following scientific investigations: search for and characterize mesoscale gravity waves, characterize atmospheric hazes – particularly around polar regions, measure the relative altitudes of cloud features from analysis of their shadows, and characterize the colors of different cloud features. (2) To fulfill a contractual obligation to NASA, we need to archive our thermal infrared observations of Jupiter from various instruments over nearly two decades with NASA's Planetary Data System (PDS). These data must be accompanied by required ancillary files in a specific PDS format. The goal of this work is to collect copies of the data and ancillary files into a single location and submit these to review by the PDS. Aspects of this work can be done concurrently with another student working on the long-term variability of Jupiter (see 5 below). (3) We will be acquiring a large volume of observations of Jupiter that are designed to support observations from instruments on the Juno spacecraft. It will be important to reduce and, to the extent possible, analyze these results to be reported by the mentor and his colleagues to the Juno science team. There are several specific objectives in this overall category. (a) Develop of quasi-automated software for combining Mercator maps derived from images taken at different times as the planet rotates; use these to create full maps of Jupiter over all longitude, as well as to polar project those maps – for example - to investigate correlations between different phenomena in the neutral atmosphere and the aurora. (b) Develop a technique for absolute photometric calibration of near-infrared images of Jupiter in the absence of cross-calibration with standard-star calibrations by reference to independent measurements of photometry by spacecraft. (c) Determine the relationship between the morphology of auroral-related stratospheric heating at Jupiter's poles with auroral emission in the ultraviolet and infrared. (d) Measure the distribution of cloud properties in the atmosphere with near-infrared reflectivity, including high-resolution adaptive-optics stabilized images. Use the to characterize the chemistry and dynamics of the atmosphere, e.g. polar hazes, their evolution and their relationship with the temperature and wind field. (e) Develop a means to reduce spectral observations of Jupiter or Saturn to derive spectra at each pixel of the slit; for scanned spectra of this type, develop a means to calibrate the geometric positions of each pixel. (4) Including these and more historical data, track high-altitude particulate wave properties of Jupiter's North Equatorial Belt to determine whether these waves appear only at the same time as the latitudinal expansion of the dark NEB or also with other planetary-scale atmospheric phenomena. (5) Examine the long-term variability of longitudinally averaged temperatures and other properties in Jupiter, continuing previous work by students to create accurate and self-consistent calibrations of all data from a variety of telescopes. Extend a current program to input longitudinally averaged data over Jupiter's full disk to include observations at facilities where only a northern or a southern hemisphere of Jupiter could be captured. Format these data to be an input to an atmospheric retrieval program. Organize the output of this program to enable rapid plotting and correlation with previous studies and between different retrieved atmospheric properties. (6) Examine the variability of Saturn's longitudinal-mean temperatures as a function of time and compare with existing Global Climate Models.

Background, Skills, Courses
The data reduction programs are written in the Interactive Data Language (IDL, which is close to Matlab in format). The analysis code is written in FORTRAN. At least rudimentary knowledge of these (or willingness to learn before the beginning of the research) is highly recommended. At least some programming experience is required of serious candidates. With a significant level of contribution, students are welcomed as co-authors on papers emerging from this research.

Major(s): Planetary Science, Astronomy/Astrophysics, Computer Science