AO# 8044

Title: Swarms of Robot Boats-- Multi-Agent Planning and Autonomy Software Architecture

Background Information: JPL leads a variety of maritime robotics projects. In this project, we are designing systems for a fleet of fast-moving surface boats, known as autonomous (or unmanned) surface vehicles (ASVs or USVs). In particular, JPL's development focuses on the perception, planning, and control systems, as well as a multi-agent autonomy software architecture. The goal is to have a software "kit" that can be deployed on arbitrary vehicles for arbitrary missions, with minimal modifications and code changes. The architecture and its components (known as "CARACaS", or Control Architecture for Robotic Agent Command and Sensing) have been demonstrated in complex missions with full-scale vehicles, showing robustness to the challenges of real-world sensing and communications systems.

Project Description: The student will assist in the development of CARACaS for use on autonomous vehicles. There are several possible focus areas, including: (1) development, implementation, and testing of algorithms for the multi-agent cooperative planning and motion control; (2) adapting CARACaS for use on aerial vehicles (quadrotors) and conducting initial experiments with multiple cooperating agents; (3) contribution to the CARACAS software framework, improving libraries and toolkits for messaging, logging, playback, visualization, simulation, and operations. The student will contribute to a JPL team of autonomy and software experts and several other student interns.

Suggested and/or Required Background/Skills: Strong software skills, with experience in C++, Python, and Linux preferable. Experience in motion planning, simulation, multi-agent systems, or web development is helpful, depending on the desired role/contribution.

References: M. T. Wolf, A. Rahmani, J.-P. de la Croix, G. Woodward, J. Vander Hook, D. Brown, S. Schaffer, C. Lim, P. Bailey, S. Tepsuporn, M. Pomerantz, V. Nguyen, C. Sorice, M. Sandoval, "CARACaS multi-agent maritime autonomy for unmanned surface vehicles in the Swarm II harbor patrol demonstration," Proc. SPIE 10195, Unmanned Systems Technology XIX, 101950O, May 2017. doi: 10.1117/12.2262067 USV Swarm Video: https://www-robotics.jpl.nasa.gov/tasks/taskVideos.cfm?TaskID=271&tdaID=700075 Y. Kuwata, M. T. Wolf, D. Zarzhitsky, and T. L. Huntsberger, "Safe Maritime Autonomous Navigation with COLREGS, Using Velocity Obstacles," IEEE Journal of Oceanic Engineering, 39(1): 110-119, 2014. M. T. Wolf, C. Assad, Y. Kuwata, A. Howard, H. Aghazarian, D. Zhu, T. Lu, A. Trebi-Ollennu, and T. Huntsberger, "360-degree visual detection and target tracking on an autonomous surface vehicle", Journal of Field Robotics, vol. 27, Nov. 2010 T. Huntsberger, H. Aghazarian, A. Howard, and D. Trotz, "Stereo vision" based navigation for autonomous surface vessels," Journal of Field Robotics, vol. 28, Jan. 2011.

Primary Discipline: Computer Science

Secondary Discipline: Electrical Engineering and Computer Science

Other Discipline:

AO# 8018

Title: Engineering Tool Development for NISAR

Background Information: The NASA-ISRO Synthetic Aperture Radar (NISAR), is a joint mission between NASA and ISRO to develop a dual band synthetic aperture radar (SAR) for satellite remote sensing measurement of the Earth's surface. The instrument will provide an unprecedented detailed view of Earth providing insight to a wide range of scientific research application including land use, water resources, ocean, sea ice, and disaster response. NISAR Radar Engineering team at JPL is responsible for the design, implementation, and testing of the L-band radar. We are seeking for a candidate to support the development of software applications that are essential for instrument testing.

Project Description: You will work with radar system engineers to develop software for facilitating instrument testing activities. Depending on experience and interest, you may also support implementation and testing of a data analysis tool for processing and validating engineering data as well as performance evaluation and optimization of the tool.

Suggested and/or Required Background/Skills: Python/C/C++. Graphic User Interface (GUI) design and implementation experience are also desired. Knowledge of basic computer science topics such as data structures, algorithm development, modular programming, and unit testing. Working knowledge of Unix.

References: http://www.jpl.nasa.gov/missions/nasa-isro-synthetic-aperture-radar-nisar/

Primary Discipline: Electrical Engineering and Computer Science

Secondary Discipline: Computer Engineering

Other Discipline:

AO# 8017

Title: JPL Technology Catalog

Background Information: NASA's Jet Propulsion Laboratory generates a significant amount of software products. Cataloging, searching, and discovering these products can be a challenge. The JPL Technology Catalog (JTC) project strives to reduce the cost of finding appropriate technical products through a user-friendly web-portal, enabling faceted search capabilities.

Project Description: The project task focuses upon upgrading the existing (prototype) JTC user interface and middleware technology to be a production-grade tool for allowing any team at JPL to launch an instance of the catalog for their own project needs. We need help from a student to perform user interface development work (HTML, Javascript, CSS), as well as middleware development work (NodeJS), for the JTC portal web-application. The student will have the opportunity to learn about a wide variety of software technical products at the laboratory through the development work involved in this project.

Suggested and/or Required Background/Skills: Programming - Javascript (ES6+), NodeJS, HTML/CSS Technologies: some experience with search technologies like Apache Solr or Elastic Search would be a plus.

References:

Primary Discipline: Computer Science

Secondary Discipline:

Other Discipline:

AO# 8016

Title: Deep Space Network's Complex Event Processing

Background Information: The Deep Space Network (https://deepspace.jpl.nasa.gov/) operates spacecraft communication links for NASA deep-space spacecraft, and has done so for over 50 years. The Complex Event Processing (CEP) sub-project is focused on building next-generation infrastructural tools for correlating real-time network data with other critical data assets which human operators manage on a regular basis.

Project Description: The task work involves making demonstration client programs showcasing capabilities or novel uses of our correlation infrastructure. We need help to make client programs (Python, Java, or Web) that query our database of real time information and provide filtered / processed results that meet an existing need for operators.

Suggested and/or Required Background/Skills: The candidate should be willing to solicit requirements from DSN personnel on tools they need and be willing to learn basics about radio communication. Skills / courses: - Python programming ability or Java / Ruby - Ability to make a GUI, either in Python or Web - Fast learning skills and interest in space communications

References: * DSN information: https://deepspace.jpl.nasa.gov/ * Live DSN status: https://eyesstage.jpl.nasa.gov/dsn/dsn.html * Background paper on CEP project: https://arc.aiaa.org/doi/pdfplus/10.2514/6.2016-2375 *

Primary Discipline: Computer Science

Secondary Discipline:

Other Discipline:

AO# 8013

Title: Microbial Culturing for Spectroscopic Biosignature Analysis

Background Information: The terrestrial subsurface is host to diverse microbial communities. Despite the large biomass in the subsurface and the importance of these microorganisms in global carbon and nutrient cycles, relatively little is known about their in situ activity. Retaining the spatial and contextual information of microbial consortia in the subsurface is crucial to understanding these complex geobiological dynamics. By coupling microbial activity experiments such as stable isotope probing with DUV spectroscopy techniques we can assess the in situ microbial community.

Project Description: The intern will be involved in microbial culturing experiments to assess the ability of deep UV spectroscopy to differentiate labeled compounds. Duties will involve media preparation, standard microbial growth curves, dilution calculations, DUV Raman and fluorescence spectroscopy, aerobic and anaerobic microbial culturing (BSL 1), crushing rock samples for microbial growth, and possible DNA extractions. Ability to work independently is critical.

Suggested and/or Required Background/Skills: Experience with sterile techniques and standard microbiology are required. An interest in spectroscopy techniques, microbial activity some geology classwork would be beneficial.

References: Wanger, M. Single-Cell Ecophysiology of Microbes as Revealed by Raman Microspectroscopy or Secondary Ion Mass Spectrometry Imaging Annual Reviews of Microbiology, William J. Abbey, et al.,Deep UV Raman spectroscopy for planetary exploration: The search for in situ organics, Icarus, Volume 290, 2017, Pages 201-214, ISSN 0019-1035, http://dx.doi.org/10.1016/j.icarus.2017.01.039.

Primary Discipline: Biology/Bioengineering

Secondary Discipline: Planetary Science

Other Discipline: Chemistry

AO# 8004

Title: Micro Air Vehicle structural design and modelling

Background Information: Micro air vehicles (MAV) have very high constraints on size, weight and power, limiting the payload that they can carry. Structural components to attach payload infrastructure (sensors, computing platforms) need to be optimized in terms of size and weight which makes custom designs with light-weight materials necessary. Since any additional structure will augment the vehicle gross weight, it will also influence the flight performance. To predict these changes a vehicle dynamics model can be used in simulation to test and evaluate new vehicle configurations and verify that the flight performance of the platform still stays within the flight envelope of the vehicle which ensures that the MAV still can be maneuvered.

Project Description: The goal of this project is to design structural components for a micro air vehicle (small autonomous quadrotor), to attach additional hardware to the vehicle. This can be additional sensors (e.g. cameras, science sensors) or other hardware components. Because of the weight restrictions the preferred material will be carbon fiber structures, which we will manufactured at JPL. The project includes CAD based designing of attachment structures (e.g. SolidWorks), supervising the production process (e.g. 3D printers, Laser cutters, etc.), and hands-on experience in flying the updated quadrotor MAVs. Based on the skill set of the applicant this could also include soldering of electronic components (not required). Optional, the project may also include the development and implementation of a vehicle dynamics model (MATLAB) to simulate the influence of weight changes on the flight characteristics of the MAV.

Suggested and/or Required Background/Skills: Good SolidWorks experience, MATLAB experience.

References: A reference to our micro air vehicle platforms that we buy from Ascending Technologies and then adapt to our own needs can be found here: http://www.asctec.de/uav-applications/research/products/asctec-hummingbird/

Primary Discipline: Mechanical Engineering

Secondary Discipline: Systems Engineering

Other Discipline:

AO# 7990

Title: Survey of Hydrogen Fluoride and Water in Nearby Galaxies

Background Information: Several atomic and ionic fine structure lines and many molecular rotational lines lie at sub-millimeter and far-infrared wavelengths. Since the chemical composition of the gas depends mostly on density, temperature, radiation field and elemental abundances of the gas, astrochemistry of the interstellar medium (ISM) is an excellent tool to probe the physical structure and evolution of the gas.

Project Description: The goal of this research project is to conduct a comprehensive survey of two molecular lines - hydrogen fluoride (HF) and water (H20) - in nearby galaxies obtained with reliable archival form the Herschel Space Observatory PACS instrument. The objective of this survey is to probe the chemistry of fluorine and oxygen-bearing molecules and to determine to what extent both species can be used as diagnostics of the physical process at play in the ISM of the host galaxy.

Suggested and/or Required Background/Skills: Python programing knowledge required. Student should be familiar with basic principles of atomic and molecular spectroscopy and the interstellar medium.

References:

Primary Discipline: Astronomy/Astrophysics

Secondary Discipline: Computer Engineering

Other Discipline:

AO# 7986

Title: PDS Imaging Node Image Atlas Search Enhancements

Background Information: The Imaging Node (IMG) of the NASA Planetary Data System (PDS) is the home to over 700 TB of digital image archives, making it one of the richest data repositories for planetary imagery in the world. The Planetary Image Atlas provides access to the entire collection of IMG data through links to online holdings and data node catalogs, enabling users to make scientific discoveries. Because of the immense volume of planetary imagery, the problem arises with remaining in sync with new missions and the data available through the Atlas. By developing an automated pipeline for metadata ingestion for newer missions, it will minimize the cost associated with ensuring data is in sync.

Project Description: The candidate will be tasked with leveraging a BPMN-like software package to verify and ingest product metadata for missions not currently accessible through the Atlas, like New Horizons, Dawn, Rosetta, EPOXI, etc. This will involve the parsing of product metadata, verification of data integrity, ingestion into Solr indexes, and processing of raw and derived data products into web-viewable image formats.

Suggested and/or Required Background/Skills: Required: Unix/Linux, Python/Java, Eclipse IDE Suggested: BPMN, GDAL, software engineering course work, understanding of image formats

References: Planetary Image Atlas - http://pds-imaging.jpl.nasa.gov/search/ . PDS Imaging Node - http://pds-imaging.jpl.nasa.gov/ . BPMN - https://en.wikipedia.org/wiki/Business_Process_Model_and_Notation The VICAR Image Processing System - http://www-mipl.jpl.nasa.gov/external/vicar.html . USGS ISIS: Integrated Software for Imagers and Spectrometers - https://isis.astrogeology.usgs.gov/ . GDAL - Geospatial Data Abstraction Library - http://www.gdal.org/ .

Primary Discipline: Computer Science

Secondary Discipline:

Other Discipline:

AO# 7974

Title: Night-based quadrotor navigation

Background Information: Vision-based navigation of quadrotors is critical to mitigate GPS multi-path or indoor failures, and work with great accuracy. These techniques have reached a research level of maturity in daylight, but have still barely been tested in the night time.

Project Description: New thermal cameras have reduced their size, weight and power envelope (SWaP). This makes it possible to fly them on board micro air vehicles but their processing still presents some significant challenges, such as the noise pattern and rolling shutter effects. Using advanced visual-inertial filtering and image processing techniques, the student will contribute extend an existing visual-inertial navigation algorithm from daytime to night time.

Suggested and/or Required Background/Skills: Computer Vision, Probability, Statistics, State Estimation, Filtering.

References:

Primary Discipline: Electrical Engineering and Computer Science

Secondary Discipline: Aerospace Engineering

Other Discipline:

AO# 7969

Title: Europa surface mapping

Background Information: Europa is the target of the future Europa Clipper and a potential lander mission. But we don't know very much about the exact composition of the surface, other than that it is mostly water ice.

Project Description: The project will be to take high-resolution Galileo SSI mosaics and georeference them to the USGS Europa basemap by lining up different features. Next, Galileo NIMS data will be also lined up to the USGS basemap and the SSI image. The work will be painstakingly detailed, but will generate one of the best datasets for analyzing and exploring Europa's surface.

Suggested and/or Required Background/Skills: ArcGIS georeferencing skills required Geology suggested

References: Prockter et al., 2017. Surface composition of pull-apart bands in Argadnel Regio, Europa: Evidence of localized cryovolcanic resurfacing during basin formation. Icarus 285, 27-42. http://dx.doi.org/10.1016/j.icarus.2016.11.024

Primary Discipline: Planetary Science

Secondary Discipline: Geological/Geophysical Engineering

Other Discipline:

AO# 7959

Title: Creating, Improving, and Refining training labels for Martian orbital imagery project COSMIC

Background Information: The COSMIC project (Content-based Orbital Summarization to Monitor Infrequent Change) is an ambitious 3-year project to create machine-learned algorithms that recognize surface features in Martian orbital imagery, summarize these findings onboard the orbiter, and provide change detection upon repeat passes. This permits scientists to build up a planet-wide summary of what's on Mars without downlinking a single image as well as a "menu" of interesting changes / objects found for optional downlink.

Project Description: COSMIC will require ample, high-quality labels that teach the system to recognize scientifically important regions, landmarks, or spectral composition. Specific duties of this position will be meeting with (friendly) scientists to learn where on Mars to look for interesting objects, labeling the objects, analyzing existing labels for purity/quality, running the prototype COSMIC system, examining errors to further refine labels and/or feedback to the algorithm dev team, and book-keeping the ever-expanding database of training imagery / labels. Careful attention to detail is an absolute requirement.

Suggested and/or Required Background/Skills: Required skills: Linux experience, basic statistics (mean, median, stdev, accuracy, random vs systematic error, uncertainty) Suggested skills: any machine-learning, signal processing, or image processing coursework.

References:

Primary Discipline: Electrical Engineering and Computer Science

Secondary Discipline: Information Systems/Technology

Other Discipline: Machine Learning

AO# 7958

Title: Electronic Reliability and Radiation Data Analysis

Background Information: A wide variety of electronic device data is generated by JPL parts programs. This data needs to be synthesized and collated to highlight trends and support new experimental plans.

Project Description: Support the NEPP program management in electronic data analysis of both radiation and reliability tasks. Support experimental data analysis, work with 3rd party testing, work directly with program management on task support activities.

Suggested and/or Required Background/Skills: Statistics, Calculus, PDE/ODE, MATLAB, Python, circuits, physics

References: https://nepp.nasa.gov

Primary Discipline: Mathematics

Secondary Discipline: Physics/Applied Physics

Other Discipline: Electrical Engineering

AO# 7955

Title: Developing Analyzable System Models Using the Ontology Modeling Language (OML)

Background Information: The Ontological Modeling Language (OML) is a language developed as a semantic equivalent to the Web Ontology Language (OWL), but with a simpler, human-readable textual syntax and graphical notation (similar to that of the System Modeling Language (SysML)). OML allow modeling vocabularies for a given discipline and using them to describe a system using those vocabularies to enable rigorous system analysis.

Project Description: This task desires to build a set of example models in OML to demonstrate the ability to use semantic approaches to design and analyse system models. The examples will incrementally demonstrate the value of this approach in a tutorial format. This tutorial will be used to teach system engineers about OML. The student will learn about existing modeling tools such as MagicDraw (for SysML), Protégé (for OWL), and the OML Workbench (for OML), model transformations, and modeling patterns used in flight system engineering. He/she will gain experience in practicing model based system engineering (MBSE).

Suggested and/or Required Background/Skills: Applicants should have some software development skills using Java , JavaScript or other OO languages. They should also have good communication and analytical thinking skills.

References: https://www.w3.org/TR/2012/REC-owl2-primer-20121211/ http://www.omgsysml.org/

Primary Discipline: Computer Science

Secondary Discipline: Systems Engineering

Other Discipline:

AO# 7946

Title: Circumstellar Matter (Jets, Disks and Torii) in Young and Dying Stars

Background Information: The research opportunity offered is related to the study of circumstellar matter around young and dying Sun-like stars. Low and intermediate mass stars are born in rotating clouds of gas and dust, and many aspects of this evolutionary phase, such as the production of accretion disks and collimated jets, is poorly understood. As these stars reach the end of their lives, they carry out much of their interesting nucleosyntheses (e.g. production of the biogenic elements C & N), and through extensive mass-loss, disperse nucleosynthetic products and dust into the interstellar medium. The dazzling shapes of planetary nebulae make them not only immensely appealing to the public (as evident by their frequent appearance in popular astronomy magazines) but also a serious challenge to professional astronomers in finding a mechanism to produce their shapes. Many of these results have attracted wide public attention and have been published by in public media. The study of young and dying stars provides an important contribution to the part of NASA's ORIGINS program which seeks to understand the life-cycles of Sun-like stars and the physical mechanisms whereby the death throes of these stars sow the seeds for the birth of new stars and solar system.

Project Description: In support of my research on these stars, I have a large number of past and current observational programs on NASA's space observatories such as the Hubble Space Telescope (HST), the Spitzer Space Telescope (SST), the Chandra X-Ray Observatory (CXO), and GALEX. These programs are generating a large amount of high-quality data, and opportunities exist for motivated students to help with the analysis and modelling of these data for addressing important scientific questions related to the death of Sun-like stars. Specific research goals include an understanding of (1) the mass-ejection processes during the the beginning and end phases of stellar evolution -- how much mass is ejected, what is the history of this ejection, what is the content and composition of dust in the ejecta; (2) the role and origin of highly collimated jets, which are an exciting, dramatic and integral feature of many astrophysical environments, yet are very poorly understood, and (4) the role of binarity in producing jets and equatorial disks/torii. In particular, the jets in dying stars and young stellar objects are, amazingly similar in their empirical properties, so an improved understanding of jets in such stars is crucial for our understanding of both the very early and late phases of the evolution of Sun-like stars. Motivated and energetic students can expect to be co-authors on papers presented at the bi-annual meetings of the AAS, and peer-reviewed journal papers related to their research (in recent years, 9 students have been co-authors on such papers).

Suggested and/or Required Background/Skills: 1) basic background in Physics and/or Astronomy 2) a reasonable level of computational skill is preferred (e.g.,some programming language like Fortran, C, C+, IDL, python)

References: 1. "A collimated, high-speed outflow from the dying star V Hydrae", Sahai, R.; Morris, M.; Knapp, G. R.; Young, K.; Barnbaum, C. 2003, Nature, 426, 261 2. "Sculpting a Pre-planetary Nebula with a Precessing Jet: IRAS 16342-3814 Sahai, R. et al. 2005, ApJ, 622, L53 3. "Magnetohydrodynamic Models of the Bipolar Knotty Jet in Henize 2-90," Lee, C-F. & Sahai, R. 2004, ApJ, 606, 483 4. "Preplanetary Nebulae: An HST Imaging Survey and a New Morphological Classification System", Sahai, R., Morris, M., S'anchez Contreras, C., & Claussen, M. 2007,AJ, 134, 2200 5. "Binarity in Cool Asymptotic Giant Branch Stars: A Galex Search for Ultraviolet Excesses", Sahai, R., Findeisen, K., Gil de Paz, A., & S'anchez Contreras, C. 2008, ApJ, 689, 1274 6. "High-Velocity Interstellar Bullets in IRAS05506+2414: A Very

Young Protostar?", Sahai, R., Claussen, M., S'anchez Contreras, C., Morris, M. & Sarkar, G. 2008, ApJ, 680, 483 7. "An EVLA and CARMA study of dusty disks and torii with large grains in dying stars", Sahai, R., Claussen, M.J., Schnee, S., Morris, M.R., & S'anchez Contreras, C. 2011, ApJ, 739, L3 8. "Shocked and Scorched: The Tail of a Tadpole in an Interstellar Pond", Sahai, R., Morris, M.R., & Claussen, M.J. 2012, ApJ (in press), arXiv:1201.5067 SELECTED WEB REFERENCES 1. "Boomerang Nebula- the naturally coldest place currently known in the Universe" http://en.wikipedia.org/wiki/Boomerang_Nebula 2. "Hubble Finds Stars That Go Ballistic" http://www.physorg.com/news150562469.html 3. "Eye in the sky: Time nearly up for Hourglass Nebula as it runs out of nuclear fuel" http://www.dailymail.co.uk/sciencetech/article-2023696/MyCn18-The-Hourglass-Nebulas-life-comes-end-runs-nuclear-fuel.html

Primary Discipline: Astronomy/Astrophysics

Secondary Discipline: Physics/Applied Physics

Other Discipline: Computational/Programming

AO# 7945

Title: Changes in Greenland Surface Melt

Background Information: The Greenland Ice Sheet is melting and many of Greenland's glaciers that flow into the ocean are retreating. Most of the ice that melts from the surface of an ice sheet in summer flows into the sea, often after falling down deep vertical channels in the ice called moulins. After reading the ground, this meltwater then flows beneath the ice sheet in and emerges into the ocean beneath at the base of glaciers, some of which can reach 1000 m below sea level. This study focuses on determining how much meltwater is currently flowing out beneath these glaciers and determining how the meltwater flow rates have changed over the past several years.

Project Description: For this project, the student will be analyzing the output of several different climate models and calculating how much summertime ice melting has changed over the past 10-20 years for several important individual glacier drainage basins around Greenland. This work will support the NASA mission, Oceans Melting Greenland.

Suggested and/or Required Background/Skills: Some programming experience will be required. No particular courses are needed as a prerequisite. An interest and enthusiasm in learning about how climate change is affecting the polar ice sheets is a must.

References: https://omg.jpl.nasa.gov/portal/ Fenty, I., J.K. Willis, A. Khazendar, S. Dinardo, R. Forsberg, I. Fukumori, D. Holland, M. Jakobsson, D. Moller, J. Morison, A. MÃ¼nchow, E. Rignot, M. Schodlok, A.F. Thompson, K. Tinto, M. Rutherford, and N. Trenholm. 2016. Oceans Melting Greenland: Early results from NASAâ€™s ocean-ice mission in Greenland. Oceanography 29(4):72â€“83, https://doi.org/10.5670/oceanog.2016.100.

Primary Discipline: Earth Science

Secondary Discipline: Physics/Applied Physics

Other Discipline:

AO# 7938

Title: Mars Data Analysis

Background Information: 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, and the Mars Exploration Rovers. 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.

Project Description: Work will be directed at characterizing the geology and safety of candidate landing sites for future Mars missions, including the NASA Discovery Program, InSight mission to land on Mars in 2018 and 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 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. 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.

Suggested and/or Required Background/Skills: 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.

References: Information on the Mars landing sites and selection can be found at: Golombek, M. P., et al., 2003, Selection of the Mars Exploration Rover landing sites: Journal of Geophysical Research, Planets, v. 108(E12), 8072, doi:10.1029/2003JE002074, 48pp. Golombek, M., et al., 2005, Assessment of Mars Exploration Rover landing site predictions: Nature, v. 436, p. 44-48 (7 July 2005), doi: 10.1038/nature03600. Golombek, M. P., et al., 2006, Erosion rates at the Mars Exploration Rover landing sites and long-term climate change on Mars: Journal of Geophysical Research, Planets, v. 111, E12S10, doi:10.1029/2006JE002754. Golombek, M. P., and McSween Jr., H. Y., 2007, Mars: Landing site geology, mineralogy and geochemistry: Chapter 17, p. 331-348, in Encyclopedia of the Solar System, Second Edition, L. A. McFadden, P. R. Weissman and T. V. Johnson, eds., Academic Press/Elsevier, San Diego, 966 pp. Golombek, M. P., et al., 2008, Martian surface properties from joint analysis of orbital, Earth-based, and surface observations: Chapter 21 in, The Martian Surface: Composition, Mineralogy and Physical Properties, J. F. Bell III editor, Cambridge University Press, p. 468-497. Golombek, M., K.

Robinson, A. McEwen, N. Bridges, B. Ivanov, L. Tornabene, and R. Sullivan, 2010, Constraints on ripple migration at Meridiani Planum from Opportunity and HiRISE observations of fresh craters, J. Geophys. Res., 115, E00F08, doi:10.1029/2010JE003628. Golombek, M., et al., 2012, Selection of the Mars Science Laboratory landing site: Space Science Reviews, v. 170, p. 641-737, DOI: 10.1007/s11214-012-9916-y. Golombek, M. P., et al., 2014, Small crater modification on Meridiani Planum and implications for erosion rates and climate change on Mars: Journal of Geophysical Research, Planets, v. 119, p. 2522-2547, 10 Dec. 2014 Golombek, M., et al., 2016, Selection of the InSight landing site: Space Science Reviews, DOI 10.1007/s11214-016-0321-9. Rock distributions and their importance in landing site selection can be found in: Golombek, M., and Rapp, D., 1997, Size-frequency distributions of rocks on Mars and Earth analog sites: Implications for future landed missions: Journal of Geophysical Research, Planets, v. 102, p. 4117-4129. Golombek, M. P., et al., 2003, Rock size-frequency distributions on Mars and implications for MER landing safety and operations: Journal of Geophysical Research, Planets, v. 108(E12), 8086, doi:10.1029/2002JE002035, 23pp. Golombek, M. P., et al., 2006, Geology of the Gusev cratered plains from the Spirit rover traverse: Journal of Geophysical Research, Planets, v. 110, E02S07, doi:10.1029/2005JE002503. Golombek, M. P., et al., 2008, Size-frequency distributions of rocks on the northern plains of Mars with special reference to Phoenix landing surfaces: Journal of Geophysical Research, Planets, v. 113, E00A09, doi:10.1029/2007JE003065. Golombek, M., Huertas, A., Kipp, D. and Calef, F., 2012, Detection and characterization of rocks and rock size-frequency distributions at the final four Mars Science Laboratory landing sites: Mars, v. 7, p. 1-22, doi:10.1555/mars.2012.0001.

Primary Discipline: Planetary Science

Secondary Discipline: Earth Science

Other Discipline:

AO# 7937

Title: Create simulation environment for testing autonomous navigation algorithms

Background Information: Simulation environment (such as Gazebo in ROS) are an important part of algorithm development for autonomous robotic applications.

Project Description: In this project, we would like to explore the application of different simulation environments such as Gazebo or V-REP in creating realistic environments to test autonomy algorithms.

Suggested and/or Required Background/Skills: The SIRI students' role is to develop software to create robot simulation environments or connect existing simulation environments (such as Gazebo or V-REP) to JPL's autonomy algorithms.

References: Gazebo simulator: http://wiki.ros.org/gazebo V-REP: http://www.coppeliarobotics.com/

Primary Discipline: Computer Science

Secondary Discipline: Computer Engineering

Other Discipline: Electrical Engineering

AO# 7936

Title: Graphics design and technical visualization

Background Information: Robotic mobility group designs novel mobility systems and out of the box concepts for space vehicles. These concepts need to be visualized in an intuitive way. This needs creating high-quality simulations, graphics, presentations, and videos to convey the complex ideas to readers/audience.

Project Description: The intern will support the robotic mobility group in creating high-quality graphics that depict complex robotic mobility concepts and concept space vehicles. The intern further will support the team on preparing high-quality technical art embedded in technical presentations, documents, and videos.

Suggested and/or Required Background/Skills: Required: Experience with software for drawing technical figures. Strong written and verbal communications skills Suggested: Experience with graphic design software Web Development Experience Experience with Technical illustration, Word processing and document formatting Experience with Making Videos Experience with simulation and game environments

References:

Primary Discipline: Computer Science

Secondary Discipline: Information Systems/Technology

Other Discipline: Mechanical Engineering, Aerospace Engineering

AO# 7934

Title: Design and Control of prototype vehicles for Mars navigation

Background Information: Rovers are slow on Mars and their mobility is limited to flat surfaces. Flying vehicles can fly over obstacle-laden environments but they suffer from short flight-time.

Project Description: In this project, we design particular vehicles that have two modes of flying in the air and moving on the Mars surface.

Suggested and/or Required Background/Skills: The student will help with the mechanical design of the vehicle (based on an already-designed concept in JPL) or Electronics and embedded programming (depending on the student's background). Past experience with quadcopters is a plus. The student will collaborate with researchers at JPL fabrication shops; he/she will also help with basic calculations on the weight, material selection, etc.

References:

Primary Discipline: Aerospace Engineering

Secondary Discipline: Mechanical Engineering

Other Discipline: Electrical Engineering, Computer Science

AO# 7933

Title: Machine learning for robot navigation (prototype for Mars robots)

Background Information: Machine Learning (e.g., deep learning) has shown a huge success in recent years. The applications ranges from object recognition, speech recognition, to planning and control. Navigation on Mars is a complex task that can benefit from machine learning techniques in general, and deep learning, in particular.

Project Description: In this project, we would like to explore the application of deep learning-based methods to rover navigation on Mars. A lot of generic open-source libraries have been developed for deep learning and are freely available on the web. We would like to feed our data from the years of navigating rover on Mars to one of these open-source software. And try to learn the navigation rules and achieve a higher level of autonomy for the rover and avoid hazards and failures on Mars.

Suggested and/or Required Background/Skills: The SIRI students' role is to closely collaborate with Mars rover operators, gather the existing data from previous rover navigation on Mars. Then, the student will work on software development for machine learning algorithms based using existing open-source software on web. Finally, we test the trained navigation system by feeding the new images from the after-training runs and compare the generated path with the path, provided by the operator. If the progress is fast, we will port the method to a physical robot to test in JPL's Mars yard. We might use openAI gym as the simulation and training system: https://gym.openai.com/

References: We might use openAI gym as the simulation and training system: https://gym.openai.com/

Primary Discipline: Computer Science

Secondary Discipline: Computer Engineering

Other Discipline: Electrical Engineering

AO# 7906

Title: Microorganisms Associated with Mars-Bound Spacecraft: Preservation, Identification, Characterization.

Background Information: Archiving of microbial cultures from spacecraft planetary protection implementation assays is a focus of planetary protection efforts at the Jet Propulsion Laboratory (JPL). Currently, the archive facility at JPL contains over 3,500 isolates collected during the assembly, testing, and launch operations of pre-flight Mars-based spacecraft ranging from Viking to the most recently launched Mars Science Laboratory (MSL) and two missions currently being built for launch. With the early phases of planning for the upcoming challenging planetary protection missions that may be planned (i.e. Mars or Europa life detection or Mars Sample Return) it is essential to understand the identification, frequency of isolation and biochemical profiles, of microbial isolates that NASA standard cleanliness assays are detecting. It is critical to preserve these organisms for long term storage, and to update the microbial archive database by providing additional biochemical data and sequence data for each isolate. Results from this study will yield details about the microbes that have been isolated from the surfaces of pre-flight spacecraft and, on a broader level, will gauge whether microorganisms from Earth have the potential to survive on Mars. Furthermore, the outcome of this study will benefit those involved in the planning of future Mars missions such as the Mars Sample Return Campaign by being able to correlate vast amounts of parallel genetic inventory datasets to NASA Standard Assays.

Project Description: The objectives of the proposed project, are to i) Identify and describe novel microbial species collected from Mars bound spacecraft surfaces using biochemical, genetic and taxanomic approach , ii) Identify existing and new isolates using MALDI-TOF system, The Biotechnology and Planetary Protection Group at JPL (BPPG) invites applications to understand the ecology of microbes found on spacecraft and to assess their potential for survival in extreme environments. The student will join an established group of researchers focusing on molecular systematic/population genetics of microbes isolated from the extreme environments of spacecraft assembly. Students will be exposed to state of the art molecular microbial techniques, sequencing, bioinformatics, etc.

Suggested and/or Required Background/Skills: Relevant requirements for the project: Community college undergraduate student of Microbiology, Molecular Biology, Bioinformatics, Biochemistry. Mentor's research: Microbial Detection; Molecular Microbial Diversity; Extremophiles.

References: http://planetaryprotection.nasa.gov/

Primary Discipline: Biology/Bioengineering

Secondary Discipline: Environmental Science

Other Discipline: Microbiology, molecular biology

AO# 7812

Title: Microbial Culturing for Spectroscopic Biosignature Analysis

Background Information: The terrestrial subsurface is host to diverse microbial communities. Despite the large biomass in the subsurface and the importance of these microorganisms in global carbon and nutrient cycles, relatively little is known about their in situ activity. Retaining the spatial and contextual information of microbial consortia in the subsurface is crucial to understanding these complex geobiological dynamics. By coupling microbial activity experiments such as stable isotope probing with DUV spectroscopy techniques we can assess the in situ microbial community.

Project Description: The intern will be involved in microbial culturing experiments to assess the ability of deep UV spectroscopy to differentiate labeled compounds. Duties will involve media preparation, standard microbial growth curves, dilution calculations, DUV Raman and fluorescence spectroscopy, aerobic and anaerobic microbial culturing (BSL 1), crushing rock samples for microbial growth, and possible DNA extractions. Ability to work independently is critical.

Suggested and/or Required Background/Skills: Experience with sterile techniques and standard microbiology are required. An interest in spectroscopy techniques, microbial activity some geology classwork would be beneficial.

References: Wanger, M. Single-Cell Ecophysiology of Microbes as Revealed by Raman Microspectroscopy or Secondary Ion Mass Spectrometry Imaging Annual Reviews of Microbiology, William J. Abbey, et al.,Deep UV Raman spectroscopy for planetary exploration: The search for in situ organics, Icarus, Volume 290, 2017, Pages 201-214, ISSN 0019-1035, http://dx.doi.org/10.1016/j.icarus.2017.01.039.

Primary Discipline: Biology/Bioengineering

Secondary Discipline: Planetary Science

Other Discipline: Chemistry

AO# 7620

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

Background Information: Images and spectra of Jupiter and Saturn from near- and mid-infrared instruments are sensitive to temperatures, abundances of a major condensate (ammonia), opacity of clouds with large particles, and the variability of the molecular para- vs ortho-hydrogen 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: MIRSI, NSFCam, and SpeX (NASA Infrared Telescope Facility), T-Recs (Gemini South Telescope), VISIR (ESO's Very Large Telescope), and COMICS (Subaru Telescope). These observations consist primarily of radiometrically filtered images. Much of these data sets have been reduced already, and the primary task of the student will be to format the data appropriately as input to an atmospheric retrieval code from which the various properties will be derived. Prioritized specific areas of investigation are given below.

Project Description: a. We will be working with a large-volume set of observations of Jupiter, both imaging and spectroscopy, that are designed to support observations of Jupiter scheduled from various instruments on the New Frontiers Juno spacecraft. It will be important to reduce and, if possible, analyze these results and report them to the Juno science team during the course of the mission. b. We want to examine long-term behavior of planetary temperatures and distribution of minor constituents using archival through current thermal images that were taken from 1995 to the present. These include some of the behaviors noted below, but the data are to be examined also in a more general sense for unexpected events or phenomena unrelated to changes that are detectable in the visible. A substantial amount of this work was completed through 2010 data by a previous student, and the task will involve corrections to the calibration of the data, combined with their interpretation to be put immediately into a publication in the open literature. c. The last few years have found Jupiter in a state described as one of "global upheaval", during which substantial and rapid changes are observed in the state of its visually prominent axisymmetric regions. Most recently Jupiter's normally dark North Temperate Belt (NTB) turned bright around 2002-2003 and in 2007 suddenly darkened again, coupled with the activity of two massive atmospheric plumes. Its normally dark South Equatorial Belt (SEB) lightened early in 2007 and then darkened later that year; late in 2009 it lightened again. This task will be to examine whether there are temperature changes associated with these visual metamorphoses, even preceding them, along with variations of their dynamical states - tracked through clouds and chemical species - as a means of understanding whether large-scale dynamics are responsible or whether they can be explained by small changes of elevation that induce phase changes in the chemicals that color the clouds. d. An effort related to (b) above is to note whether there are temperature or compositional changes associated with the re-darkening of the South Equatorial Belt (SEB) that began in November of 2007 in a series of spectacular events. Some early work on this will be accomplished by a student in the spring of 2011, but there will be much work left over. e. For Saturn, besides the long-term response to seasonal variations of radiation, we are investigating the appearance of thermal wave trains in the atmosphere. f. For Saturn, we are examining the persistence and frequency of 'patchy' thick clouds in its upper atmosphere that were detected by observations of thermal emission from deep clouds.

Suggested and/or Required Background/Skills: 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.

References: Data reduction and the retrieval process are described by Fletcher et al. (2009, Icarus 200, 154). a. Little work has been done on Jupiter in the past, but we did a similar study for Saturn, discovering a long-term (~15-year) wave phenomenon (Orton et al. 2008, Nature 453, 196). b. See Sanchez-Lavega et al. (2007, Nature 251, 437) for an introduction to our initial work in this area. c. Nothing has been done on this phenomena in the thermal. An account of the visible changes of the atmosphere were reviewed by Sanchez-Lavega and Gomez (1996, Icarus, 121, 1). d. We detected thermal waves in Saturn initially in 2003 from Keck Telescope data (Orton et al. 2005 Science 307, 696). e. Our initial work in this area was described by Yanamandra-Fisher et al. (2001, Icarus 150, 189).

Primary Discipline: Planetary Science

Secondary Discipline: Astronomy/Astrophysics

Other Discipline: Computer Sciences