Ph.D. Program in Robotics
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Statement of Purpose

Since childhood, I have been longing to explore the universe. It was during my junior year in college when I first saw the Space Shuttle Endeavor at the California Space Center. The bruised, solemn rocket taught me how technologies can be used for the service of humankind, by creating spacecraft and unveiling the secrets that broaden our understanding of the universe. The excitement I felt has been the stepping stone of my career decisions. Since then, my dream has been to become a distinguished engineer who builds spacecraft and contributes to the expansion of the *noosphere* of humankind.

As the first step towards my dream of becoming a prominent engineer, I went through the M.S. program at Tohoku University, Japan. I joined Professor XXXX's research group, where I have been researching the automation of celestial body exploration robots, or rovers. During the missions to the Moon and Mars, we have to operate rovers with poor communication signals and non-negligible communication lag. Thus, rovers have to automatically recognize their surrounding environment, detect obstacles, and travel through uncharted regions. I have been trying to solve problems such as how to identify and avoid loose granular materials which make the robot's wheels slip and sometimes permanently entrap the robots. In order to deal with uncertain, non-geometrical obstacles, my idea is to process visual information and predict wheel slip before entering the terrain. Such predictive navigation will reduce the risk for the rover. Inspired by this idea, both theoretically and experimentally, I have conducted my research work.

The theoretical contribution of my research work lies in the development of visual-information-based wheel-slip prediction for a rover using machine learning. Wheel slip depends on the state of the soil as well as the composition and slope of the terrain. Thus, visual sensors provide useful information for navigation. In addition, due to high nonlinearity, it is hard to model rover-terrain interactions. I conjectured that the data-driven machine-learning approaches would be able to predict wheel slip even without accurate modeling of rover-terrain interactions. My approach consists of the following two steps. The first step classifies the terrain from an image. Specifically, I use Python to extract features from images and have trained a terrain-property classifier using machine learning methods such as Random Forests. Then, in order to predict wheel slip and as the second step, I use a Gaussian Process regressor. The data set to train the approaches was collected from field experiments in various terrain. By using rich and ample data, both these algorithms were expected to predict wheel slip on terrain, which the rover has never encountered before.

In order to validate the proposed approach, I have conducted experiments using a four-wheeled rover testbed and run the rover in uncertain, rough environments. I integrated Time-of-Flight cameras and an RGB-D sensor to the vehicle, and I connected all the system components using ROS and C++. The proposed framework demonstrated its performance on the prediction of wheel slip at each scene without traversing over high-slip areas, and the testbed successfully traversed the outdoor, rough terrain. I have contributed to the improvement of the rover's perception

based on a learning-based quantitative assessment. I will present this work at XXXX.

Through my research experience, I have acquired in-depth knowledge about environmental recognition, such as sensing and learning methodologies, as well as practical programming skills and hands-on experience in robotics development. In addition, I have learned the difference between the cyber and physical systems through experimental issues due to sensor noise as well as unobservable system states, which are sometimes overlooked by purely theoretical approaches. I am confident that my theoretical and practical research experiences have best prepared me to conduct my Ph.D. study at the Department of Mechanical, Industrial, and Manufacturing Engineering at Oregon State University, the leading institute in the world.

During my Ph.D. study, my goal is to create fully-autonomous robots, which possess a robustness, high efficiency, and adaptability to accomplish long-duration operations even in challenging, unknown environments. In such environments, robots are influenced by uncertainties caused by external disturbances and time-varying situation. Therefore, I would like to study predictive perception and optimal path planning methods under uncertainties.

In order to pursue this research objective, I would like to especially conduct my Ph.D. research under the supervision of Prof. XXXX. I contacted Prof. XXXX for discussing my potential research opportunities. I am interested in his research works on intelligent mobile robots in unstructured environments with imperfect information. I would love to present optimal path planning methods for unmanned marine or aerial vehicles in time-varying, uncertain environments and integrate environmental recognition systems, which I will propose based on my research experiences. Furthermore, as I believe the importance of experiments in robotics research, I would like to develop both skills on establishing new theories as well as in conducting experiments. His strong emphasis on experimental validations for his newly proposed approaches assures me that Prof. XXXX's group is the best place for my Ph.D. study.

The attractive research opportunities with Prof. XXXX are not the only reason why I think OSU is a perfect place for my Ph.D. study. I am eager to study and obtain fundamental and systematic knowledge directly related to my research by taking advanced courses, such as Sequential Decision Making in Robotics and Intelligent Robotics, offered by the robotics course. In addition, the Collaborative Robotics and Intelligent Systems Institute, which fosters collaboration between students, researchers, and faculties with diverse backgrounds convinces me that OSU is the best place for me to deepen my expertise in robotics.

After I obtain my Ph.D. degree from OSU, I would like to embark on my journey as a professional engineer and as a Quaker. In order to continue pursuing my dream of contributing to future space exploration as an exceptional roboticist, I would like to join the space probe missions at a research institute such as XXXX.

I am confident that OSU will best prepare me for achieving my ultimate goals. I am also convinced that my knowledge and research experience will all contribute to your program. Hence, I earnestly ask for your favorable consideration in reviewing my application.