SMART-ART Annual Summit 2022

Student Presentation Abstracts

SMART-ART

Smart Autonomous Robotic Technology for Space Exploration

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Content

Sorting Flesh, Making Waste: A Lawscape of Human Remains

Joshua Shaw, PhD student, York University

Common lawyers and jurisprudents generally understand the human dead either as evincing the human person and deserving dignified disposal or, due to technological advances enabling different uses of the body and its derivative parts, as evincing property. But some bodies and parts, produced by changes in socio-technical conditions, are not understood as either person or property. These bodies and parts appear to be disposable as waste. The dissertation deconstructs the common law and jurisprudence by drawing on three contemporary and historical case-studies, involving theory-driven, qualitative (e.g., interviews, arts-based methods) and archival research. The case-studies require the author to look beyond legal concepts of 'personality' and 'property', identifying what else might constitute the condition of disposability. The author engages in and contributes to jurisprudence of the body, specifically, and jurisprudence generally, especially in regard to how legal meaning is produced by material things such as the decomposing body and technology.

Characterizing the dielectric properties of icy regolith using Radar through work in the field and in the laboratory in preparation for the future Mars Ice Mapper mission

Abigail Lee, PhD student, York University

The international Mars Ice Mapper Mission is tentatively scheduled to launch in 2028 with the main goal of quantifying the presence, depth, distribution and purity of water ice at the sites that are promising for future human exploration and colonization of Mars. In preparation for this mission, we aim to quantify the performance of a dual-mode L-band SAR/Sounder radar in the field. Flights will be made with the Simon Fraser radar system over locations with buried ground ice. My project will be to support the interpretation of the radar data by making ground-based measurements with lidar and ground-penetrating radar, extracting cores, and measuring them in the lab. Most important for assessing the radar performance is finding the dielectric properties of the cores. To do this, I will use a Vector Network Analyzer at York University within the same frequency range as the airborne radar to determine these dielectric properties.

Development of autonomous mobile 3d bioprinting system for regenerative medicine

Salman Chaudhry, PhD student, York University

The advent of 3D bioprinting in tissue engineering has become an example of additive manufacturing's impact in many other fields. Technology advances in 3D printing, coupled with the increasing sophistication required for printing on biological platforms, have the potential to revolutionize tissue engineering. In this study, we present a novel approach to in situ bioprinting to address the challenges inherent in operating at the interface between complex living systems and technology. These attributes are principally derived from the variation of customary 3D printing strategy to the innately unpredictable frameworks of the human body. The aim of this exploration is to overcome this issue by tending to certain innovative hindrances that obstruct consistent in situ 3D printing of biological tissue. Clearly, 3D printing has enabled the future of tissue bioengineering through its state-of-the-art technology. Further development of 3D printing technology will be necessary to successfully adopt the technique for in situ printing.

Image-based Visual Servoing using Image Moments: Canadarm 2 Implementation

Shayan Ghiasvand, Master student, Concordia University

Several robotics tasks have been automated by leveraging computer vision techniques. The space industry, though, is not entirely automated, which makes it susceptible to human error. In this Research, we are trying to automate a catching process on the International Space Station using Canadarm2. A human operator is currently controlling Canadarm2 by aligning its end-effector with a symmetrical 2D object attached to the servicing satellite close to the connection port. The automation is therefore done through an image-based visual servo using image moments. In addition, various sets of visual features are going to be compared based on their Interaction Matrix and their robustness to different initial values. To improve the system's response, other linear controllers (P, PI, and PID) are also applied. Finally, to confirm the robustness of our approach, we will experiment with our methods on a 6 DOF manipulator named Denso.

Artificial Intelligence Enhance Tactile Feedback Control for Capturing RSO (Resident Space Object)

Bahador Beigomi, PhD student, York University

With the development of space projects, space on-orbit service has gradually become a research focus in the aeronautical field, and space robots are expected to perform more and more important tasks in future space services. When the spacecraft is in orbit, the space robot needs to complete various operations and the primary operation of on-orbit tasks is to capture the floating target. Due to the continuous increase in the number of satellites orbiting the Earth, any left unchecked space debris can be considered a critical potential hazard for near-Earth space activities. Thus, effective measures and efforts in this regard are urgent and this problem is gaining attention in engineering and business disciplines. Concerning the existing space debris issues which is the focus of this study, the possible and effective methods would be using spacecraft to actively remove debris objects and to retrieve failed satellites.

Optimal Path Planning and Control for Autonomous Robotic Space Debris Removal Using Artificial Intelligence

Ahmad Al Ali, PhD student, York University

Space technologies have risen a great amount during the last century, sending into space all kinds of rockets, spacecrafts, and other objects. The density of these drifting objects in orbit is about to reach a dangerous point; where these debris will start posing a great threat for collisions in space as well as start to compromise any future space missions. Space robotics is considered one of the most promising applications for orbital debris removal. This research explores novel approaches to create an autonomous free-floating space robot for use in space debris removal, employing artificial intelligence (AI). This includes building an accurate model for a space manipulator system (kinematics and dynamics), and exploring path planning and control techniques for autonomous robots. Furthermore, how to deal with space manipulator singularities, and obstacle avoidance. along with the implementation of artificial intelligence and finally, experimental testing of these algorithms.

System Dynamics Analysis and Optimal Control Design using Computational Artificial Neural Networks

Zhengze Liu, PhD student, York University

As the technique of using system dynamics to study stability analysis of nonlinear dynamical systems widens when Artificial Neural Networks (NNs) were introduced into the area, various forms or groups of NNs were proposed and trained to produce aspects of the target dynamic systems such as Region of Attraction (ROA), Lyapunov functions, etc. The proposed research subject is to present a systematic way to accurately estimate the dynamics of the system in a piecewise method. A Multilayer Perceptron Neural Network (MLP) will be trained to divide the system domain into subdomains in a Finite Element Analysis meshing fashion and a Bidirectional Recurrent neural network (BRNN) will be trained to derive ROA and dynamic analysis for each subdomain. The accuracy of subdomain analysis would be done using a feedback loop. After the desired dynamics analysis was completed, an optimal control scheme would be developed for each subsystem using MLP-NN.

A Deep Generative Network for Ultra-resolving Face Images

Seyed Nima Tayarani Bathaie, Master student, York University

This research focuses on Single Image Super-Resolution of face images known as Face Hallucination (FH) which aims to reconstruct a High-Resolution (HR) face image from a Low-Resolution (LR) counterpart. One of the major applications of FH is for surveillance cameras, where the quality and dimension of the facial images are not adequate for verification purposes. FH methods can be utilized to overcome this physical limitation. There are many challenges yet to be addressed in the task of FH. Single image super-resolution is an ill-posed inverse problem, since the same LR image may correspond to multiple HR images. Overall, many state-of-the-art methods generate smooth results in high upscaling factors and are not capable of preserving identities during face hallucination. The main focus of this research is to develop deep neural networks trained with a combination of loss functions to overcome these challenges.

Design of Multispectral Imager Validation Prototype for Lunar Rover Applications

Jin Sing Sia, Master student, Western University

The Canadian Space Agency (CSA)-funded Integrated Vision System (IVS) project is developing an instrument to be mounted on the mast of a future Canadian lunar rover that integrates a Multispectral Imager (MSI) and a multispectral LIDAR. It will be the first planetary rover-based imager that can image in the short-wave infrared (SWIR) band, allowing enhanced spectral signature recognition for important lunar minerals such as olivine, pyroxene, plagioclase, and lunar glasses. The preliminary MSI prototype has currently achieved TRL 4 status. It has already undergone component-level vibration testing, which will be presented, and lunar analog testing. The focus of the thesis work will be to prototype the next iteration of the MSI, with the objective of raising its TRL to 5-6 as a foundation for constructing a flight unit. This will be achieved through detailed analysis and qualification of its filter wheel mechanism as well as refining its concept of operations.

Design of Space-hardened Electronics in a Multispectral Imager for Lunar Rover Applications

Stephen Amey, Master student, Western University

Spacecraft instrumentation is important in a variety of applications ranging from Earth observation to the planetary surface investigation. Outside the Earth’s atmosphere, spacecraft instrumentation is subject to harsh conditions arising from high energy radiation and vast temperature swings. If not properly designed to withstand these conditions, electronic components have the potential to fail to result in the loss of the instrument or mission. Recently, a Multi-Spectral Imager (MSI) prototype capable of capturing images over a wide spectral range (400-1700nm) was built as part of a CSA-funded project at Western. The next step is to design and fabricate a space-rated instrument suitable for the lunar environment. This work aims to understand the conditions that will be experienced by the instrument’s electronic sub-system on the lunar surface, investigate how electronic systems should be designed for these conditions, and then apply these findings to the design and component selection of the MSI’s electronics sub-system.

Computational control for multiple flexible systems

Qi Zhang, PhD student, York University

As we know, the task of computing a simple control action, namely, the design of a controller to generate such action via state feedback. In general, feedback control design focuses on finding a 'closed-form' mapping $\varphi: X \rightarrow U$ so that the controlled plant under the action $u = \varphi(x)$ has the desired performance. The sole task of the onboard computer is to reliably implement this precomputed mapping. However, it is difficult for restricting the search for state-feedback strategies to such perfect closed-form mappings. Also, such a mapping may not even exist. Over the years, computers and computer algorithms have redefined and extended the meaning of “solvability” in engineering. Many traditional fields have adopted computers and numerical methods. By comparison, control theory has been somewhat reluctant to incorporate purely numerical methods for deriving feedback controllers. Therefore, we expect to propose a computational control method for multiple flexible.

Experimental AI System of Space Debris Removal Using Free Floating Robot

Ping Li, PhD student, York University

This research explores novel approaches to space debris removal using a free-floating robot with artificial intelligence (AI) systems. The proposed AI system will be broken down into three main components: tracking, pursuing and capturing space debris. Each component will be tackled with different AI algorithms to find the most optimal solution. Together, the three AI components present a fully autonomous debris removal system. A set of stereo vision cameras, LiDAR and other sensing technologies will be used to feed data into the proposed AI solution. In order to evaluate and test this system, a simulation environment, consisting of both the targeted debris and the robot, will be developed. The results will be used to benchmark against other state-of-the-art space debris removal technologies.