Presentation Preference:
__X__ Oral
__X__ Poster

17th Hypervelocity Impact Symposium
September 8-13, 2024
Tsukuba, Ibaraki, Japan

THE APPLICATION OF ARTIFICIAL INTELLIGENCE DEEP LEARNING TO VISUALLY IDENTIFY MICROMETEOROID AND ORBITAL DEBRIS IMPACTS

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ABSTRACT

Introduction

Recent advances in Artificial Intelligence (AI) are changing the World. Novel approaches to training AI systems have led to dramatic reductions in the amount of time required. Training an AI system could take years and teams of people using traditional methods, but with the advancements of Deep Learning (DL) models this training can now be accomplished by an individual in a matter of minutes. The development of "fast AI" libraries has delivered AI to essentially everyone. Democratization of AI power has inspired many to revisit past problems that will benefit from DL approaches.

For example, the application of AI has improved detection of breast cancer by 20% compared to traditional detection methods. Computer vision and machine learning are being used to identify soil deficiencies and provide planting recommendations to farmers. Success stories like these and many others have provided inspiration to see if AI can help improve one of our needed capabilities – that of visually identifying micrometeoroid and orbital debris (MMOD) impact damage to spacecraft from images of the spacecraft exterior.

The need to visually locate and characterize spacecraft MMOD impact damage has been present since the early days of space travel. This is often done by either having a crew member take photographs of the spacecraft through a window using a hand-held camera or

ground personnel directing externally-mounted cameras. The photographs are then transmitted back to Earth for visual analysis. This method of MMOD damage inspection works well and has been used on various spacecraft including the Space Shuttle and the International Space Station (ISS).

One of the issues with the current method that we believe AI could improve is the speed and possibly the accuracy in identifying MMOD impacts. Note that detecting MMOD impacts in images can be very difficult. The visual appearance of an MMOD impact can change dramatically with lighting conditions, size of impact, depth of penetration, material types, surface waviness, fabric coverings, camera & lens, distance to surface, spacecraft orientation, analyst experience, and many other factors. Currently, this takes a team of highly-experienced specialists in both the fields of Image Analysis and MMOD impacts.

This paper documents our initial research in training an AI DL model using the fast-AI library to identify actual and simulated MMOD impacts and perforations into exposed flat surfaces. While we recognize that this initial goal seems modest, it must be noted that what we have done would have taken teams of individuals and years of training just ten years ago. Our long-term goal is to add complexity and use-cases to the DL model being trained to expand the capabilities of this model so that it can be used to identify MMOD impacts on all types of spacecraft surfaces.