4th RFP : Automatic and autonomous exploration technology / Ideas Icubating Research

November 2018 to October 2019

Project title The Control method study using AI, IoT technology to realize autonomous motion of excavating machine (Road Header)

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Project outline

Objective

In a partial face machine (road header), which is used for excavating bedrock and similar materials in dangerous confined work sites such as tunnels, the rotation of the cutting head and the hydraulic cylinder mechanism are under the control of an operator. During excavation, every time a new geological section that is harder or softer than predicted by the geological survey appears, the condition of the excavation gravel also changes, requiring the operator to change the excavation strategy to fit the new situation.

On the surface of the moon, where there is no prior information on the terrain and where remote operation introduces a time lag, the survey excavators and similar equipment need to be controlled autonomously and continuously in accordance with the surrounding conditions.

This study investigates the modeling of autonomous action planning and control methods for road headers based on the measurement and recognition of the surrounding environment and situation, including the prototyping of the component systems that use AI and IoT technology.

Contents

- 1. Prototyping and verification of systems that recognize the surrounding environment:
 - Deep-learning AI models for object detection and region identification in images from various cameras
 - Combining multiple LiDAR sensors for the measurement of distances to the environment at simulated tunnel test site and similar tasks
- 2. Prototyping and verification of systems for collecting and analyzing operation log data:
 - Collection and visualization of operation log data (electric current, oil pressure, vibration, etc.) and anomaly detection by AI machine learning in the cloud
- 3. Investigation of AI learning models required for the autonomous operation of road headers:
 - Examination and evaluation of AI reinforcement learning models to plan construction (excavation) patterns based on the recognition of the environment and road header conditions
- 4. Prototyping and verification of AI hydraulic control systems:
 - Implementation and verification of AI control models for road headers



Fig. 1. AI road header system / overhead view of test site



Fig. 3. Excavation verification at simulated tunnel test site



Fig. 2. Example of 3-D underground scan combining multiple LiDAR sensors





Fig. 4. Examples of image recognition using AI deep learning Left: Original image (during simulated rock excavation) Right: Region identification (yellow: excavated gravel, green: tunnel cross-section)