Science-centric Coverage Approaches for Intelligent Robot Navigation

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Background & Motivation

NASA (Earth Sciences Division) needs improved ground-based sensing of changes in environmental phenomena (i.e. soil moisture, chemical concentrations in air or water, and ice sheet deformation).

Previous research has shown that robotic technology can significantly aid the Earth scientist in this task, yet, the question remains: "*How should a robot navigate for the purpose of collecting data in an unknown environment?*"

We present a **robotic surveyor system** that incorporates on-line measurements to dictate the path of navigation. GOAL: Ensure that the area of interest is properly surveyed and minimizes error between estimated values and ground truth data.

Approach

Define the type of phenomena the robotic system will operate within (i.e. variable terrain, hills, valleys, etc.)

- ➢ 50 different DEMs generated to test navigation algorithms.

Design suitable navigation options for the chosen environment type .

- ➢ Data measured ONLINE should dictate the path that will provide the most dispersive sample set (i.e. best coverage) and yield the lowest resource usage (i.e. least distance traveled).
- ➢ Possible sampling options considered: Navigate according to a **Parallel Transect Framework** (i.e. Lawnmower), **Random waypoints**, or a custom **Piece-wise continuous** rule-set.
- ➢ Of these three, **Piece-wise continuous** is the only pattern that incrementally uses the measurements collected to dictate navigation *ONLINE*.

Execute each navigation option (in simulation), collecting samples along each path, and interpolate across the entire Area Under Test to create an estimated map for comparison with ground truth data.

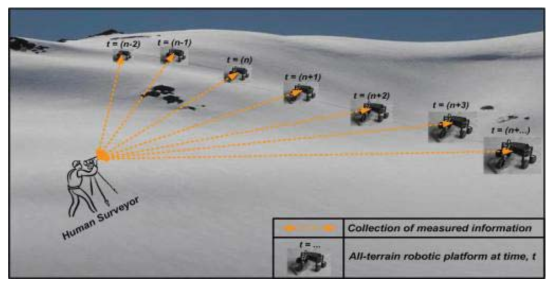

Fig 1. Future of robotic surveying – Teams of intelligent robot traversing the terrain and relaying relevant science data to a human surveyor

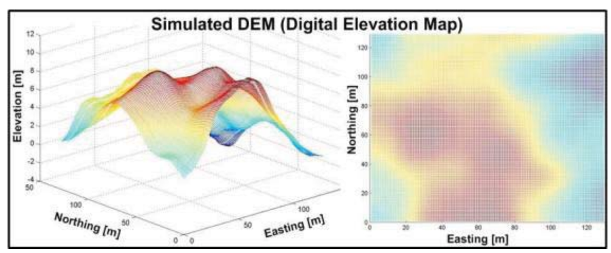

Fig 2. Sample digital elevation map

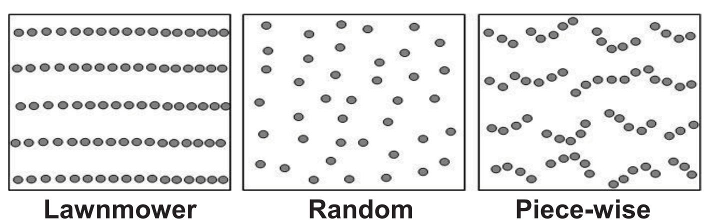

Fig 3. Sampling strategies that impact robot navigation

Results & Future Work

The **Piece-wise continuous** navigation rule-set proves to be the most beneficial, yielding the ***lowest RMSE*** across **50** simulated terrains and the ***lowest resource usage*** in terms of total Euclidean distance traveled.

The next step will be to develop navigation options for environmental phenomena other than elevation. Also, we will evaluate the performance of navigation patterns under noisy measurement conditions.