Path Planning with Power Schedules for Solar-Powered Ground Robot

Optimization Method, Types of Path Plans, Test Environment Setup and Evaluation, and Future Work

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OBJECTIVE

Minimize the travel time of a solar-powered, unmanned, ground vehicle through an area with no net energy loss
**Modified Particle Swarm Optimization**

- Non-uniform solar radiation distributions
- Particle Swarm Optimization (PSO) creates a number of candidate solutions or particles
  - It is an iterative process
  - After each iteration, the particles are evaluated and compared to each particle’s best recorded parameters and the group’s best.
  - Each particle is comprised of the vehicle’s waypoint locations, linear velocities, and rotational velocities at each turn.
- Constraints of the Problem
  - Negligible Net Energy Loss over path
  - Minimize Travel Time

**Graphical Representation**

**Example Motion Plan**
Types of Path Plans

Balkcom-Mason
- Governed by three differential – drive primitives
  - Forward, clockwise, and counterclockwise rotation

Pseudo-Dubin
- Derived from Dubin Curves
- Characterized by variable turn radius and continuous differential drive
  - Allows for forward and circular arc turns

Example of Balkin-Mason Path Planning

Example of Pseudo-Dubin Path Planning
The solar energy density produced by a single light is sampled and generated into a scalar field.
Solar Energy Map Example

0:00.000

Iowa State University
A three light environment is navigated with negligible net energy change using a Balkcom-Mason motion plan produced from our modified heuristic optimizer.
BALKCOM-MASON MOTION PLAN EXAMPLE

IOWA STATE UNIVERSITY
The three light environment is now navigated with negligible net energy change using the previous waypoints and a Pseudo-Dubin motion plan.
PSEUDO-DUBIN MOTION PLAN EXAMPLE
PSEUDO-DUBIN MOTION PLAN EXAMPLE

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**MOTION PLAN RESULTS**

**Balkcom-Mason Motion PLAN**
- Time: 25.22 s
- Final Battery Energy: -0.56 J

**Pseudo-Dubin Motion PLAN**
- Time: 20.12 s
- Final Battery Energy: +3.67 J

**TIME REDUCTION: 20.22%**
**Future Work: Visual Light Density Mapping**

Benefits:
- Have knowledge of an area before entering
- Faster and more efficient than current point-based data gathering approach
- Allows for snap-shots of Time-Variant areas.