Robot Landmine Detection
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When robotic sensors are deployed for sensing or surveillance purposes, the whole system constitutes a new paradigm, where the problems of planning sensor measurements and robot motions are dependent and the measurement process should guide the robot control and navigation.

In this landmine detection and classification application, first an IR (infrared) sensor on an airplane flying over the region is used, and then autonomous ground vehicles carrying other sensors (e.g., GPR and EMI) must move around to improve the discovery and classification of objects buried under ground.

This example presents a shift with respect to the traditional paradigm, where sensor information is used as feedback to the vehicle for control purposes.

**Importance:** our proposed new decision and control techniques described below treat the problems of sensor fusion and inference, as well as control, path planning and sensor planning in a unified way, while traditional methods address these problems individually.

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**Problem Formulation:** for a given layout \( W \subset \mathbb{R}^2 \) with \( r \) targets and \( n \) obstacles and a given joint probability distribution \( P(y, m_1, ..., m_n) \) of an hypothesis variable, \( y \), and \( r \) measurements, find the obstacle-free path that minimizes the distance traveled by a robot \( \mathcal{A} \), between two configurations \( q_0 \) and \( q_f \).

\( q_f \) and maximizes the cumulative information profit of a sensor with field of view \( \mathcal{S} \) installed on \( \mathcal{A} \).

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**Goal:** to plan robot navigation and sensor measurement as well as sensor mode to maximize classification gain and minimize the cost.

Uncertainty, reliability, and causal information embedded in the sensor data are used to build the Bayesian network (BN) model of a sensor.

Inference is used to estimate target features in the presence of heterogeneous soil and varying environmental conditions.

A multi-sensor fusion technique operating on BN models is developed to exploit the complementarity of the sensor measurements.

A target BN classifier is obtained to estimate the target typology, mine or clutter. The binary classification node “Target” is parent to the four feature nodes representing the depth, size, shape and metal content that are measured by one or more of the three sensors.

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**New in the proposed approach:**
(1) Our decomposition accounts for the presence of targets.
(2) Solution is an optimal policy for both robot motions and sensor measurements, i.e., optimal tradeoff between cost and information benefit, e.g., detection and classification.

**Results:** High Path & Coverage Efficiency

(1) Connection between sampling probability and expected benefit guarantees covering high percentage of important targets.
(2) Optimal tradeoff between targets coverage and distance can achieved by various utility weights accordingly.