Is minimization the right answer?

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Today’s topics

What are we designing?

- Custom robot structures
- Feedback controllers
- Sensor fusion algorithms
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- Custom robot structures
- Feedback controllers
- Sensor fusion algorithms

What can we minimize?
- ⇒ User abilities
  - to make robots on demand
- ⇒ System knowledge
  - to control autonomous vehicles
- ⇒ Hardware resources
  - to estimate location state
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What does that get us? What *doesn’t* that get us?

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RoCo: The Robot Compiler

**Input**: Functional specification

**Output**: Mission accomplished!

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Parameterized component library

Structural building blocks
- dimensions (c)

Electrical building blocks
- models (d)

Software building blocks
- gains (c), classes (d)

User interface elements

```cpp
bool setSpeed(int servoNum, int speed);
void calibrateServo(int servoNum);
```
Design solving

Physical components
  State: 7 (dynamic) parameters, 1 (nonlinear) equation
  Connections: 6 (nonlinear) equations
Electromechanical components
  Discrete + continuous parameters
  Differential equations
Environment?
High level compilation vision

Autonomously design, manufacture, and control robotic systems from a high-level task specification

Big picture goal:
$ vim myrobot.rbt
   “I want a robot to play chess with me”

$ make myrobot
   Parsing specification ...done.
   Determining behaviors ...done.
   Generating mechanisms ...done.
   Assembling components ...done.
   Printing ...done.
   Success!
User in the loop

Questions \[\rightarrow\] Answers \[\leftarrow\] USER \[\rightarrow\] Design

Minimality tradeoffs
Robotic design automation
User in the loop

Specification → USER → Design

Questions → Answers → USER → Design

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User in the loop

Specification

Questions

Answers

Design

Questions

Answers

Design

Design

Design

Design
Spontaneous traffic jams

Human driven cars

Autonomous vehicle
Minimize computation: oracle

Minimize knowledge: reinforcement learning


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Distributed state estimation
What resources can we minimize?

Computation

Centralized equivalent state estimation
All sensing data shared equally among all nodes
Extensive communication: wasted bandwidth, energy

Communication

Local state estimation
Dependent requirements from independent subsystems
Potentially wasted sensor readings
What resources can we minimize?

**Computation**
- Centralized equivalent state estimation
- All sensing data shared equally among all nodes
- Extensive communication: wasted bandwidth, energy

**Communication**
- Local state estimation
- Dependent requirements from independent subsystems
- Potentially wasted sensor readings

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What would we like to minimize?

System requirements
- Minimal impact on mission
- Robust to uncorrelated sensing and communications dropouts
- Guaranteed performance

Goal: Automate algorithm design based on user requirements
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Goal: Automate algorithm design based on user requirements
Minimality

What are resources we’d like to minimize?

Claim: Sensing, actuation, computation, communication, power

Physical constraints: Energy, weight, size, bandwidth, ...

Operational constraints: Error, uncertainty, misuse, ...

Development constraints: Experience / ability, effort, illegibility, ...