

# 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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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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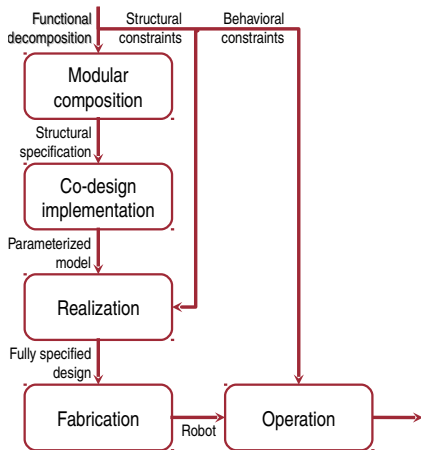
⇒ Hardware resources

–to estimate location state

What does that get us? What *doesn't* that get us?



# RoCo: The Robot Compiler



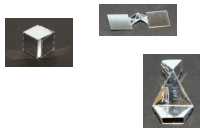
**Input:** Functional specification

**Output:** Mission accomplished!

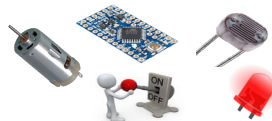


# Parameterized component library

## Structural building blocks – dimensions (c)

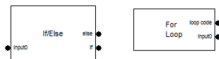


## Electrical building blocks – models (d)

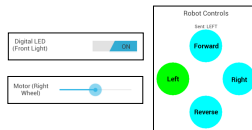


## Software building blocks – gains (c), classes (d)

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



## User interface elements



# 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.

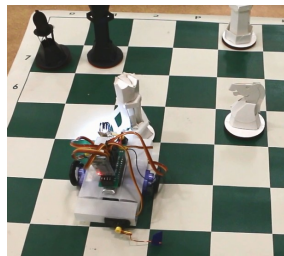
Determining behaviors ...done.

Generating mechanisms ...done.

Assembling components ...done.

Printing ...done.

Success!

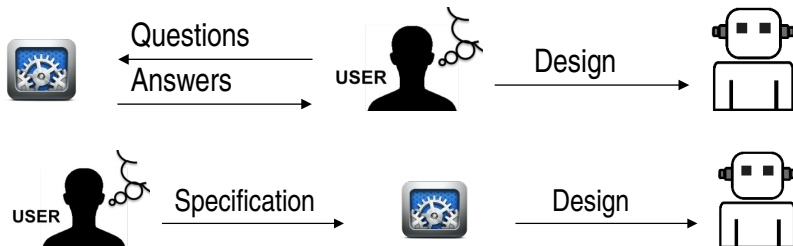




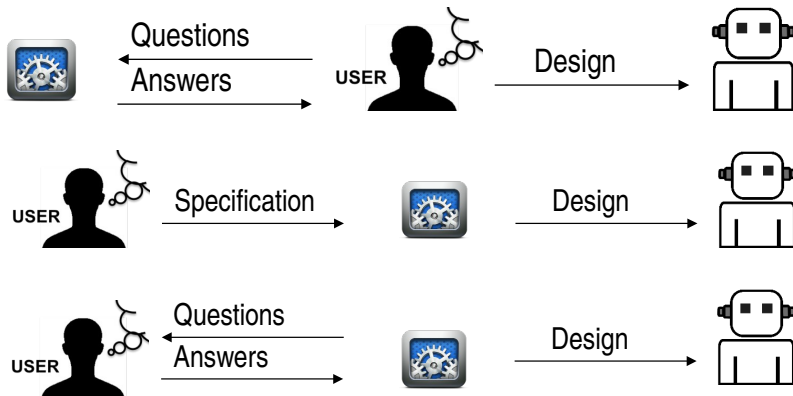
# User in the loop



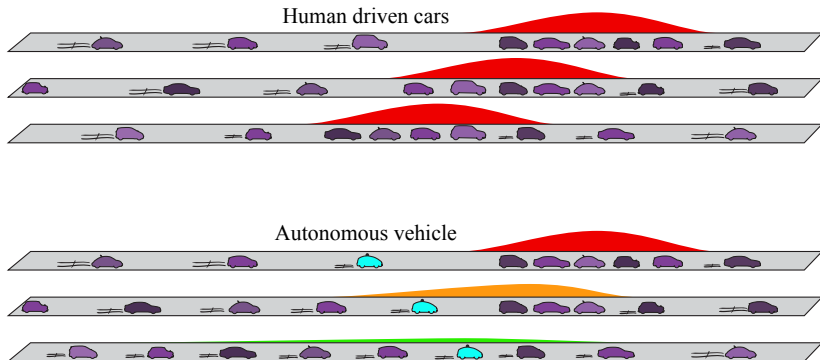
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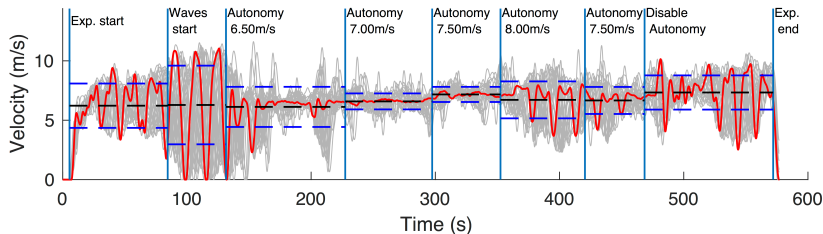
# User in the loop



# Spontaneous traffic jams



# Minimize computation: oracle

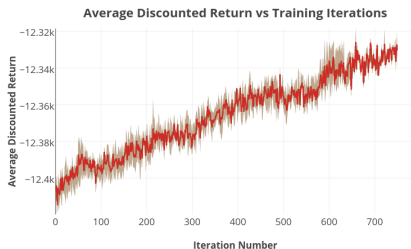
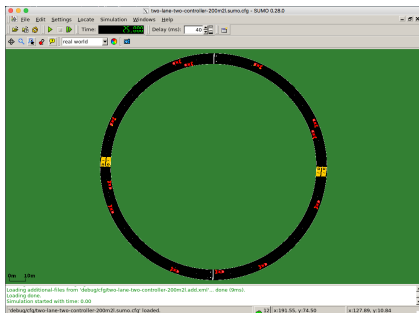


Stern et al., "Dissipation of stop-and-go waves via control of autonomous vehicles: Field experiments",

Transportation Research Part C, 2017

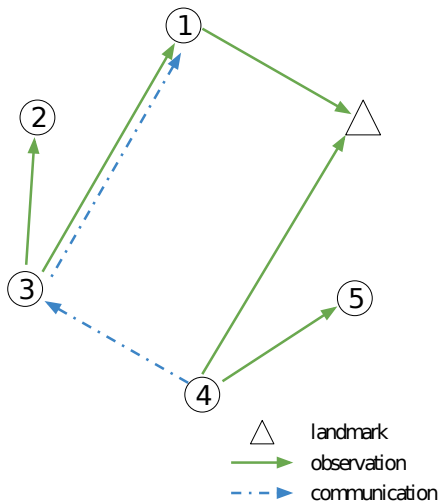


# Minimize knowledge: reinforcement learning



Wu et al., "Framework for Control and Deep Reinforcement Learning in Traffic", ITSC 2017

# 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





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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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# 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, ...

