



# ***DARPA*Tech**

## ***2002 Symposium***

*Transforming*  
***Fantasy***



**Douglas W. Gage**  
Program Manager



# Software Programs For Robotic Autonomy

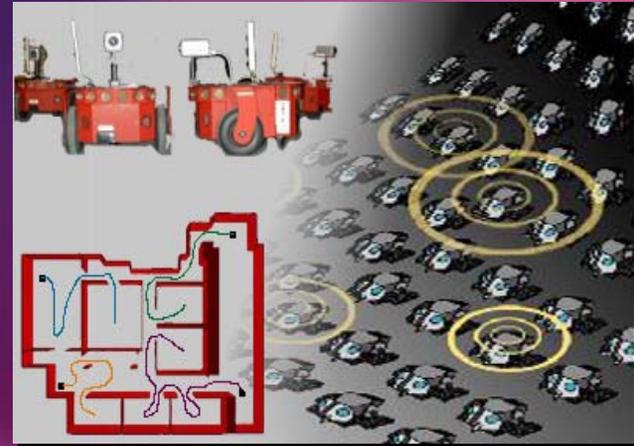
Douglas W. Gage

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# Software for Distributed Robots

## SDR



*Behaviors and user interfaces for large groups of small robots*



# Software for Distributed Robotics

*Our Inspiration...*



# Software for Distributed Robotics

- ▶ Large numbers of robots provide
  - Parallelism
  - Spatial diversity
  - Redundancy and Expendability
  - Dedication



# Software for Distributed Robotics

- ▶ SDR is developing
  - Group behaviors
  - Inter-robot communications
  - User interface for
    - Tasking
    - Monitoring
    - Intervention
    - Assessment



# Software for Distributed Robotics

- ▶ Small robots are
  - Lightweight
  - Easy to transport
  - Fit into small spaces

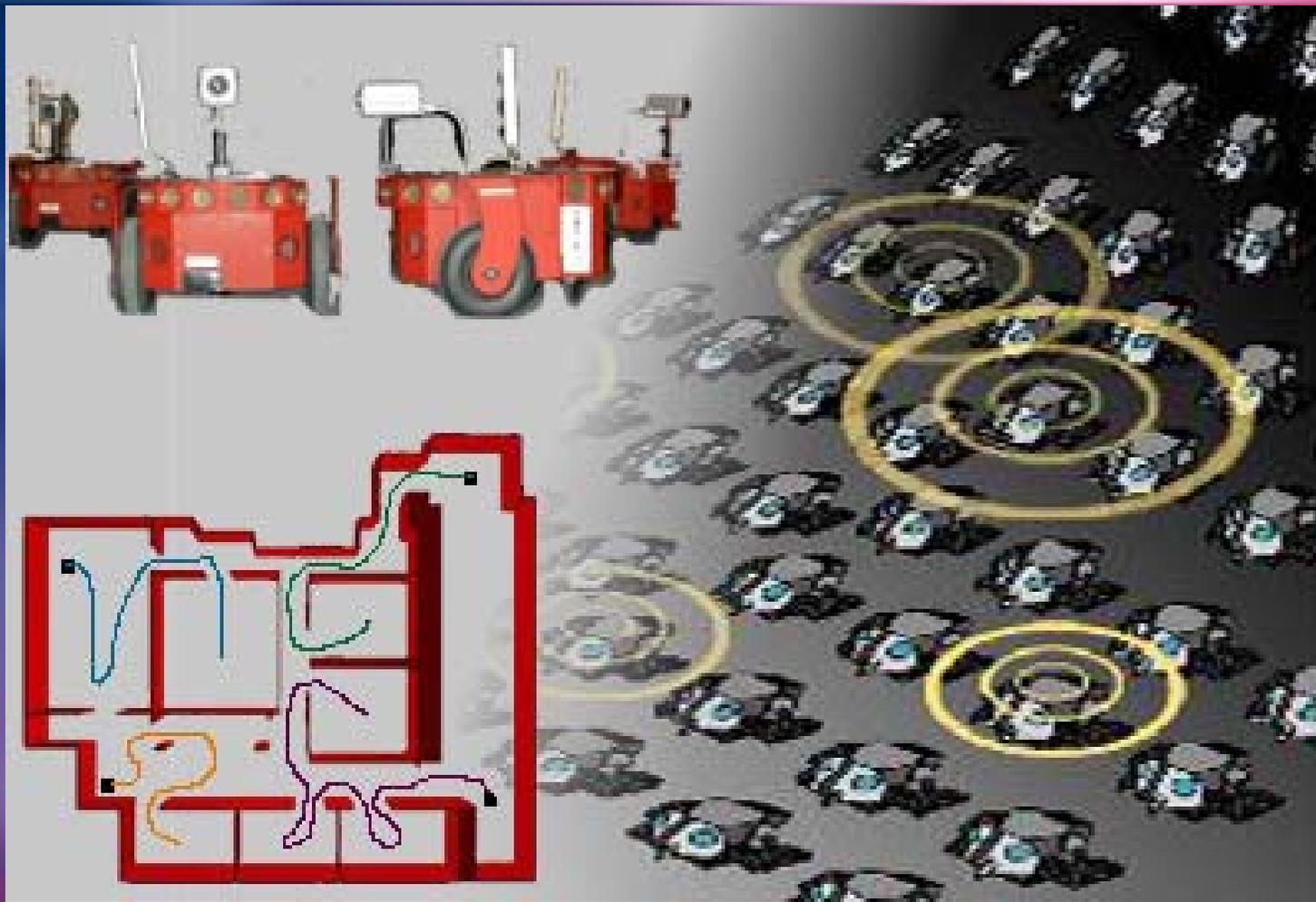


# Software for Distributed Robotics

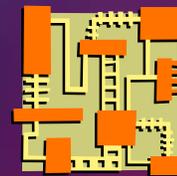
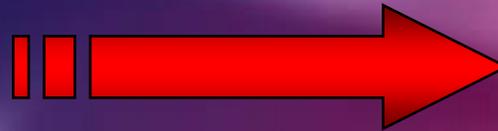
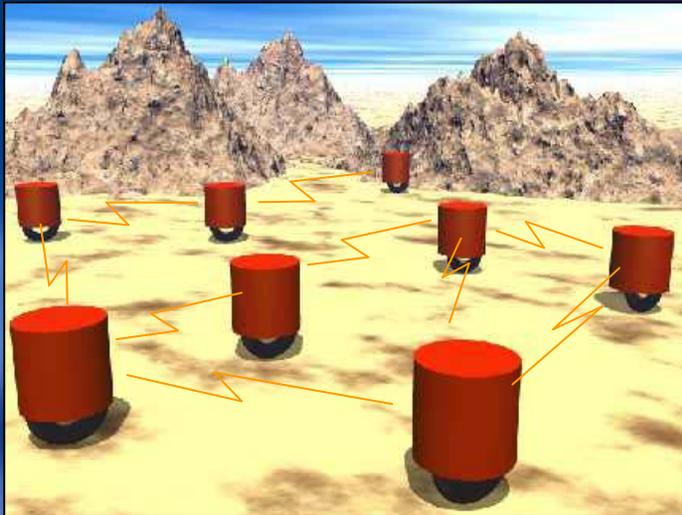
- ▶ Software for many small robots each limited in:
  - Strength
  - Power
  - Communications
  - Sensing
  - Processing



# Software for Distributed Robotics



# Software for Distributed Robotics



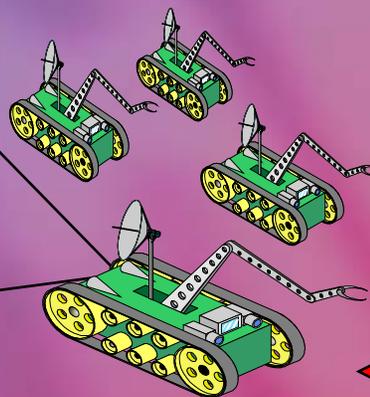
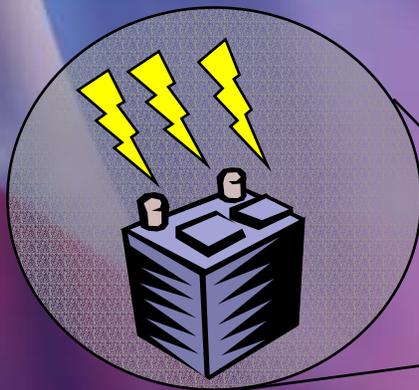
Application

Transport

Network

Link

Physical



# Software for Distributed Robotics



# Robotic System Requirements

## ► Deployment

- Mass produced robots
- Disposable
- Non-rechargeable batteries
- Minimal communications

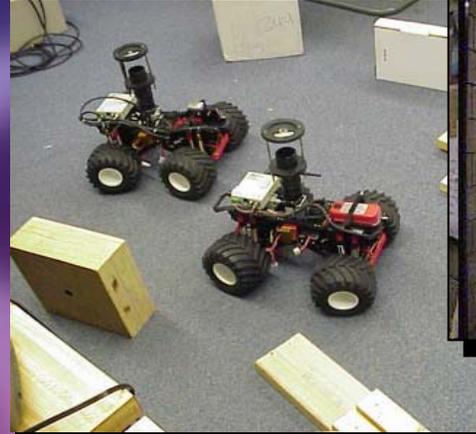
## ► Development

- Reusable robot
- Rechargeable batteries
- Communications for debugging and reprogramming



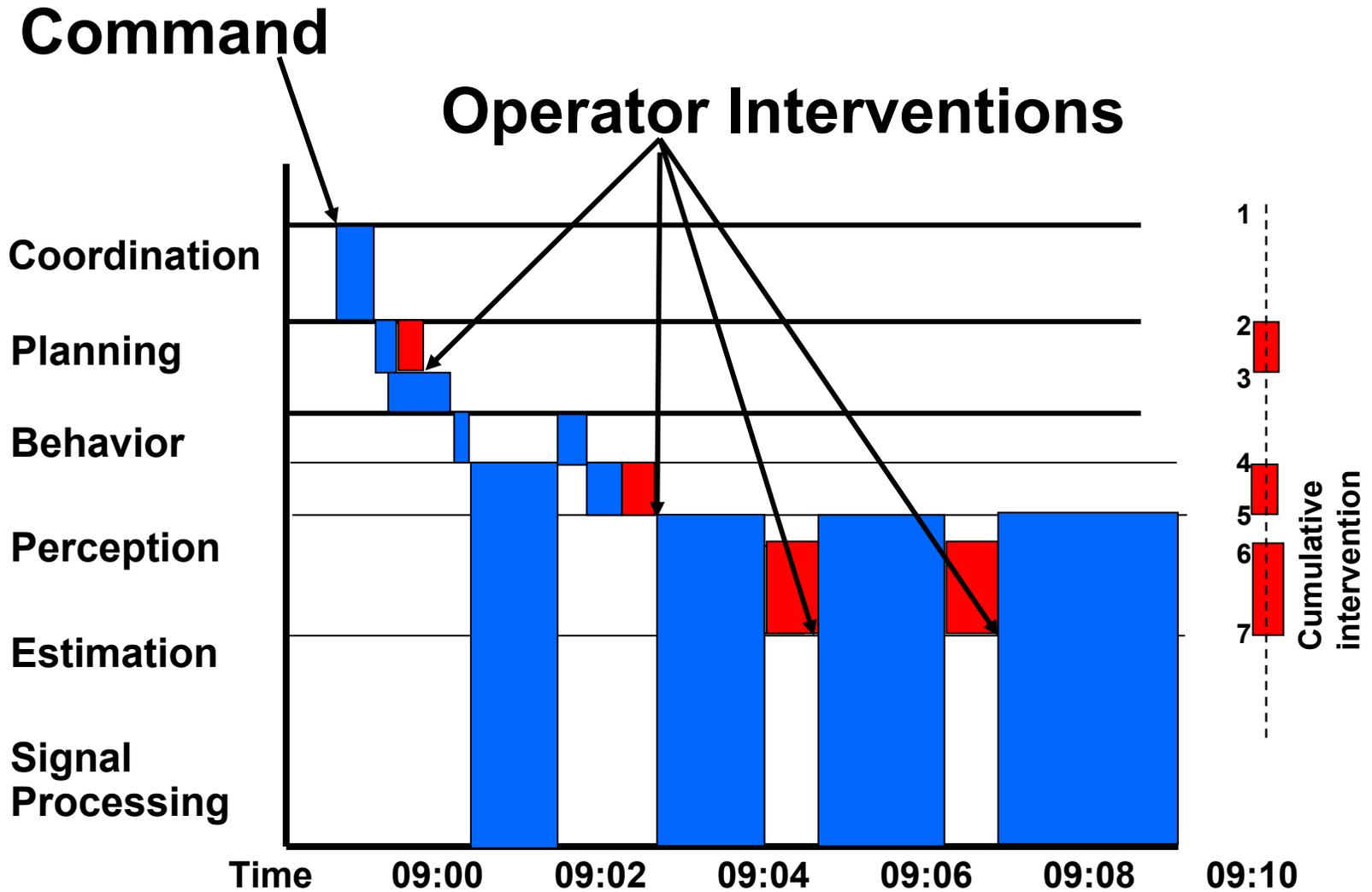
# Mobile Autonomous Robot Software

# MARS



*Software Technologies  
for autonomous  
vehicle navigation and  
interaction with  
humans*

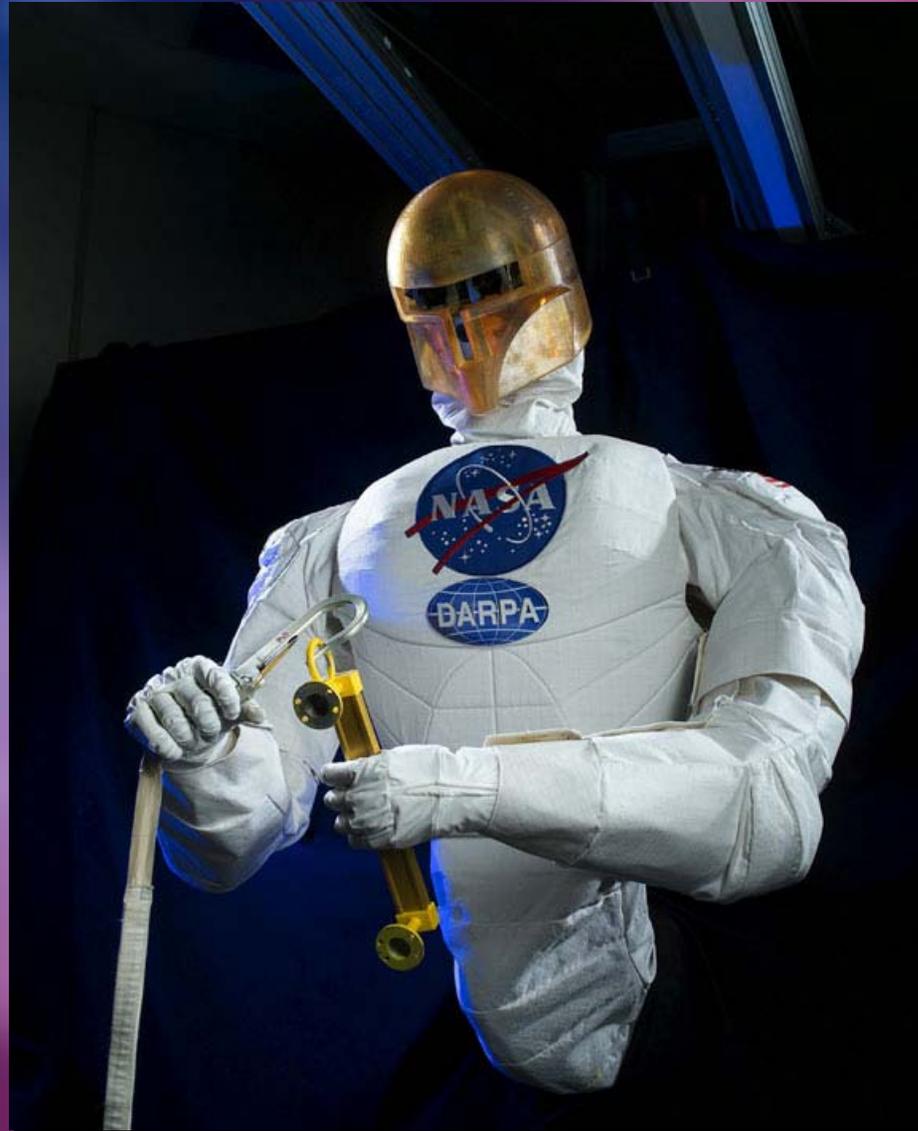
# Structured Operator Intervention



# Learning and Adaptation

- ▶ Supervised learning
  - Guided by measuring progress to goal
- ▶ Reinforcement learning
  - Guided by measuring how well goals are achieved
- ▶ Imitative learning
  - Guided by human demonstration

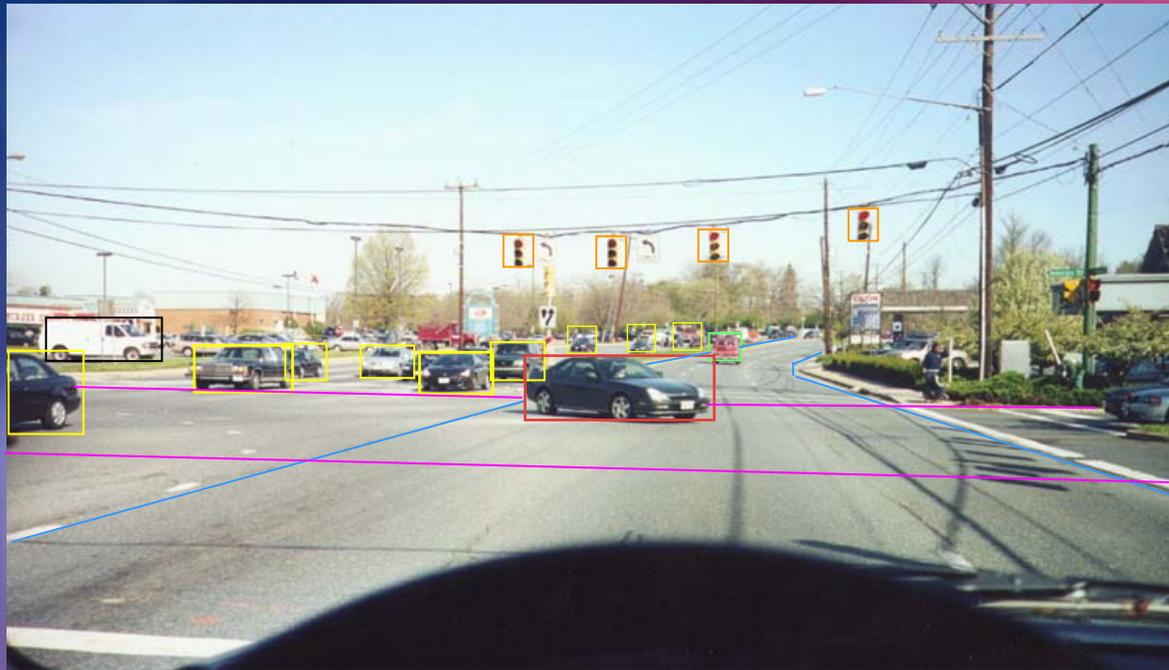
# Interaction



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# Perception of the Environment

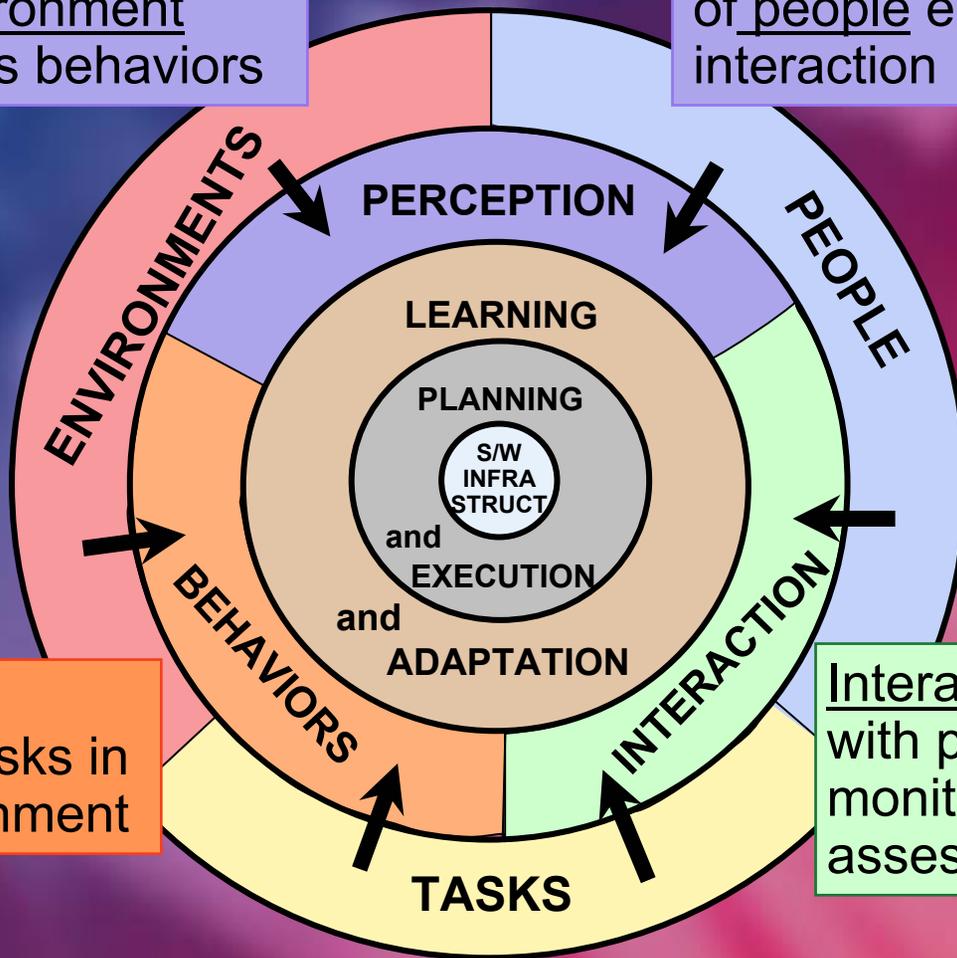


- Car turning left (position, velocity)**
- Oncoming cars (position, velocity)**
- Traffic signals (stop)**
- Truck on own road (position, velocity)**
- Own road edges (Old Georgetown Road, heading North)**
- Intersecting road edges (Democracy Boulevard, to West)**
- Self in lane 2 (position, velocity) intent (go straight)**

# A Robot's "Intelligence" is Embodied, Situated, and Taskable

Perception  
of environment  
enables behaviors

Perception  
of people enables  
interaction



Behaviors  
execute tasks in  
the environment

Interaction  
with people enables tasking,  
monitoring, intervention, and  
assessment



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