Agenda:

- ✓ **Timing of these administration meetings**
- ✓ **Career development plans and the technology (Alex)**
- ✓ **Upcoming conferences**
- ✓ **New wiki-pages**
- ✓ **Coffee machine**
- ✓ **Misc**

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IRIDIA

Evolutionary Robotics approach for vehicle safety systems

Overall Purpose

- ✓ vehicle safety system, what’s going on about driver assistance
- ✓ evolutionary robotics approach for vehicle controller

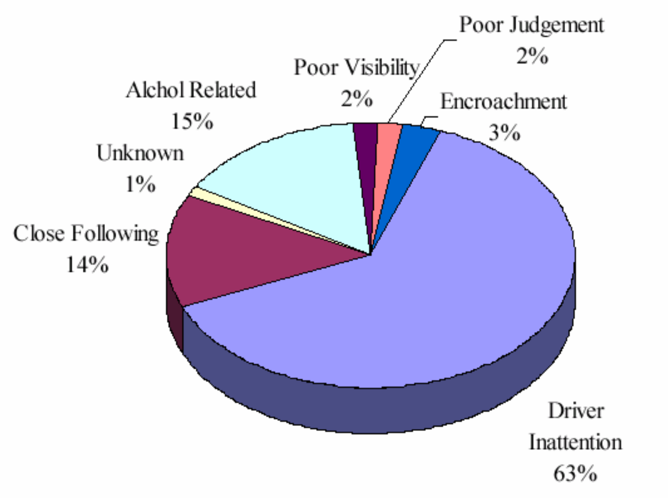
My work at IRIDIA

- ✓ relationships with real world application
- ✓ multirobot context
- ✓ simulator and new features
- ✓ simulator evaluation: the Quinn experiment
- ✓ test with real robots, results

Discussion

- ✓ (validated) simulator update, features for real world
- ✓ which level the ER controller should work to..
- ✓ autonomous vehicle vs. parallel assistanship

ISTAT 2002



Car Safety: Requirements

Coping with:

- unforeseen events
- unpredictable environment

System required features:

- fast response
- information reliability
- filtering properties for uncertainty and noise

How to perform:

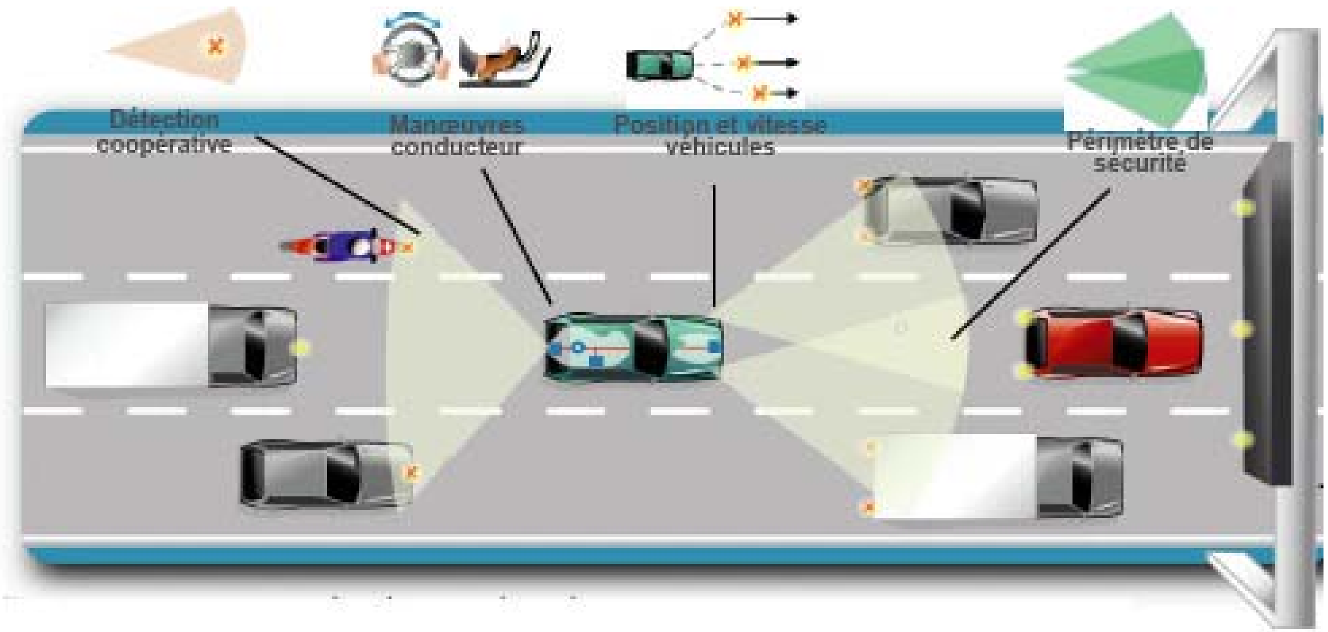
- total/partial driver replacement during hazards

Reference framework:

Former projects in automated highways

Alag, S, K. Goebel, A.M. Agogino, *A Framework for Intelligent Sensor Validation, Sensor Fusion and Supervisory Control of Automated Vehicles in IVHS,* Proceedings of the 1995 Annual Meeting of ITS AMERICA

A.M. Agogino, *Intelligent Sensor Validation And Sensor Fusion For Reliability And Safety Enhancement In Vehicle Control*
Final Report PATH Project 1995



Reference framework:

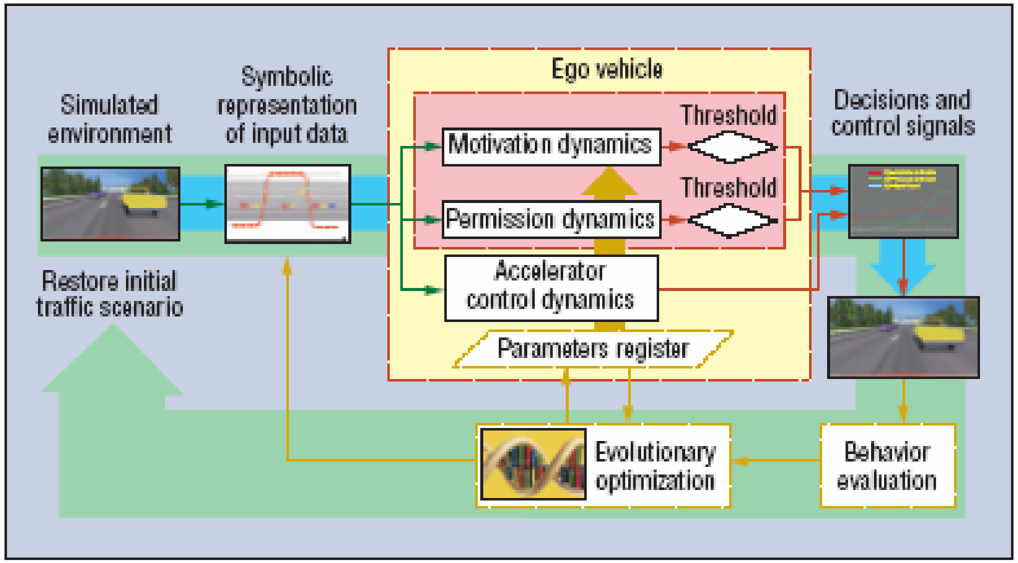
Intelligent Driver Assistance and Partially/Totally Autonomous Driving

A. Pellecchia, C. Igel, J. Edelbrunner, G. Schoner.
"Making Driver Modeling Attractive"
IEEE Intelligent Systems, vol. 20, no. 2, pp. 8-12, March/April 2005.

- Descision making module:

  Actractors dynamic for evaluation function or ANN. Evolved parameters.

- Multivehicle simulator

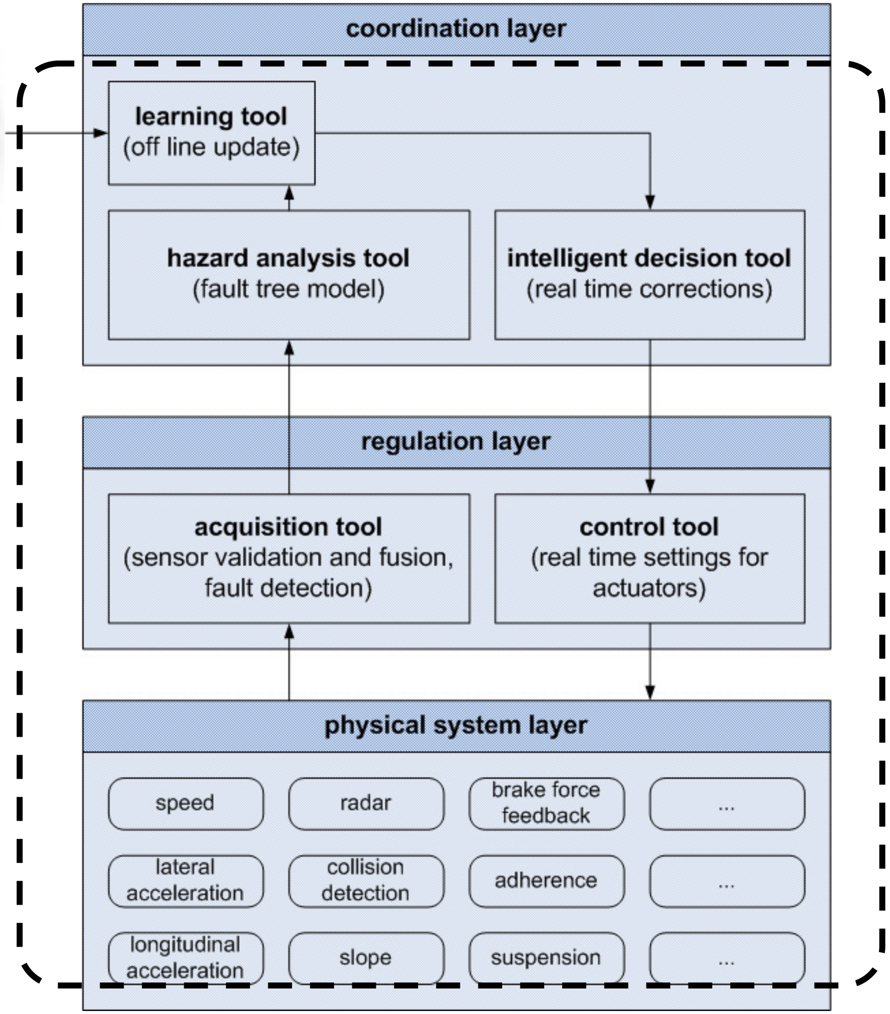


Why Evolutionary Robotics?

1. to study how (and how well) the ***evolutionary approach*** perform in all-comprehensive tasks, in particular about:
   a) direct reactive control
   b) task-solving skills against rough minimal information
   c) learning capabilities
   d) embodiement
2. to study how (and how well) evolved ***CTRNNs*** accomplish reliable behavior in presence of:
   a) Minimal equipment
   b) Noisy signals
   c) Ambiguous input
   d) Noisy feedback on output
3. to study how (and how well) the nets perform in ***discrimination tasks***:

   Example: IR input signals from mobile vs fixed environmental hurdles

The evolutionary approach

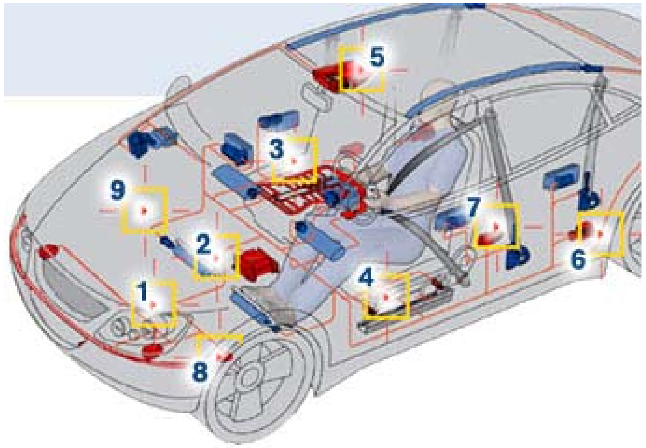


Global approach by ER:

Study if (and how) a single stand alone ER controller can perform multiple tasks.

Study the structure and evaluate which level can be performed by ER module (if cooperative to other modules)

Car Safety: Equipment



output (mainly):
1 anti-collision sensor: **Radar**
2 inertial: **accelerometers, gyros**
4 driver sensors
5 **Out-of-position**
8 impact sensor,
9 lane keeping

output (mainly):
ESP
ACC
ABS

targets:
- Collision Warning
- Pre-Crash
- Adaptive Cruise Control (ACC)
- Stop&Go
- Urban Collision Avoidance (UCA)

In traffic environment global supervising systems, broadcast communication and infrastructures may fail…

↳ local on-board control mode, global self-organization

↳ **swarm intelligence** approach:

- if one vehicle fails, the traffic system doesn't..
- collective task

environment-agent and agent-agent interactions hard to model..

↳ analysis of performance on simplified platform

↳ **multi robot** context:

- limited equipment, but keeping noise and unrieliability
- basic output feedback (kinematic control loop)
- relying only on NN controller capabilities

1. homogeneous system: each vehicle equipped with the same hw/sw
2. no explicit communication among agents
3. only IR proximity equipment

⇩

- ✓ NN controller performance in multirobot navigation task
- ✓ Emergence of roles
- ✓ The same net (morphology and genotypes) accomplishes all agents behaviors
- ✓ Reactive skills
- ✓ Non-reactive skills

the Quinn experiment

Benchmarking for simulation and tools performance:

✓ understanding interactions

✓ analysis of topologies

✓ task exploitation vs. fitness encoding

✓ randomness, set up and robustness

High level description of the tasks:

✓limited (in range e quality) input signals

✓ memory skills

✓ non hand-coded behavior and roles

✓ the only example in multirobot context

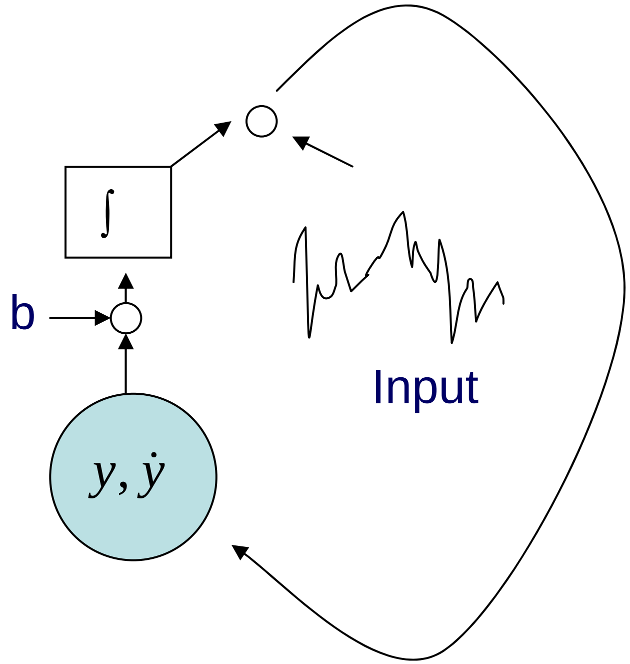
References:

• Quinn, M., Smith, L., Mayley, G. and Husbands, P. “Evolving controllers for a homogeneous system of physical robots: Structured cooperation with minimal sensors” *Philosophical Transactions of the Royal Society of London, Series A: Mathematical, Physical and Engineering Sciences* 361, pages 2321-2344. October 2003.

Core bricks: the CTRNNs

analysis:

- non linear dynamics approximation
- states description
- recurrencies and time constants
- integration
- topology



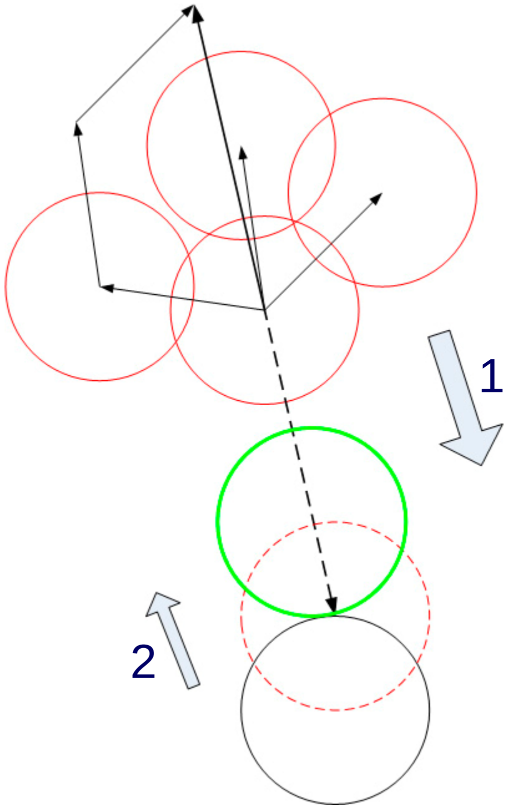
$$\tau \cdot \dot{y}_i = -y_i + \sum_j w_{ij} \sigma\left(y_i + b_i\right) + I_i$$

References:
• Beer, R. "A dynamical systems perspective on agent-environment interaction"
Artificial Intelligence, (1995) no. 72 vol.1, 173—215
• Beer, R. "The Dynamics of Active Categorical Perception in an Evolved Model Agent"
Adaptive Behavior 2003; 11: 209-243.
• Yamauchi B. M., Beer R. "Sequential behavior and learning in evolved dynamical neural networks Source"
Adaptive Behavior 1994 Volume 2 , Issue 3 : 219 – 246

some features for the Quinn experiment

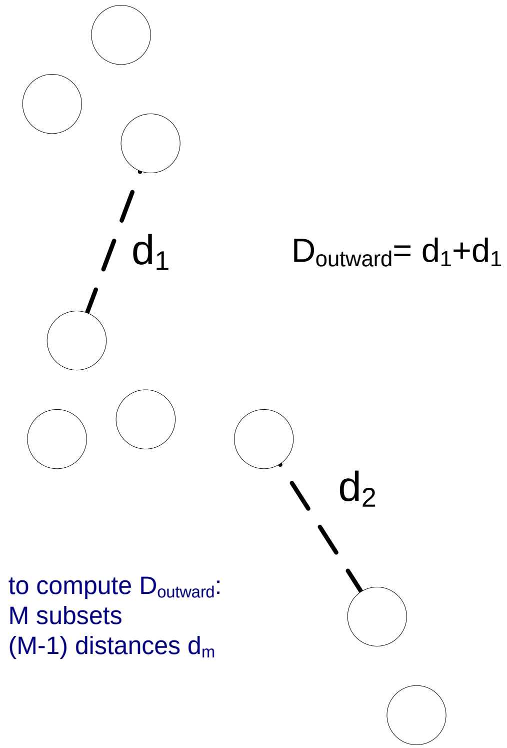
collision avoidance

- no rules provided for avoiding behavior
- more effective (than Quinn)



team packing – outward distance

- agents scattering punished during evaluation..
- n>3 rule coding

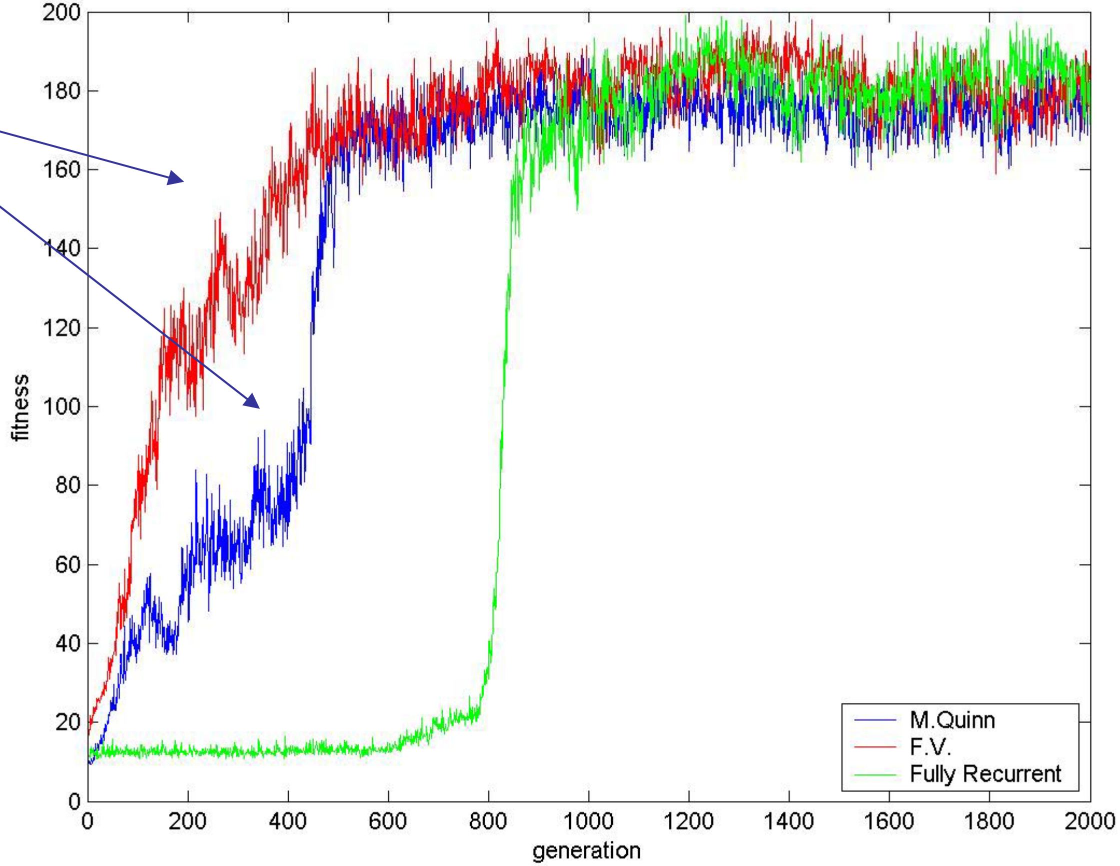


the Quinn experiment

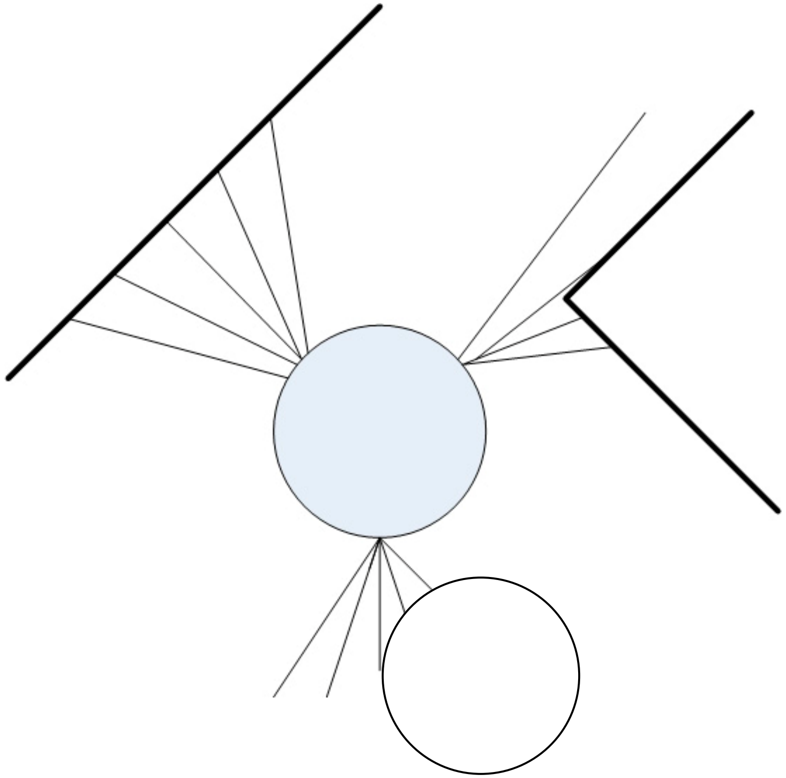
- collision management
- effective learning (red vs. blue)
- testing topologies (blue vs. green)

Remarks:

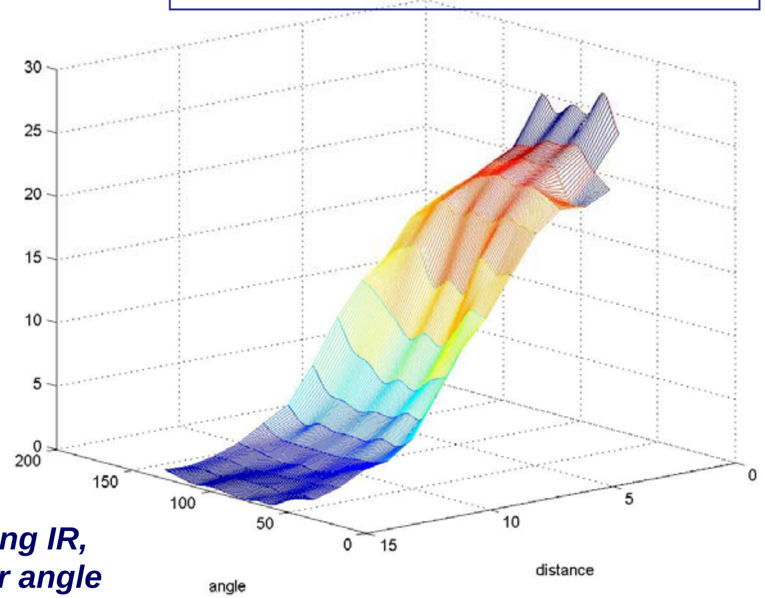
Better evolutive condition let the controller tackle and solve faster the task



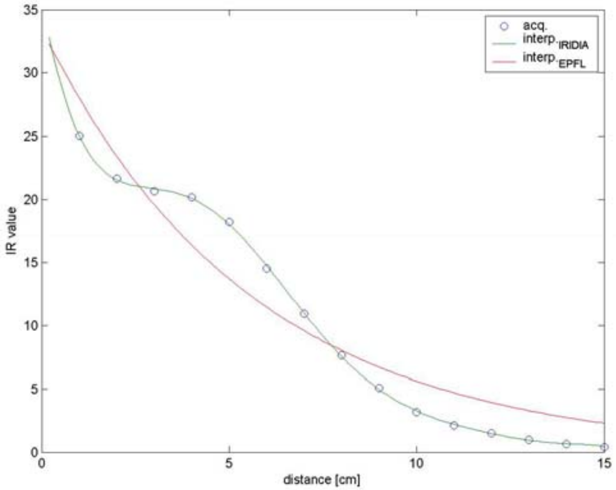
• only R-R interaction → •environmental interaction



simulation target



1. Sampling IR, fitting over angle & distance

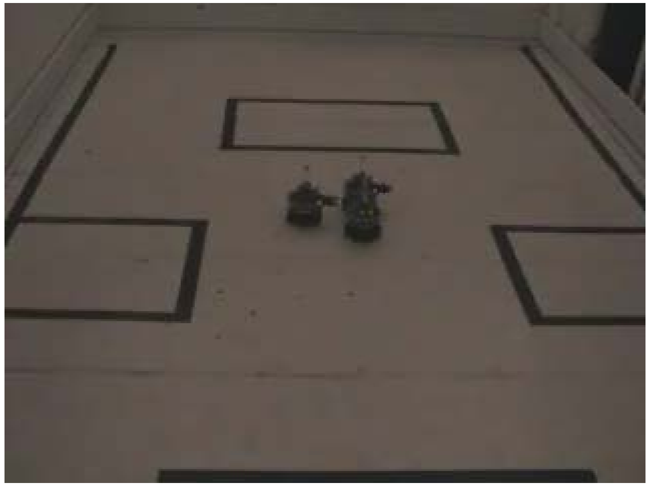


2. IR beam intensity interpolation

the Quinn experiment

See the simulator..

.. and results




www.swarm-bots.org
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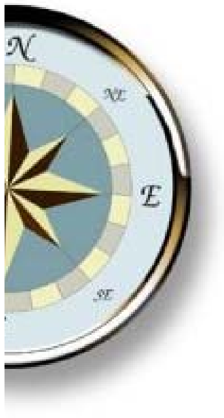


now on simulator:	next on simulator:
• basic ER features	• basic ER features
• feedfw and FR nets	• feedfw and FR nets
• ctrl loop on speed	• ctrl loop on acc/force
• kinematics model	• dynamical model
• linear systems	• non linear systems
• only R-R interaction	• environmental interaction
• simple agent	• real vehicle
• limited analytical tool	• net analytical tool
• …	• …

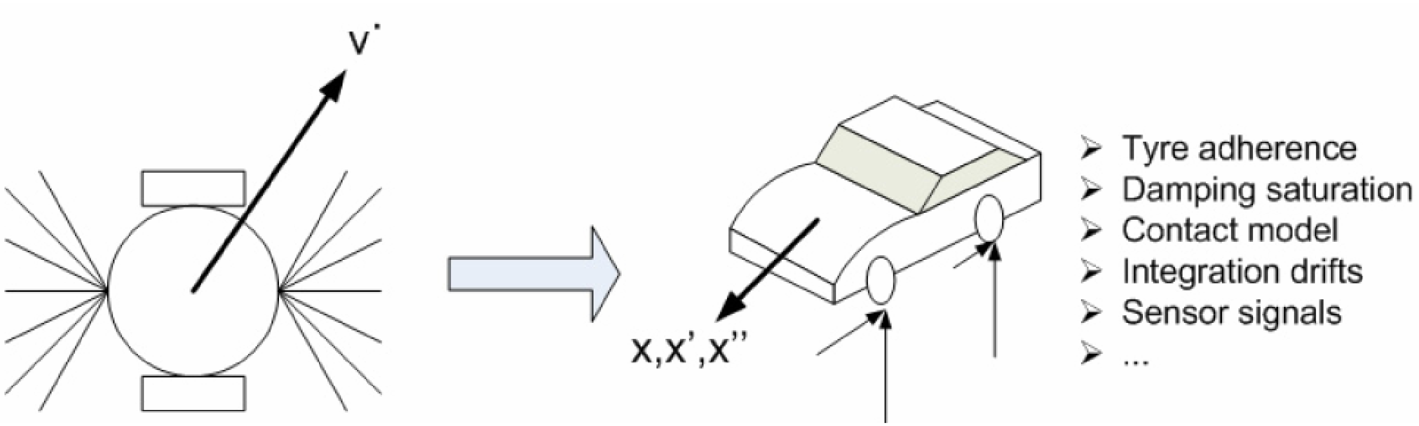
from s-bot to vehicle model

now on simulator:

- ..
- ctrl loop on speed
- kinematics model
- linear systems
-

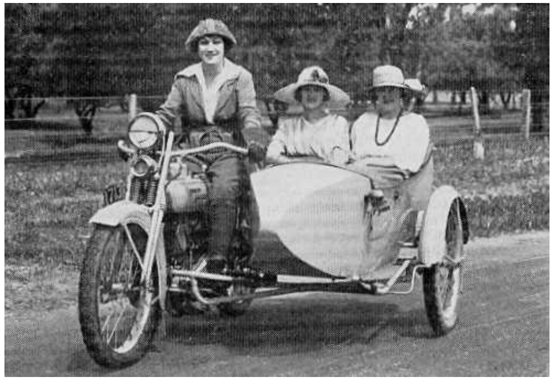
next on simulator:

- ..
- ctrl loop on acc/force
- dynamical model
- non linear systems
- ..



What an ER controller can safely drive?
In which scenario?

Vs.



Autonomous controller

(totally sw driven vehicle)

Driver Assistant

(redundant?)