

Architecture

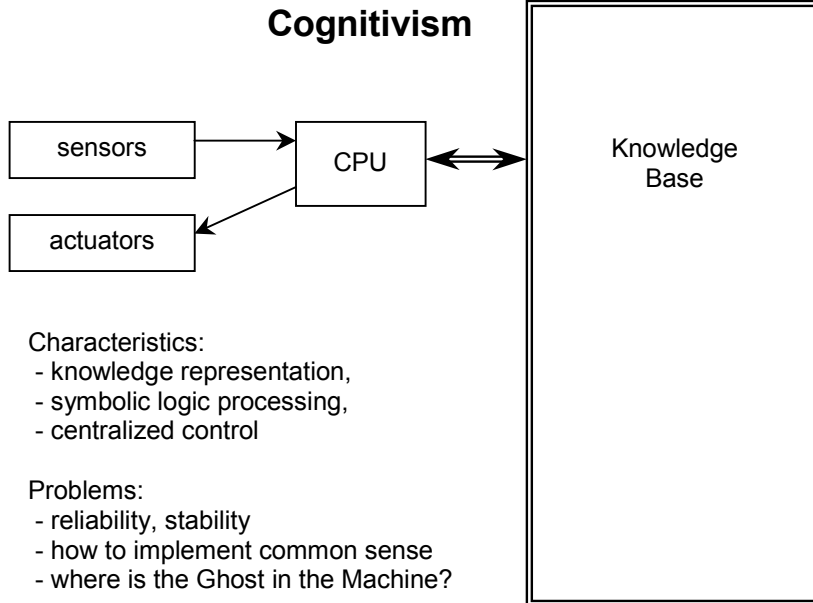
**Future Directions Seminar
Navigation & Control**

14-Apr-2000

Eric Jackson

Theories of Intelligence

Cognitivism



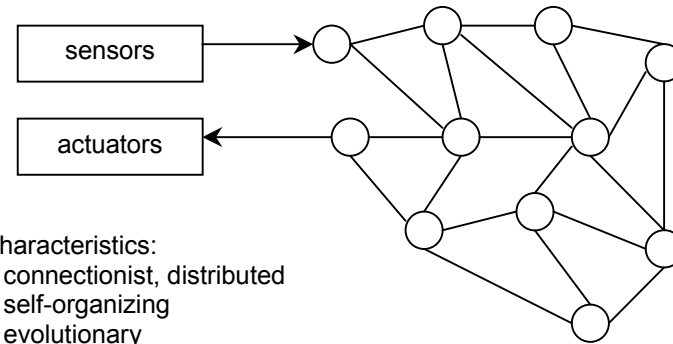
Characteristics:

- knowledge representation,
- symbolic logic processing,
- centralized control

Problems:

- reliability, stability
- how to implement common sense
- where is the Ghost in the Machine?

Emergence



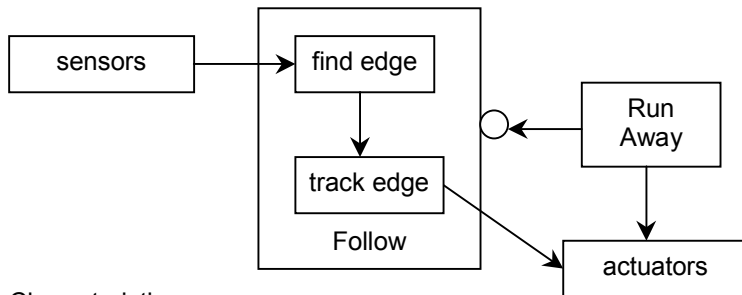
Characteristics:

- connectionist, distributed
- self-organizing
- evolutionary

Problems:

- evolutionary process
- thinking
- conscious intent

Embodied / Enactive



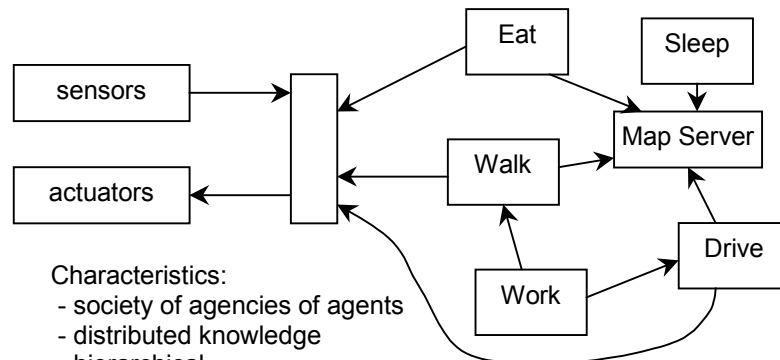
Characteristics:

- no knowledge representation
- ad hoc, pragmatic
- skill acquisition
- animal/environment coupling

Problems:

- adaptability
- thinking, conscious intent
- stability

Holonic / Society of Mind



Characteristics:

- society of agencies of agents
- distributed knowledge
- hierarchical

Problems:

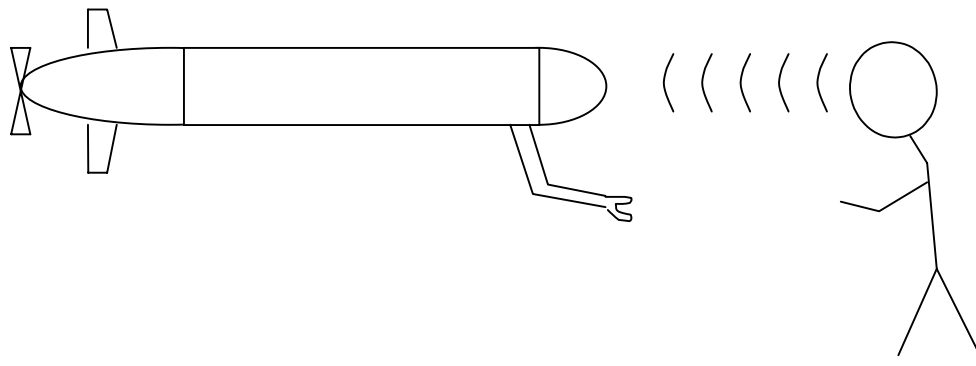
- organization, stability
- thinking, conscious intent
- common sense

Intelligent Robots

We (the designers) provide the intelligence:

- we embed it - we don't create it
- we ensure reliability and stability
- we provide common sense
- we provide adaptability as required
- we provide the organization

We are the Ghosts in the Machine - we provide the conscious intent.



Approaches to Robot Control Architectures

Cognitive:

Embedded Expert Systems, Symbolic & Fuzzy Logic, Knowledge-based control

Emergent:

Neural Networks, Neural/Fuzzy Control

Embodied:

Subsumption Architectures, Ad Hoc Control Structures

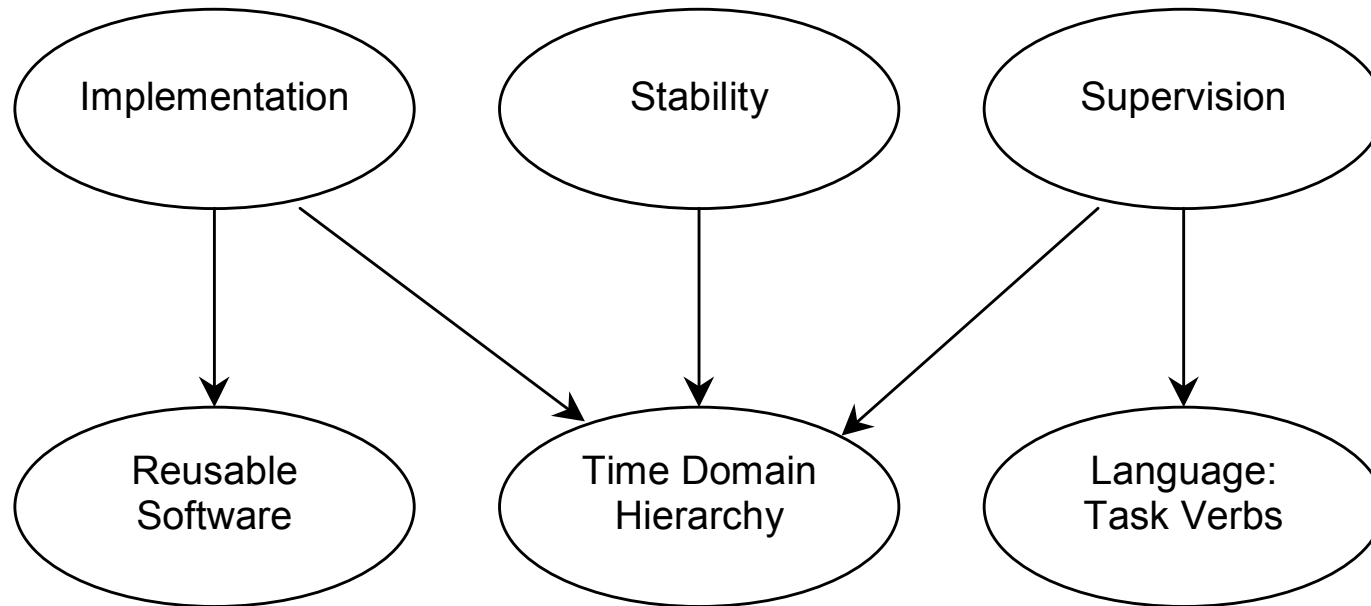
Holonic:

Hierarchical Behaviours

Pragmatic:

Implementable, Stable, Supervisable

Pragmatic Robot Controllers



Notes:

Resolving Conflicting Goals – arithmetic (e.g. potential fields, weighted sums), logic (e.g. subsumption, fuzzy logic), probabilistic

Events & Actions scheduler – designed to support time-domain hierarchical control on commercially available processors

Supervisory/Autonomous Control

	Sensory Processing	Knowledge	Task Decomposition
5	Situation Assessment	Mission Criteria	Mission Sequencing
4	Mission progress	Geographic	Trajectory Generation
3	Vehicle Location, Obstacle Locations	Vehicle Maneuvering Behaviour	Line Following, Obstacle Avoidance
2	Vehicle Attitude	Control Laws	Attitude Control
1	Actuator Feedback	Control Laws	Actuator Control

Top-Down Design – Hierarchical Task Verb decomposition

Bottom-up Design – determined by controller bandwidth requirements

Lower Bandwidth communications required at higher levels

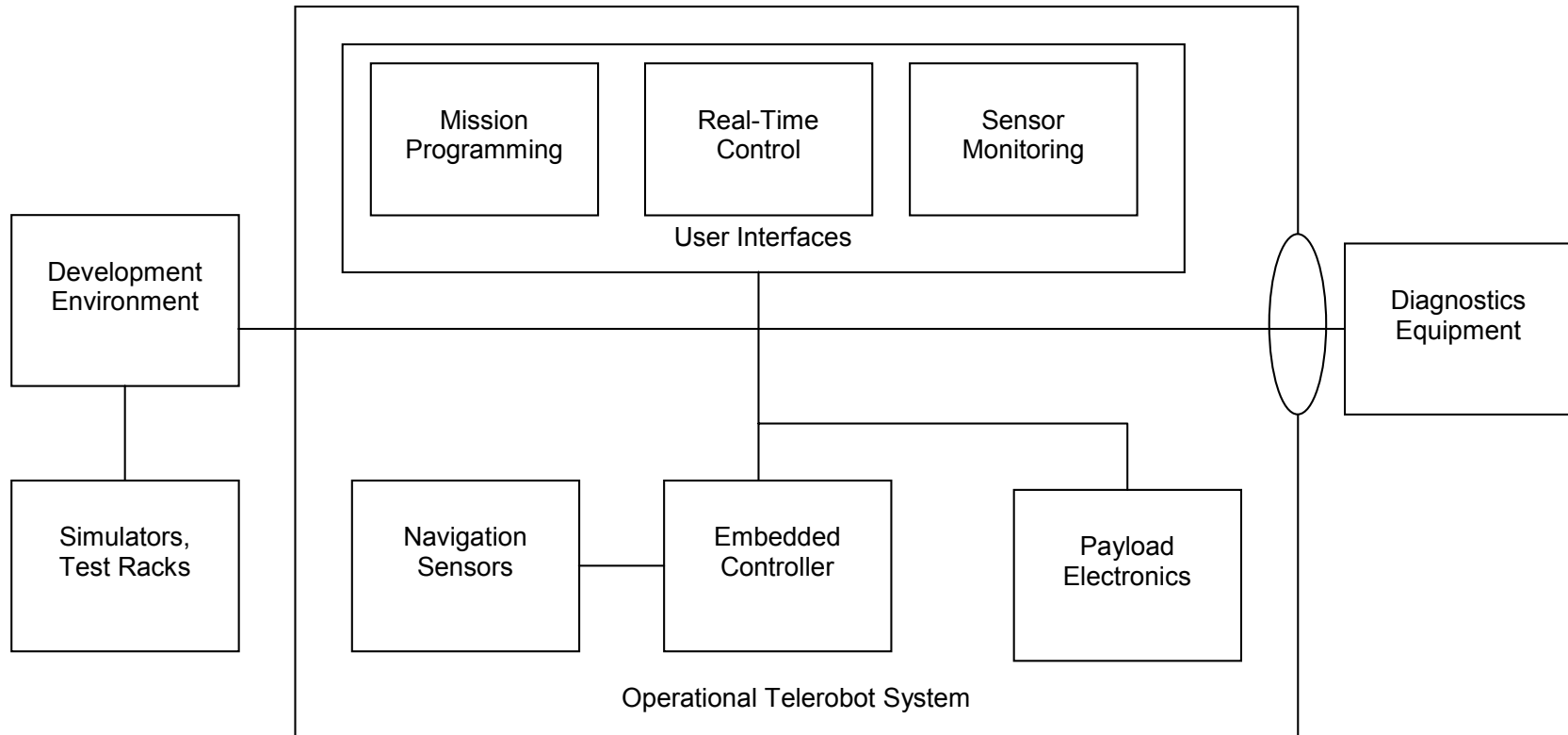
Technology Solutions can be mixed, e.g:

- neural net obstacle classifier
- rule based mission sequencer
- PD actuator controller
- adaptive line-following controller

Knowledge - can be either:

- embedded, or
- translated by the designer into simple algorithms

Navigation / Control System Elements



Issues:

Communications Infrastructure for development, test, and maintenance

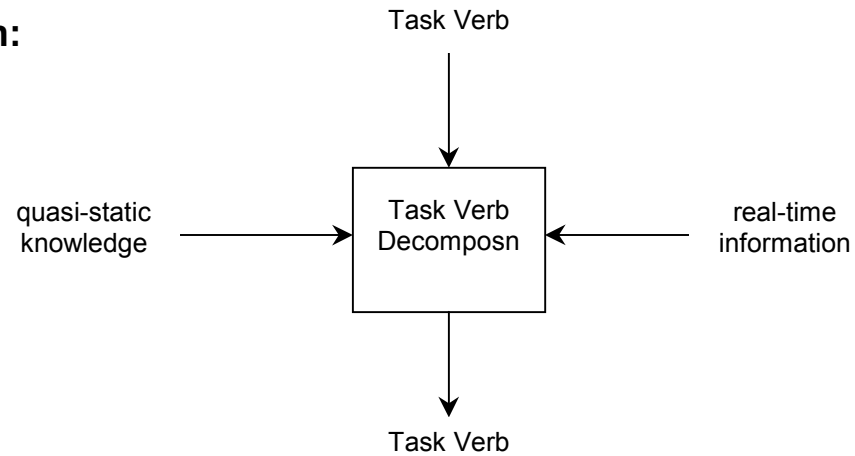
Design-Support and Mission-Support Simulators

S/W Configuration Management during integration, test, and after delivery

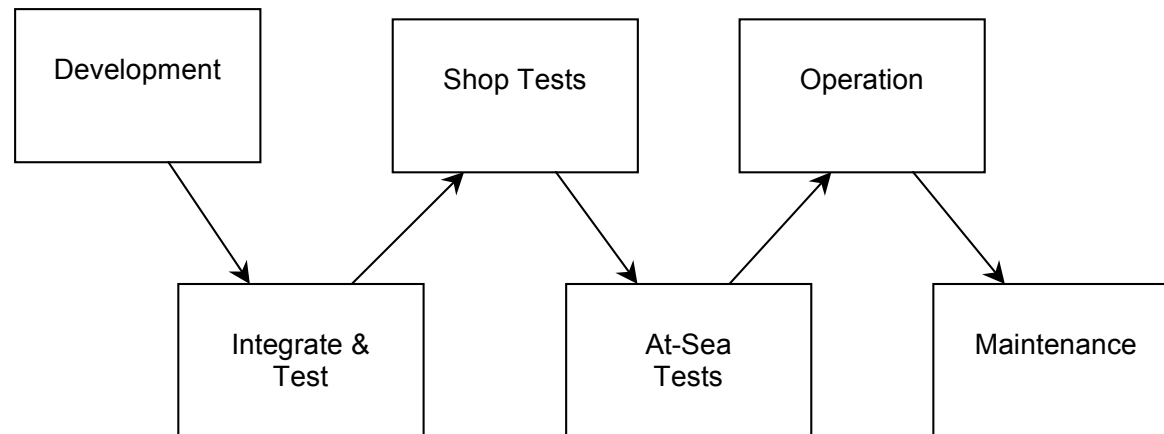
Requirements

User Interface: mission programming, data quality checking, system monitoring, task assistance

Task Decomposition:



Life Cycle:



Cooperating Robots

Seamless Interaction with Humans is required:

“rules of the road”

tactical doctrine for military applications

Robots must be able to communicate findings to humans and to each other

A value system must be defined in order to allow the robots to make decisions autonomously

Distributed decision-making in the absence of human operators and with incomplete knowledge is required

The hierarchical control architecture must be extended upward to describe Actions to be performed by multiple robots

Conclusions

We are not trying to make robotic systems that are intelligent – we are trying to use our own intelligence to make robotic systems that are effective.

Using a pragmatic hierarchical control architecture, we can integrate many different navigation and control technologies (and theories of intelligence) into a working robot controller.

Requirements for the navigation & control system must be derived from the entire project life cycle.

To build cooperating robots, we must extend our hierarchical control concept to include multiple robot scenarios.

Definitions

Engineering – Mechanization of Human Intent

Robotics – Reprogrammable Mechanization of Human Intent

Autonomy – Capability of operating in the absence of human intervention

Human Intervention – measured in bits/second

Task metrics – degrees of freedom, bandwidth, uncertainty

Stability – measured by gain/phase margin

Architecture – ???