A.I. Robotics (Murphy, 2000)

5 **Robotic paradigms:**

1. FUNCTIONS: SENSE - ACT - PLAN (primatives)
2. GLOBAL V. LOCAL - DATA DISTRIBUTION

HIERARCHICAL : 1967 - 1990 : SENSE - PLAN - ACT

2 **REACTIVE** : Biol. / Cog. Ψ : SENSE - ACT

- SKINNER
- FAST PROCESSING

HYBRID DELIBERATIVE - REACTIVE

- planned decomposition

10 **ARCHITECTURES:**

- ORGANIZATION / CONSTRAINT
- INTERACTION

EVAL. CRITERIA : Modular, Niche, portability, Robustness

34 7 A.I. AREAS

2. **Hierarchical Paradigm:**

41 OLDEST - SENSE - PLAN - ACT

- EYES CLOSED PLANNING

43 - Global data structure

44 - Single representation .: slow

↳ STRIPS : GPS - REDUCTION = MEANS-END

- PLAN HANDOFF -> EXECUTION program
- RECURSIVE

52 STRIPS EXECUTION STEPS

Closed world Problem:

- NON-INTUITIVE TO MAINTAIN
- multiple abstraction levels

54 SAMPLE ARCHITECTURES : NMC / RCS

- INTERLEAVING, TASK-DEPENDENCE, MODULARITY, Feature EXTRACTION

61 **DISADVATAGES**: PLANNING - UPDATE world MODEL

3 **Biological:**

67 Arbib / Braitenberg

Braitenberg : Add more complexity

*> 68 KEY: BEHAVIOR REQUIRES PERCEPTION

69 ANIMALS = OPEN world w/o FRAME problem

AGENT : SELF-CONTAINED / INDEPEN.

COMPUTATIONAL THEORY : MARR

71 . "GOAL" : INTELLIGENCE ORGANIZATION

73 BEHAVIOR : FUND. building block - INTELLIGENCE

· REFLEXIVE - REACTIVE - CS

· REFLEXIVE : NO COGNITION

77 IRM's : SPEC. STIM. - RELEASES ACTION PATTERN

: SIMPLE program

82 : RESULT = COMPLEX ACTION SEQUENCE

: CONCURRENT / INDEPEN. EXECUTION

ACTION-PERCEPTION CYCLE

85 GIBSON : AFFORDANCES : PERCEIVABLE POTENTIALITIES : directly perceivable

: WORLD = BEST MODEL

: PERCEPTION EVOLVES TO SUPPORT ACTIONS

88 - VISION : TRAD. = STRUCTURE : COMPONENTS

: FUNCTION w/o FORM

91 SCHEMAS : HOW TO ACT + COMP. PROCESS

: DATA + METHODS : GENERIC TEMPLATE

: MOTOR + PERCEPTION

97 PRINCIPLES FROM NATURE :

· decomposition

· boolean activation

· filter sensing to relevance

· Direct percep

· Behav. = ind. - but = combinable / inhibitory

4. REACTIVE

106 VERTICAL decomp.

108 All actions = accomplished via behaviors

· behaviors = TRANSFER FUNCTION

· SENSE - ACT w/o PLAN

111 1. situated Agents

2. behav. = building blocks

3. Local sensing only

4. Modularity

5. Biological

113 Subsumption:

- Embedded proc. - behavior
- AFSM's

1. Layers of competance

115 2. Subsumption

3. Internal states avoided

4. Task: Activate layer

118 Inhibition / Suppression = subsump. methods

122 Potential Fields

- motor action must = rep. by vectors (mag / dir) (m,d)

124 - Force field actions

134 - Vector summation

145 - pros / cons

149 Reactive Eval:

- portability - needs modifications

Emergence: building block consequence

5. Design

157 Schema + OOP

163 Design steps

165 Case study

174 FSA's

184 - Drawbacks: prediction-based

- different initialization sequences

6. Common Sensing:

197 Logical sensor = equivalence in data output

Sensor Fusion

200 Sensor Fission (Brooks)

" Fashion: change of circumstances

Sensor Suite design

203 - Attributes

206 Suite Attributes: Simplicity - Modularity - Redundancy (physical / logical)

Proprioception : dead reckoning : signal from self

· shaft encoder

INS : Accelerometers - cost / jarring

208 GPS : non-exteroceptive

: error

: Building interiors

210 Proximity : most = active

SONAR : Moravec : Rings

: 1-25' / 30°

212 · Specular reflection, etc.

· Cross-talk (Rings)

· Code v. environment

215 · Power Levels - average of 3 readings

I.R.

217 Light washout / Absorbtion

TACTILE : Adjustment / sensitivity

Vision : multiple readings

: separate Discipline

· CCD - A/D = slow translation

· Framegrabbers

226 · Region segmentation : color (Thresholding) CMU cam

· Color Histogramming

231 · Range from vision

235 · Algorithmic complexity

239 · LASER Ranging

241 · Lightweight Vision (Horswill) : map

7. Hybrid

257 Reactive = new processors

· no planning

* > Emergent behavior: Art 'lo science

258 RESTORE PLANNING COMPONENT

CONSENSUS: behavioral / REACTIVE: low LEVEL

AURA: (ARKIN): Add COGNITIVE FEATURES

BOTTOM-UP LAYERING: NEW hybrid Approach

REACTIVE PLANNING: NEW model

- more TOP-DOWN
- best ARCHITECTURAL SOLUTION
  - Asynchronous deliberation
  - SELECTIVE USE OF deliberation - modularity
- PLANNING = decoupled FROM EXECUTION

261 Hybrid Behavior: ≠ purely REFLEXIVE

- ETHOLOGICAL - REFLEXIVE + INNATE + LEARNED (SKILL)
- ASSEMBLAGES OF BEHAVIORS ≠ PRIMITIVES

Global models: ≠ purely global - CONTACT w/ CURRENT STATE

263 COMPONENTS:

- SEQUENCER
- Behav. RESOURCE MANAGER
- CARTOGRAPHER
- Mission PLANNER
- Perf. MONITOR

265 ARCHITECTURES:

- MANAGERIAL
  - AURA: schema / OO
    - 267 Biology / HOMEOSTATIC
- SENSOR FUSION: SENSOR STREAM
- 274 STATE HIERARCHY: TIME
- Model-ORIENTED: more TOP-DOWN / Symbolic
  - world model: supplies perception
  - "EAVESdropping" on behaviors = distrib. processing
  - 278 SAPHIRA: COORDINATION
    : beyond REACTIVE
- 280 TASK CONTROL

285 SHAKEY COMPARISON

286 PATH PLANNING Algorithms

- FASTER PROCESSING
- Symbolic v. REACTIVE MIXING
- SELECTIVE ATTENTION + PLANNER

288 COGNIZANT FAILURE : WESSON OIL problem

8. Multi-AGENTS :

295 EMERGENT SOCIAL behAVIOR

300 SOCIAL ENTROPY : diversity FACTOR

II. NAVIGATION

317 4 QUESTIONS

319 PATH PLANNING : programming

· CRITERIA

SENSOR UNCERTAINTY :

· localization (mis-) ASSUMPTION

· ACCURACY (mis-) ASSUMPTION

PLANNING - AS- DeliberATIVE

321 SPATIAL MEMORY :

· ATTENTION

· REPORTING

· PATH PLANNING

· COLLECTION

·FORMS : ROUTE / QUALITATIVE + layout / METRIC

· ROUTE : PERSPECTIVE / EGO-CENTRIC

· LAYOUT : MAP : NON-PERSPECTIVE

TRADEOFFS / FACTORS : TIME / EFFICIENCY / DENSITY

9. TOPOLOGICAL :

Relational : connect DOTS

326 ASSOCIATIVE : SENSING

LANDMARK - GATEWAY

347 DESIGN IMPLICATIONS

10. METRIC

351 · measure 'to LANDMARKS

· WAYPOINTS : decomposed path

353 CSPACE

360 A* search Algorithm

11. LOCALIZATION

375 ENCODERS: INACCURATE, SURFACE DEPENDENT

378 SONAR - SENSOR MODEL

- BAYESIAN: probabilities

386 - DEMPSTER - SHAFER: probabilistic belief F.

395 - HIMM

  - +/- = ∠ CPU cycles

415 localization:

- ICONIC (raw) v. FEATURE-BASED

417 - TRADEOFFS

419 STM / LTM : MATCHING FUNCTION

FEATURE-based local:

421 - CONTINUOUS v. TOPOLOGICAL

435 12. HORIZON:

- CURRENT = NASCENT
- VISION / Robotics split = UNFORTUNATE

437 - lack of learning THEORIES (COMPUTATIONAL)

- Polymorphic ROBOTS
- AGENTS