Design of Physically Grounded Communication System
実世界コミュニケーション特論

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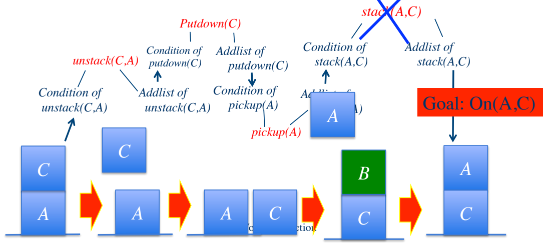
Planning

- Get a plan and execute the planed actions.



Intelligent System in Real World

- The system must deal with
  - Dynamic changes in environments
  - Unpredictable events
  - Vast number of entities
    - Difficulty to make a model
- Vertical System and Horizontal System

Typical design of a system

- Horizontal decomposition with vertical slices
  - A traditional decomposition of a system is based on functional modules
    - Functional modules: Sensing, Mapping sensor data into a world representation, Planning, Task execution, Motor control
    - Modeling and planning has an expression corresponding to the virtual expressions of SHRDLU.

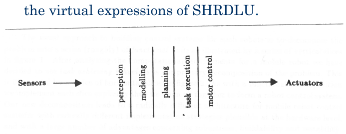
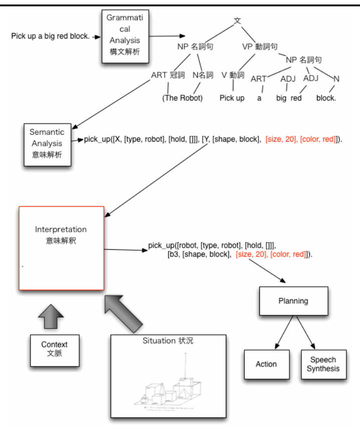


Figure 1. A traditional decomposition of a mobile robot control system into functional modules.



Typical design of a system

- A designer must consider the overall performance of a robot.
- Difficulty of modification

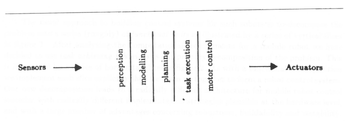


Figure 1. A traditional decomposition of a mobile robot control system into functional modules.

Typical design of a system

- Disadvantage of the traditional decomposition is that the system cannot react the changes in an environment immediately.

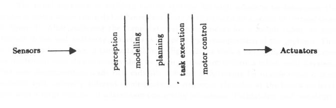


Figure 1. A traditional decomposition of a mobile robot control system into functional modules.

Horizontal System

- A decomposition of a control system based on achieving behaviors
- Subsumption Architecture (SSA)

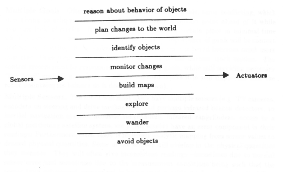


Figure 2. A decomposition of a mobile robot control system based on task achieving behaviors.

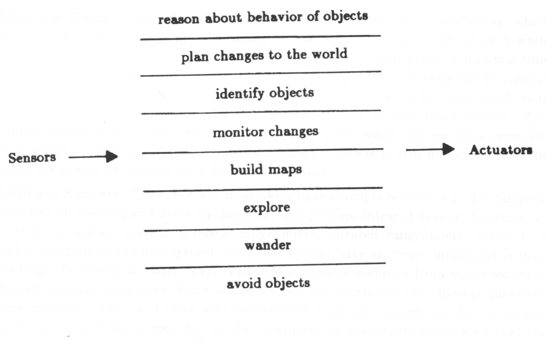
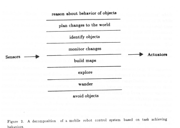


Figure 2. A decomposition of a mobile robot control system based on task achieving behaviors.

- https://www.youtube.com/watch?v=K2xUHYFcYKI

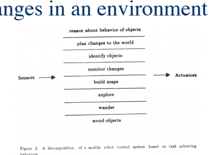
Horizontal System

- How to design
  - Decomposing the problem vertically
  - Rather than the slice based on internal workings of the solution, a designer should slice the problem on the basis of desired external manifestations of the system.
  - The designer is able to design each module independently of others



Horizontal System

- Complex behaviors are the reflection of a complex environment.
  - The complex behaviors of traditional systems come from the internal computations.
- Easy to react the changes in an environment immediately



Horizontal

- SSA generates robot's behaviors as if it has an intelligent module to generate complex behaviors to deal with the dynamics of an environment.

Robot

- Mobile robot
- Sensors
  - a ring of twelve sonar
  - pan tilt camera

Levels of competence

- *Level 0:* Avoid contact with objects
- *Level 1:* Wander aimlessly around without hitting things
- *Level 2:* Explore the world by seeing places in the distance which look reachable and heading for them.
- *Level 3:* Build a map of the environment and plan routes from one place to another.
- *Level 4:* Notice changes in the static environment.
- *Level 5:* Reason about the world in terms of identifiable objects and perform tasks related to certain objects.
- *Level 6:* Formulate and execute plans which involve changing the state of the world in some desirable way.
- *Level 7:* Reason about the behavior of objects in the world and modify plans accordingly.

Level of competence

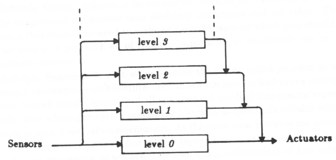


Figure 3. Control is layered with higher level layers subsuming the roles of lower level layers when they wish to take control. The system can be partioned at any level, and the layers below form a complete operational control system.

Robot control system instance

- *level 0*: prevent a robot from contacting with an object.
- *level 1*: wander avoiding obstacles.
- *level 2*: generate a path to reach a certain place.

Robot control system instance Instance of *level 0*

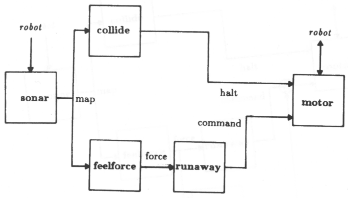


Figure 5. The level *0* control system.

Robot control system instance
Instance of *level 1*

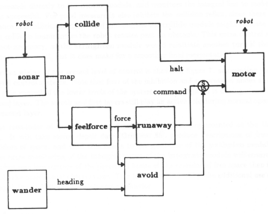


Figure 6. The level *0* control system augmented with the level *1* system.

Instance of *level 2*

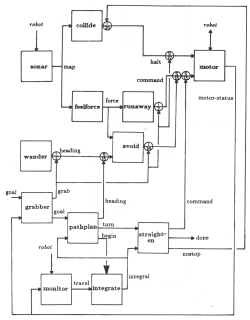


Figure 7. The level *0* and *1* control systems augmented with the level *2* system.

Simulation of SSA

- Sonar data

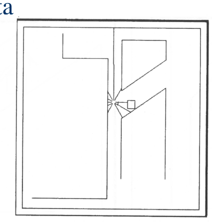


Figure 8. The simulated robot receives 12 sonar readings. Some sonar beams glance off walls and do not return within a certain time.

Simulation of SSA
Simulation of level 1

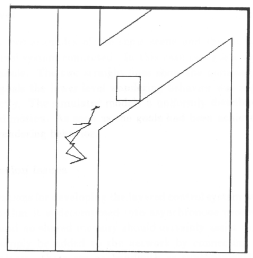


Figure 9. Under levels *0* and *1* control the robot wanders around aimlessly. It does not hit obstacles.

Simulation of SSA
Simulation of level 2

- After tracing the given path, level 1 controls the robot.

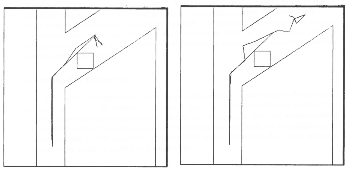


Figure 10. With level *2* control the robot tries to achieve commanded goals. The nominal goals are the two straight lines. After reaching the second goal, since there are no new goals forthcoming, the robot reverts to aimless level *1* behavior.

Advantage of Layers design

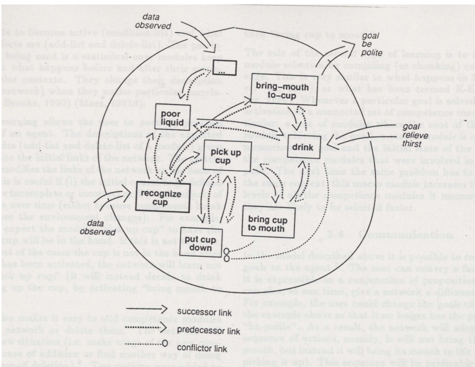
- Behavior selection reflects the structure of environments themselves.
  - No need to knowledge to select them.

Disadvantage of SSA

- Consistency between goal-oriented behavior selection and environment-oriented behavior selection
- Difficulty of developing actual implementation
- Self-recognition

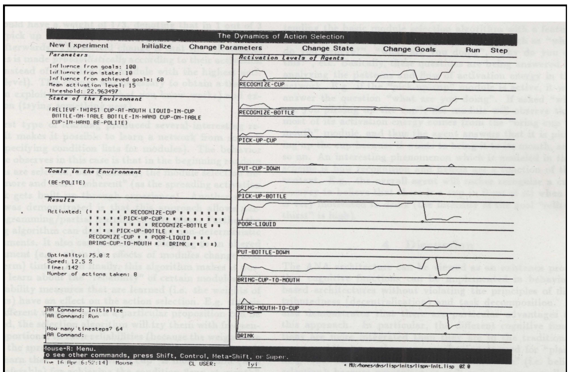
3.5 ANA (Agent Network Architecture)

- Behavior generation satisfies a goal-oriented method and an environment oriented method.
- ANA has both features of planner and SSA.
- The features vary depending on parameters.



3.5.1 ANA

- Calculation process
  1. Energy from environmental information
  2. Energy from goals
  3. Energy from other agents
  4. Agents which has highest energy and executable conditions and whose energy is beyond a threshold θ are executed.
  5. Update world model (add-list and delet-list)
  6. Try 1-5 until given goals are satisfied.



re 2: An example run of the module selection algorithm. The panes on the right side of the interface show the activa
s of the modules evolving over time. The small circles on the time axis denote when a module has been activated.
s on the left show (from top to bottom): the global parameter values, the current state of the environment, the cu
s of the agent, the list of modules that have been activated (chronologically, where "*" stands for a timestep in whic

3.5.4 The effect of parameter setting

- The effect of parameter values

$$\theta \propto \frac{1}{speed} \qquad \theta \propto optimality$$

$$\beta \propto goal-oriented$$

Env-orientented ⟷ *Goal-oriented*

$0 < \beta < 1.0$

3.5.5 Effect of environments and goals

- The effect of environments and goals

$$\#agents-realizing-goals \propto time-necessary-for-goal$$

$$\#goals \propto \frac{1}{goal-orientedness}$$

$$\#propositions-in-state \propto \frac{1}{data-orientedness}$$

Real World Interaction

Disadvantages of ANA

- Disadvantage
  - The problem of planner
    - Symbol grounding problem

Real World Interaction

Intention, Goal, Action

- Intention: If someone have an intention to achieve something, s/he set a goal to satisfy her/his intention.
- Goal: If someone want to achieve a goal, s/he consider an (action) plan.
- Action: If someone have a plan to do something, s/he takes actions along the plan.

Real World Interaction