Fakultas Ilmu Komputer, Universitas Indonesia

Probabilistic Robotics

Robot Navigation and Control Architectures

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Outline

- Robot Navigation
- Path Planning
- Control Architectures

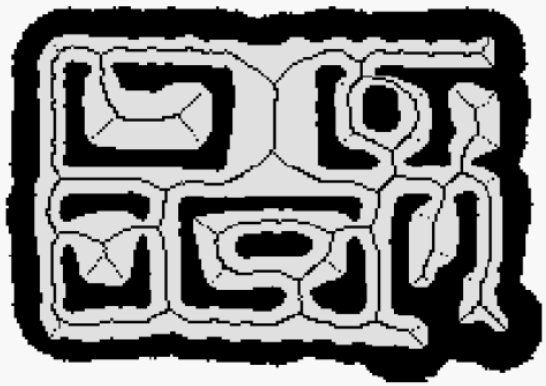
Robot Navigation

Typical problems

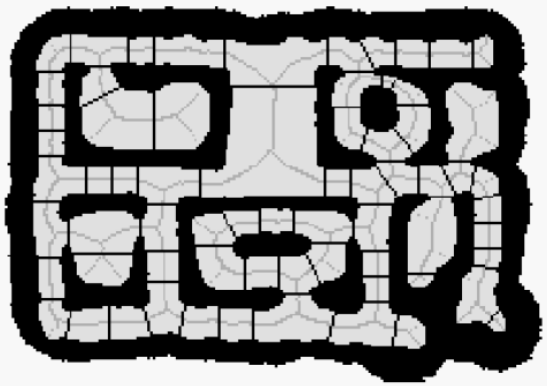
- Obstacle avoidance
- Localisation
- Adaptation to changes in the environment
- Map learning
- Path planning

Path Planning Techniques

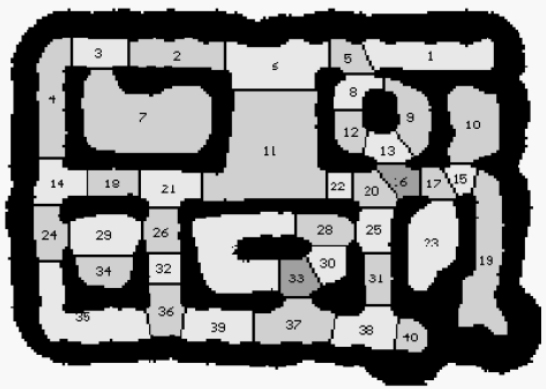
(a) Voronoi diagram



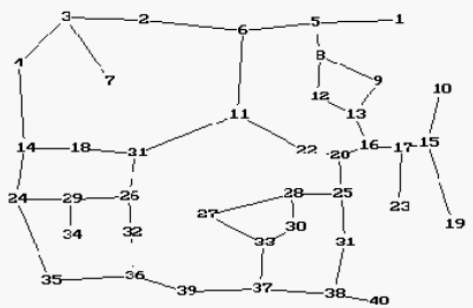
(b) Critical lines



(e) Pruned regions



(f) Pruned topological graph



Robot Behaviours

A behaviour is a regularity in the interaction dynamics between the agent and the environment.

Example

- Obstacle avoidance

Mechanism to realise a behaviour

- Set of components (sensors, body parts, actuators)
- Control program

Requirements of a Robot Behaviour

Reactivity

- React to sudden changes in the environment

Robustness

- Handle imperfect inputs, unexpected events, uncertainties, malfunctions

Reliability

- Operate without failure or performance degradation

Multiple-goal resolution

- Responsive to high-priority goals while still servicing low-level goals

Requirements of a Robot System Architecture

Modularity

- Crucial to incremental design, maintenance, failure detection and correction

Flexibility

- Continuous design changes during the implementation phase

Expandability

- Incremental implementation of robot skills

Adaptability

- Operation in different or changing environments

Multi-sensor integration

- Compensate for limited accuracy

Hierarchical Systems

Separating robot software into functional modules for perception, reasoning, and action

Advantage

- Components controlled by single modules

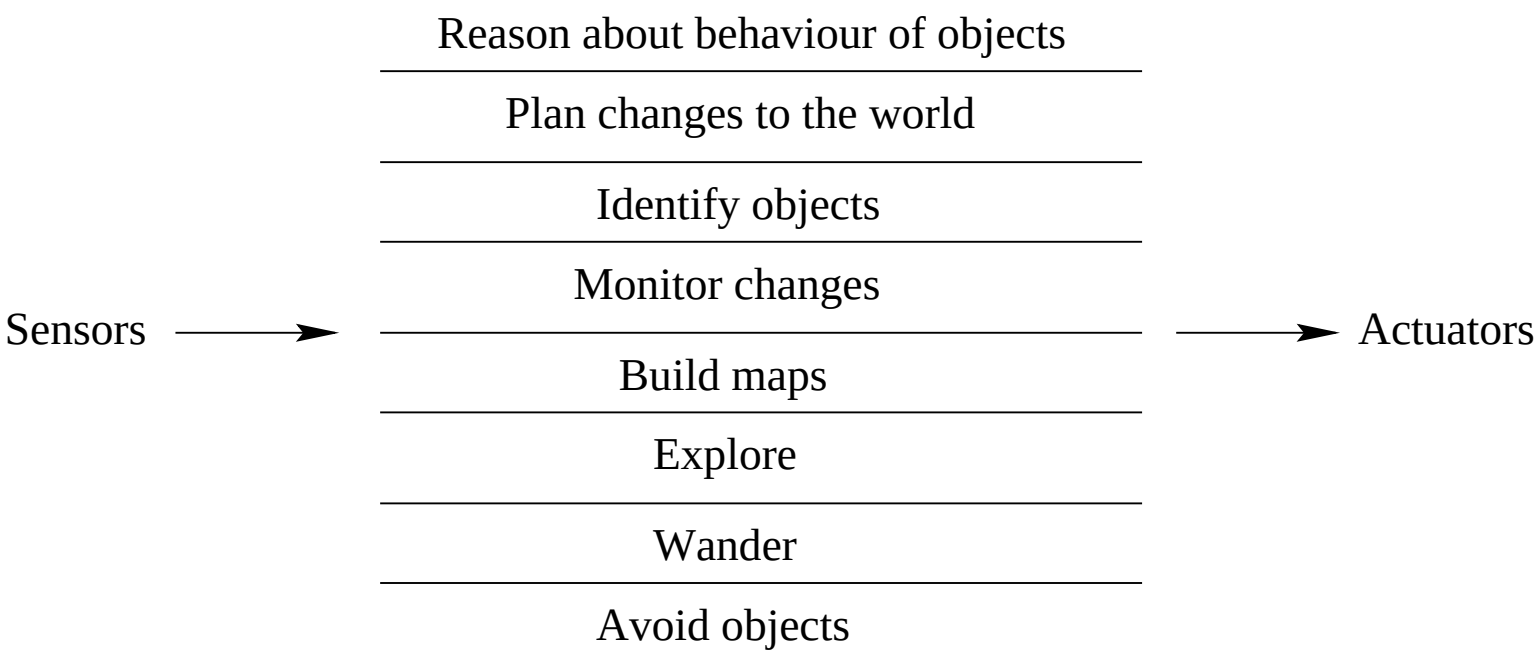
Drawbacks

- Sluggishness in reacting to rapid changes
- Not very robust due to sequential processing
- Reconfiguration almost impossible

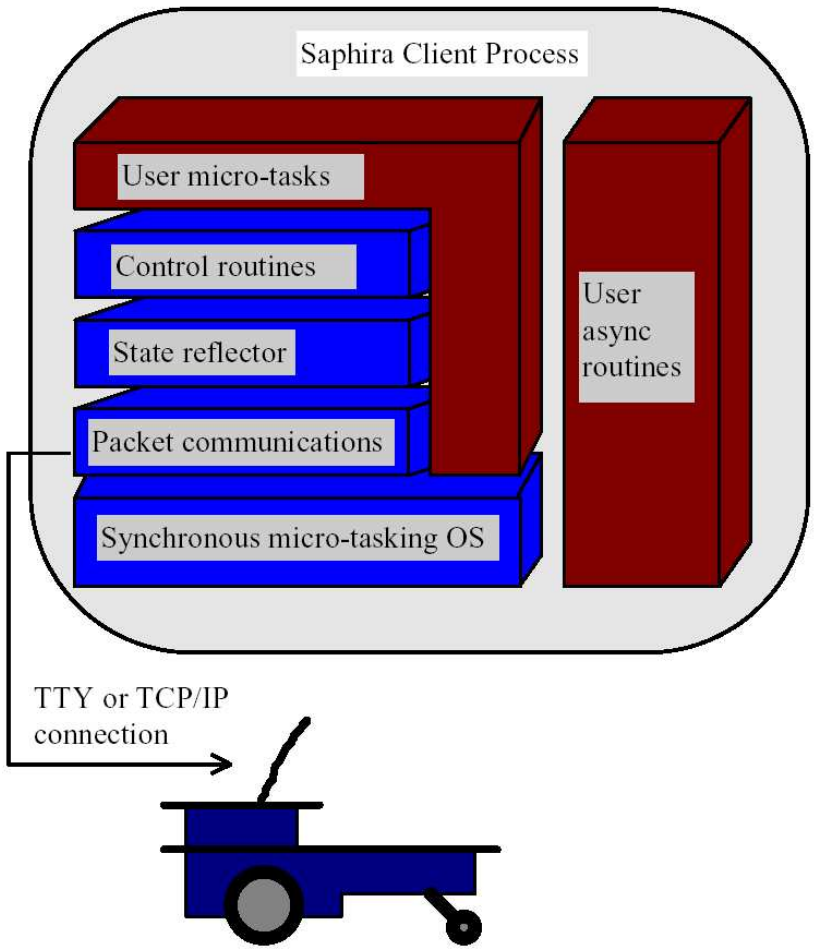
Behavioural Systems

Set of sensing, reasoning, and action loops that operate concurrently to control the robot

Decomposing the robot control problem into the robot's behaviours



Saphira Robot Control System



Motion Control in Saphira

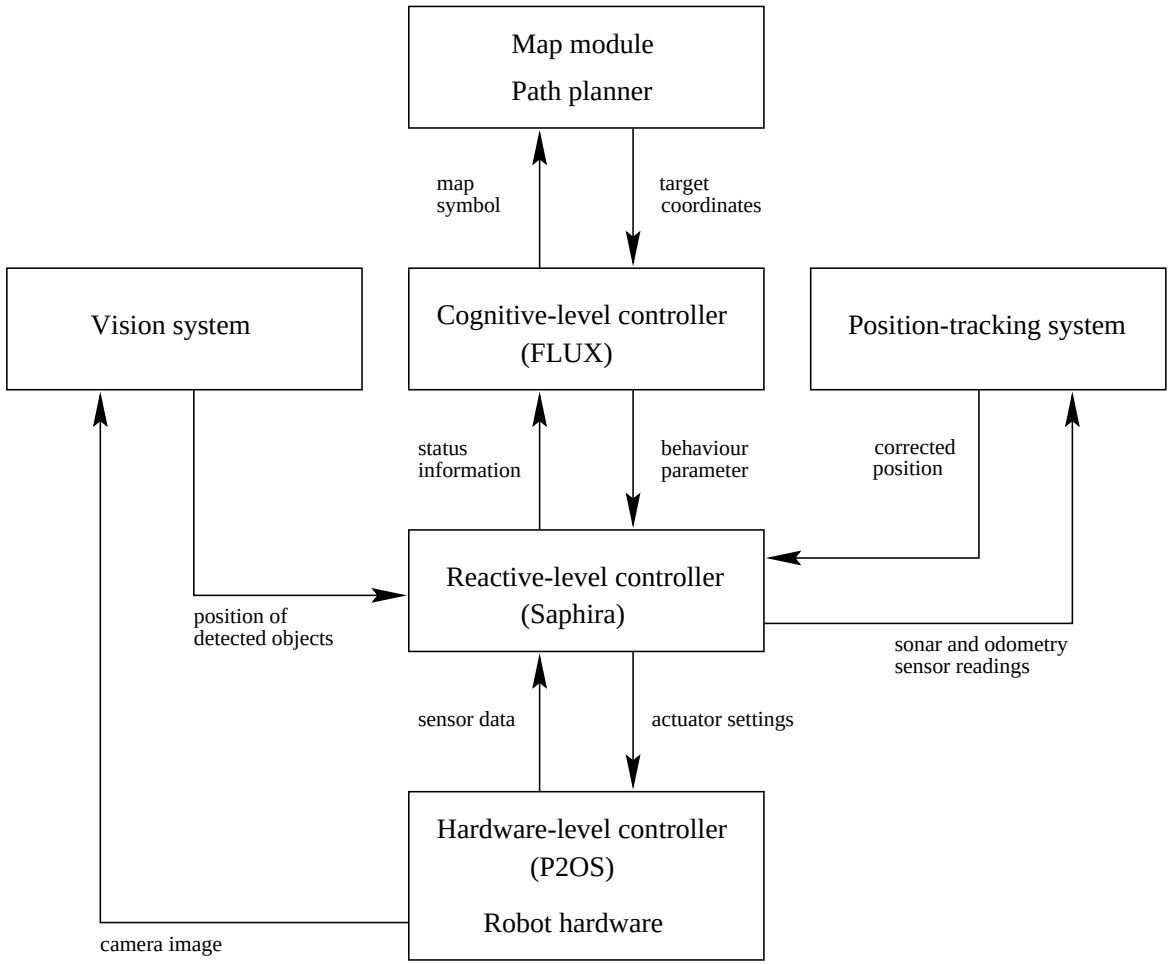
Direct control

- Monolithic controller

Behavioural control

- set of behavioural actions
- resolver to produce motion
- indirect or partitioned way of controlling robot motion

An Office Delivery Robot



An Office Delivery Robot: System Architecture (1)

Reactive-level controller

- Maintaining a model of the robot's environment using the readings of the robot's distance and odometry sensors
- Computing target values of the robot's actuators based on the output of a set of reactive behaviours
- Execution monitoring at the level of reactive behaviours

Vision system

- Model-based object detection using colour segmentation

Position tracking system

- Implementation of Monte-Carlo localisation
- Computing a probability distribution (belief) about the robot's position with respect to a map of the environment using laser range data

An Office Delivery Robot: System Architecture (2)

Map module and path planner

- Computing a topological graph for global navigation using Voronoi segmentation
- Translating symbols for locations into target coordinates

Cognitive-level controller

- Planning and reasoning system
- Implementation of the Fluent Calculus
- Execution monitoring at the cognitive level

Practical Exercises Using Player/Stage