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# An autonomous robot architecture for tidying up chairs in a room

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**Abstract**

*The video shows a mobile robot tidying up chairs in a room. It is meant as an example application of a behavioural architecture used to achieve autonomy of a mobile robot. In this paper, we present the state automaton and the behaviours involved in the implementation of the task.*

## 1 Introduction

The task of tidying up chairs in a room with a mobile robot, while simple in principle, raises several interesting problems:

- The robot must be autonomous, meaning there should be as little human intervention as possible.
- Fast interaction with the environment is required for obstacle avoidance.
- Accurate navigation is needed for fetching and parking chairs in the room.
- The robot is not a passive observer: it actually changes the environment by moving chairs within it.

The mobile robot architecture used to implement the task provides three main fetures. A behavioral approach for the advantages it provides concerning autonomy. Positioning (or geometric navigation) is provided by means of vision-based behaviors that *home* the robot relatively to features of the environment [1]. Hence, the task of tidying up chairs consists in several behaviours, including one homing behaviour. Finally, a state automaton fixes the sequence of behaviours that perform the task, since only one behaviour may actually control the robot moves at a given time.

## 2 The vision-based behavioral architecture

The behavioral concept aims at designing simple autonomous behaviors that grouped together may perform structured tasks in real worlds. The behavioral approach is inspired to some extent by the animal world. A behavior may be described as an independent stereotyped action that is maintained by a specific perceived stimulus.

MANO (Mobile Autonomous NOmad) is our implementation of the behavioural approach [3]. It consists of a development and experimentation environment based on a Nomadic-200 mobile robot (Nomadic Technologies, Palo Alto), dedicated vision hardware and a number of interconnected workstations. This environment offers features such as network-wide development and experimentation capabilities, virtual robot interface (allowing equivalent experimentation on simulator or real robot) and multi-language support. The selection of one behavior is performed according to a planer, which is implemented as a state automaton.

Vision-based behaviors are characterized by the fact that their stimulus is a visual primitive that triggers and maintains the behavior active as long as it exists. The vision systems we use are described in [2, 3]. Examples of vision-based behaviors we developed for the MANO architecture are *going towards a landmark*, *going along a wall*, *avoiding obstacle*, *pushing chairs* and *homing on landmarks* . The planer also relies on behaviors based on other sensor devices such as odometers, IR sensors and sonars.

## 3 The tidy up chairs task

The task consists in searching chairs disposed ramdomly in a room, and to push them up to a parking zone. This zone is defined with respect to a fixed position in the room, called home, characterized by two landmarks. The homing position is also used for relocating the robot relatively to the parking zone. Two vision sensors are used: the vision by landmark detects chairs marked with reflective material and the homing position, while vision by structured light detects obstacles lying in front of the robot. Odometry is used to move the robot to the parking zone and to bring the robot back to the homing position.

The video shows one cycle of the tidy up task. First the robots makes a homing (HO), then searches a chair in the room (SC); if a chair is found it goes toward it (GC). The robot must be positioned on the side of the chair opposite to parking zone. Then, the robot turns around the chair (AC) and pushes it (PC) until the parking zone is reached. Finally it returns back to the homing area (RH) and relocates itself (HO).

The behaviours needed to tidy up chairs are describe below:

- Wander around (WA): this behaviour moves the robot forward until the homing landmarks are viewed. It uses the ring of infrared sensors to detect possible obstacles. If an obstacle is detected, the robot turns away and starts moving forward again.
- Homing (HO): Based on the vision by landmarks system, the homing behaviour brings the robot in a fixed configuration with respect to two landmarks.
- Searching a chair (SC): searching a chairs is a behaviour which is stimulated when a chair landmark is detected.
- Going to a chair (GC): this behaviour moves the robot forward and servoes its orientation by centring the centermost landmark in the image. The robot stops when it is near the landmark.
- Aligning on the chair (AC): this behaviour uses the odometric sensor. Its goal is to move around the chair until the absolute robot orientation is perpendicular to the parking zone.
- Pushing the chair (PC): as for the alignment behaviour, the pushing behaviour uses odometric sensing to move the robot up to the parking zone.
- Returning home (RH): this behaviour bring the robot back to a given position using odometric sensors.
- Get position (GP): this internal behaviour returns the current robot position.

The tidying up chairs task has a pre-programmed structure described by a state automaton (figure 1). A circle indicates the selected behaviours, and the arrows show the result that behaviours provide. The concentric circles are final *successful* or *failed* final states. The normal flow while the task is being performed follows the outputs labelled *ok*. If an unexpected event is detected, such as an obstacle lying between the robot and the chair to be put away, then the current behaviour exits with a *fail* status. The robot then tries to return back home and starts a new cycle.

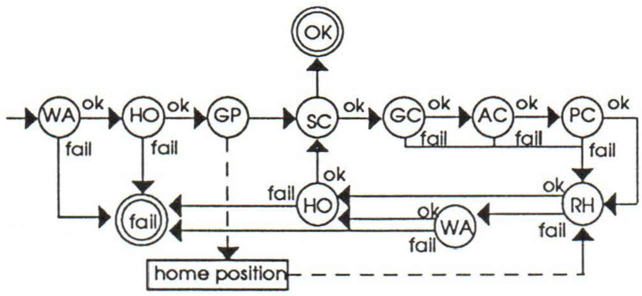


Figure 1: *state automaton describing the tidy up chairs task.*

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## References

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